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PLENARY SESSION
ASSESSMENT OF SUPPLIER’S RISK IN LOGISTICS NETWORKS

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Abstract

The aim of this paper is to propose a new methodology of supplier’s risk assessment. Based on the classic method of FMEA and its modifications we have developed a new method of supplier’s risk assessment. This modification is closely linked with the concept of risk-based thinking as well as fuzzy reasoning, and therefore seems to be appropriate for assessment of supplier’s risk in logistics networks. The method is applied iteratively in seven main steps. Firstly, a team of experts selects potential risk categories, based on the literature, data and their own experience. The set of risk categories is the basis for generating of possible threats and hazards, which may occur within the analysed system. These risks become system exposures, and can interrupt the supply process continuity. To these events we prescribe the measures of uncertainty of their occurrence in the form of fuzzy probabilities. The next step of the process is an evaluation of the exposure frequency, which represents a rating of how often a supplier performs the activity where risk exposure occurs. The last step is to assess the impact severity in the form of losses caused by these events, and to calculate the risk priority number as a product of fuzzy numbers.

Keywords: Risk, logistics networks, FMEA, fuzzy

1. INTRODUCTION

The issue of risk in supply chains, and particular in those with global scale, becomes recently more and more important. ISO 9001:2015 [14] recommends to use the concept of risk-based thinking for “carrying out preventive action to eliminate potential nonconformities, analysing any nonconformities that do occur, and taking action to prevent recurrence that is appropriate for the effects of the nonconformity”. To conform to the requirements of this Standard, each organization needs to plan and implement actions to address all possible risks as well as opportunities. “Addressing both risks and opportunities establishes a basis for increasing the effectiveness of the quality management system, achieving improved results and preventing negative effects.” Based on these assumptions the Automotive Quality Management System Standard - IATF 16949 [13] introduces a requirement that each organization shall have a documented supplier selection process, which shall include “an assessment of the selected supplier’s risk to product conformity and uninterrupted supply of the organization’s product to their customers”. IATF 16949 requires that “organizations shall ensure conformance of all products and processes, including service parts and those that are outsourced.” This use of the term “ensure” implies that the organization needs to establish and maintain a system that mitigates the risk of non-conformance throughout the whole supply chain. The organization is ultimately responsible for all conformity and must cascade all applicable requirements down the supply chain to the point of manufacture. Manufacturing processes have the same output requirements as those specified for the product, and often require the use of specific method, such as capturing and analysing risk via a FMEA (Failure Mode and Effect Analysis).

2. SUPPLIER SELECTION METHODS

The basic criteria typically utilized for supplier selection are: costs, delivery time, product quality, and service level. Traditionally most buyers consider cost as the primary decision factor, but recently more and more
various criteria for the supplier selection are taken into account: performance history, warranties & claims policies, production facilities and capacity, financial position, procedural compliance, reputation and position in industry, desire for business, repair service, attitude, packaging ability, geographical location, amount of past business, and reciprocal arrangement. With economic globalization, companies can choose suppliers from anywhere in the world, and developing countries are becoming more competitive because of their low labour and operating costs.

Different supplier selection methods observed in the literature can be classified as follows:

- **Categorical Methods (CM).** CM are qualitative models. Based on historical data and experience, current suppliers are evaluated on a set of criteria. After a supplier has been rated on all criteria, the buyer gives an overall rating. The primary advantage of the categorical approach is that the evaluation process is clear and systematic [1].

- **Data Envelopment Analysis (DEA).** DEA is a classification system that splits suppliers between two categories, 'efficient' or 'inefficient'. Suppliers are judged on two sets of criteria, i.e. outputs and inputs. Weber et al. have discussed the application of DEA in supplier selection in several publications [25].

- **Cluster Analysis (CA).** CA is a method based on statistics which uses a classification algorithm to group a number of items described by a set of numerical attribute scores into a number of clusters. This classification is used to reduce a larger set of suppliers into smaller more manageable subsets (Hinkle et al. [12]).

- **Analytical Hierarchical Process (AHP).** AHP is a decision-making method developed for prioritizing alternatives when multiple criteria have to be considered and allows the decision maker to structure complex problems in the form of a hierarchy. This method incorporates qualitative and quantitative criteria. The hierarchy usually consists of three different levels, which include goals, criteria, and alternatives. Because AHP utilizes a ratio scale for human judgments, the alternatives weights reflect the relative importance of the criteria in achieving the goal of the hierarchy [11, 16, 22].

- **Analytic Network Process (ANP).** ANP [18] is a comprehensive decision-making technique that captures the outcome of the dependence and feedback within and between the clusters of elements. ANP is a more general then AHP, incorporating feedback and interdependent relationships among decision attributes and alternatives. ANP is a coupling of two parts, where the first consists of a control hierarchy or network of criteria and subcriteria that controls the interactions, while the second part is a network of influences among the elements and clusters [19, 20].

- **Total Cost of Ownership (TCO).** TCO-based models for supplier choice consists of summarization and quantification of several costs associated with the choice of vendors and subsequently adjusting or penalizing the unit price quoted by the supplier. TCO is a methodology and philosophy, which looks beyond the price of a purchase to include many other purchase-related costs (Ellram [8]).

- **Technique for the Order Performance by Similarity to Ideal Solution (TOPSIS).** According to the concept of the TOPSIS, a closeness coefficient is defined to determine the ranking order of all suppliers and linguistic values are used to assess the ratings and weights of the factors. TOPSIS is based on the concept that the optimal alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS) [22].

- **Multiple Attribute Utility Theory (MAUT).** The MAUT proposed by Min, H. [17] is considered a linear weighting technique. The MAUT method has the advantage that it enables purchasing professionals to formulate feasible sourcing strategies and is capable of handling multiple conflicting attributes. However, this method is mostly used for international supplier selection, where the environment is more complicated and risky [23].

- **Outranking Methods (OM).** OM are useful decision tool to solve multi-criteria problems. These methods are capable of dealing with situations in which imprecision is present. Lot of attention has been paid to
outranking models, however, so far, in the literature there is no evidence of applications of outranking models in purchasing decisions [1].

- Mathematical programming models (MPM). MPM often consider only the quantitative criteria. Mathematical programming models allow decision makers to consider different constraints in selecting the best set of suppliers. MPM are particularly useful for solving the supplier selection problem because they can optimize results using either single objective models or multiple objective models [6, 26].

- Case-Based-Reasoning (CBR). CBR systems fall in the category of the artificial intelligence (AI) approach. Basically, a CBR system is a software-driven database which provides a decision-maker with useful information and experiences from similar, previous decision situations. CBR is still very new and only few systems have been developed for purchasing decision making [15].

- Artificial Neural Network (ANN). The ANN models are very efficient when we have a large number of credible data. The weakness of this model is that it demands specialized software and requires qualified personnel who are expert [15].

- Fuzzy logic approach (FLA). In this method, linguistic values are used to assess the ratings and weights for various factors. Usually these linguistic ratings can be expressed in trapezoidal or triangular fuzzy numbers. Since human judgments including preferences are often vague and cannot estimate his preference with an exact numerical value, the ratings and weights of the criteria in the problem are assessed by means of linguistic variables [2, 6, 9, 24].


None of the above methods meet the requirements of the IATF 16949 regarding risk-based thinking. Thus there is a need to develop a new method, which is focused on “an assessment of the selected supplier’s risk to product conformity and uninterrupted supply of the organization’s product to their customers”.

3. SUPPLIER’S RISK ASSESSMENT METHOD BASED ON THE MODIFIED FMEA METHODOLOGY

Based on the classic method of FMEA and its modifications proposed in papers [3, 4, 5 and 27] we have developed a new methodology of supplier’s risk assessment. This modification is closely linked with the concept of risk-based thinking, and therefore seems to be an appropriate method for assessment of supplier’s risk in logistics networks. The process of evaluation of supplier’s risk can be represented in the form of the general algorithm presented in Figure 1. The method is applied iteratively in seven main steps. Firstly, a team of experts selects potential risk categories (RC), based on their own experience. The set (RC) is the basis for generating a set of threats and hazards (TH), which may occur within the analysed system. These risks become system exposures and are defined as the initiating events that can interrupt the continuity of supply process. To these events we should prescribe the measures of uncertainty of their occurrence, e.g. in the form of probabilities P(TH). The next step of the process is the evaluation of the exposure frequency F(TH), which represents a rating of how often a supplier performs the activity where risk exposure occurs. The next step is to assess the impact severity in the form of losses caused by these events S(TH) (e.g. consequences of a delivery delay). Having evaluated parameters - P(TH), F(TH) and S(TH) we can calculate the risk priority number as the product of fuzzy numbers:

$$RPN(TH) = P(TH) \times F(TH) \times S(TH)$$  (1)
If the value of RPN exceeds the acceptable level of risk it should proceed to planning of risk mitigation actions, and recalculation of the RPN (Figure 1).

The method has been verified on the example of a real supply chain. Due to the lack of statistical data on the occurrence of threats and their possible consequences in the past, we used the expert knowledge for the evaluation of numerical indicators $X_i$, e.g. $P(TH_j)$, $F(TH_j)$ and $S(TH_j)$. The team of three experts evaluated each of the above parameters by the three numbers corresponding to the minimum value, the most likely value and the maximum value of the indicators. These numbers were the basis for describing a triangular membership function of a random variable $X$ in terms of the fuzzy sets theory. The result of the evaluation are therefore triangular membership functions in a number equal to the amount of the experts involved in the assessment process. Aggregation of expert assessments can be done by building a collective triangular membership function with the parameters:

$$X_i = f(x_i - a, x_m, x_i + b), \text{ for } i = 1 \ldots n$$  \hspace{1cm} (2)

where: $x_m = 0.5 (x_{\text{max}} + x_{\text{min}})$

and the parameters "a" and "b" are calculated from the Hartley’s formula (Hartley 1928) as a function of two standard deviation of the all three experts evaluations.

In the first step the team of three experts selected potential sources of risk $\{RS_i\}$, based on the literature, data and their own experience. The set $\{RS_i\}$ was the basis for describing a most dangerous scenario of the threats and hazards $\{TH_j\}$, which potentially may occur within the analysed supply system. The probability of occurrence for this scenario was assessed by each of three experts, and Table 1 shows an example of the threat likelihood assessment. The graphic interpretation of these assessments is presented in the left side of
Figure 2, and the result of aggregation of all three expert evaluations is shown in Figure 2 (right side). The parameters of the function \( P(TH) \) after aggregation are \([0.27, 0.4, 0.57]\).

### Table 1 An example of the threat likelihood assessment

<table>
<thead>
<tr>
<th>( P(TH_{min}) )</th>
<th>( P(TH_m) )</th>
<th>( P(TH_{max}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 1</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>Expert 2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Expert 3</td>
<td>0.25</td>
<td>0.45</td>
</tr>
</tbody>
</table>

![Experts evaluation of \( P(TH) \)](image)

Figure 2 The graphic interpretation of the threat likelihood assessment and the \( P(TH) \) function after aggregation
(Source: Own elaboration)

The second step of the assessment process is an evaluation of the exposure frequency \( F(TH) \). Table 1 shows an example of the exposure frequency rating by the experts, a graphic interpretation of these assessments is presented in Figure 3 (left side), and the result of aggregation of all three expert evaluations is shown in Figure 3 (right side). The parameters of the function \( F(TH) \) after aggregation are \([0.58, 0.73, 0.83]\).

The next step of the process involves the evaluation of robustness and resilience of the system to given exposure, and the prediction of the effects of the dangerous scenario in the form of impact severity \( S(DE) \). Table 3 shows an example of the impact severity rating by the experts, a graphic interpretation of these assessments is presented in Figure 4 (left side), and the result of aggregation of all three expert opinions is shown in Figure 4 (right side). The parameters of the function \( S(TH) \) after aggregation are \([0.32, 0.43, 0.53]\).

### Table 2 An example of the exposure frequency assessment

<table>
<thead>
<tr>
<th>( F(TH_{min}) )</th>
<th>( F(TH_m) )</th>
<th>( F(TH_{max}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 1</td>
<td>0.7</td>
<td>0.75</td>
</tr>
<tr>
<td>Expert 2</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Expert 3</td>
<td>0.55</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Figure 3 The graphic interpretation of the exposure frequency assessment and the F(TH) function after aggregation (Source: Own elaboration)

Table 3 An example of the severity impact assessment

<table>
<thead>
<tr>
<th></th>
<th>F(TH min)</th>
<th>F(TH m)</th>
<th>F(TH max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 1</td>
<td>0.4</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>Expert 2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Expert 3</td>
<td>0.35</td>
<td>0.45</td>
<td>0.55</td>
</tr>
</tbody>
</table>

The last step of the procedure is risk priority number calculation using the equation (1). The result of the multiplication of three fuzzy numbers [0.050, 0.124, 0.252] is shown in Figure 5. After defuzzification process we achieve the crisp number for RPN(TH) = 0.138. In case of the analysed systems, the maximum acceptable RPN value was set at 0.2, so the scenario meet this requirement.

Figure 4 The graphic interpretation of the impact severity assessment and the S(TH) function after aggregation

(Source: Own elaboration)
4. CONCLUSION

Supplier’s risk assessment for logistics networks is a process that can be represented in the form of the framework presented in the section 3. This method is based on the modified FMEA methodology, and can be implemented iteratively. The procedure for the risk assessment was based on the assumption of incomplete information about the possible sources of risk, threats and hazards, as well as their probabilities and consequences for the system. Therefore, as a knowledge base we accepted expert evaluation procedure and fuzzy inference process.

The applicability of the presented method has been verified on the example of a real logistics system. As a practical measure of risk we have chosen the product of three fuzzy numbers: probability of threats occurrence, exposure frequency and impact severity, for each of the possible scenarios. The maximum acceptable risk value was set and for the scenarios which do not meet this requirement the appropriate risk mitigation actions have to be planned. This procedure should be iteratively repeated as long as all scenarios reach a satisfactory result.

REFERENCES


METHODOLOGY FOR THE SYNTHESIS OF LOGISTICS SYSTEMS

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Abstract

Projects, projection are one of the basic characteristics of the society’s evolution at the end of 20th century and the beginning of the 21st century. Projection, preparation of projects and their management is one of the basic factors for success of a human being, firm, institution in logistic area too. One of the base steps in logistic system/LS/ creation is synthesis. Generally, synthesis is understood as a process of the logistic system creation.

Keywords: Project, synthesis, logistic systems, benchmarking, simulation, heuristics, model

1. INTRODUCTION

What is the project? A project is planned and organized allocation of resources focused on fulfilment of particular aims. From logistic point of view, project consists of aims, tasks and activities which create the chains and nets. Tasks and activities are work units between particular dates, which has define the resources for its realization. Project has a creative and technical-managerial side [1] [2].

Creative side of a project defines and describes how such a logistical system will function, fulfil the aims and behaving, how particular activities will be carried out, how the parameters will be managed, what organizational structure such a logistical system will have, how individual parts of the systems will be coordinated, what priorities and methods of optimization will be applied, how the gathering of data, control and feedback will be provided, etc.

Technical – managerial side of the project solves the problem of the functions, structure of the solving team, division of the project into phases, technique of work verification (control days), project documentation, time schedule, realization technique, delivery of the project, etc. [1] [2].

Steps in logistic systems design are described by algorithm on Figure 1 [1], [2], [6], [8].

Project design for logistical system can be solved by three approaches:

• by an order.
• by an cooperation approach.
• by own work team

Order approach is such a strategy, when preparation of the design and project is ordered from other projection-consultant company. This approach is also called “key design” - tailored made. A company names the workers responsible for the realization of the project and communication with the solution company. One of the disadvantages is that the solution is bought as a “black-box”, when all other changes require the same author’s company (from which we ordered the solution). It is an expensive approach with a permanent dependency on the supplying company.
The cooperation approach operation is defined by a creation of a common solution team consisting of the solution company and from the experts company itself. The composition is of a great importance for its solution as well as for the future application:

- It is very effective if the top management is also involved in the solution. Top management knows the best what they want from their own company and where are the problem areas. Their involvement improves the communication with the subordinate workers.
- It is also very important that the managers of logistics, planning, operative management, maintenance, procurement and marketing are also members of the solution team. They know the processes and their functions in detail and mostly in the analytical and evaluation part of the design, these persons are irretrievable.

**Figure 1** Steps in the logistic system design
• The leader of the team should be a creative person (outside of the company) who is capable of generating and reviewing ideas and solutions with sufficient theoretical background and experiences in the projection of logistic systems.

• Wide-spectral team of workers (university, research institutions, consulting companies) from economic, technical, logistical, information, mathematical, etc. background is also of great importance for the future success of the project.

Design - project - solution carried out by such a team is easily applicable because it has been done by a person from inside of the company and so it is considered as “their own”, they have their piece of involvement in it and possibly can be directly financially involved in the solution and realization.

LS design which is made up of workers of his own business has benefited from the knowledge of the system, easier application of solutions and operation and updates. Workers do not have the theoretical knowledge and experience from design.

2. DECISION ABOUT THE PARADIGM OF THE DESIGN PROCESS

Next steps for the design process, methods, forms, tools, expenses, etc. depend on the selection of the paradigm (Figure 1). It is possible to select the design paradigm based on the current analysis and project aims:

1) Case study.
2) Re-engineering.
3) Systems (model) approach.

The order is given by the multitude, volume and quality of the solution.

1) We choose the case study, if we are talking about the solution of a separate case, which does not have a definitive impact on the other logistical activities and significantly does not interfere with the whole logistic system. E.g. if a problem is to find an optimal distribution path of goods ordered for customers for summer season; this is a one-shot solution prepared and realized fast.

2) Re-engineering method is applied when we are talking about radical change of the logistical system, which interfere with several functional areas of the company.

3) Model, system approach is chosen in case of a new proposal for new logistic system for an enlarged company, for an area which was not taken into consideration so far. There is enough time and financial resources for such a change. E.g. a company enlarges its production with some new range of goods for a new market. It is important to design logistical system for a new division, new procurement system, system of production processes management, distribution system, etc. and connect such a system to the existing logistical system of the company. This is a change in the structure of the logistical system, systemic change.

The selection of the paradigm will influence the whole further design process and project preparation.

E.g. in case we will select a system approach design, we have to take into consideration the system analysis, respectively method of multi-criteria evaluation (but almost never a SWOT analysis, or heuristic analysis). For the synthesis is typical model approach.

Other way, if we choose “case study”, then we apply SWOT analysis focusing on the problem area (but not the system analysis) and for the synthesis we will choose the heuristic approach or benchmarking but not the model approach.

3. LS SYNTHESIS

Synthesis is the process of logistic systems creation and it has 2 phases:
Synthesis = Know-How + Design

1st - How to do it - proposal for methods, rules, algorithms and techniques (know-how),
2nd - To do it - projection - creation of particular system on the base proposal methods and inputs, parameters and conditions gathers during the analysis.

Synthesis LS differs according to a project type:

1) Routine project - always looked for analogy of a problem with a problem solved in the past; this solution is applied synthesis bases on correctly defined conditions of similarity.
2) Innovation project, where know-how exists and is applied on new conditions of a new problem. This is not a change of philosophy, solution principles or systemic change but this is an adaptation and innovation of functions and processes.
3) Creative project - when a new system is created or re-structured. Its structure from previous system into a new one is created. For these purposes new know-how and new system must be generated.

Synthesis of a LS aims in:
- Designing effectively functioning LS with less expenses or.
- Designing a new system according a detailed analysis of a previous system or.
- Defining and designing the creation of new LS based on theoretical knowledge and methods.

In general, synthesis includes these basic steps:
- Specified definition of LS goals (after analysis).
- Conceptual design (design of a LS structure and behaving, its parameters, elements - subsystems, their relations and connections to other systems).
- Function and process design (in a form of steps, algorithms, input and outputs).
- Method of design, optimization (know-how) of the system and its functions.
- Technical solution.
- Information solution.
- Schedule plan for realization and verification.

Final synthesis is completed with:
- Conceptual project (Preliminary study).
- Technical project.
- Executive project.

In some cases the solution conception can appear in the preliminary study.

Synthesis Method Selection: For synthesis can by apply:
- benchmarking,
- analytical models,
- simulation models,
- heuristic models.

Definition of a problem and solution objectives, selection of paradigm and analysis results predefine the selection of a method for synthesis. Simulation model, respectively heuristic model is used for LS synthesis when there is none analytical model capable to solve the situation or we are not able to create such analytical model. Simulation models are used when searched parameters and structure cannot be calculated analytically, e.g. a manufacturing process with several operating machines. The range of goods is wide and each product has different production method, different operation times and we want to e.g. localize buffers, calculate the machines’ capacity utilization, find the optimal lay out, etc. In this case mathematical calculation for bulk service is very complex and non-realistic [2], [4].
Heuristic models are applied in cases when people can solve particular problem but mathematics and operation analysis can’t. Then we model their behaving during particular problem solving - create heuristic model [5], [6], [7], [8]. Benchmarking is used when we are able to find the problem solution in analogical case.

**a) Benchmarking**

Synthesis principle for case study is benchmarking. This principle is used either directly - analogical solution is looked for when solving particular problem, or in case of a more complex situation. E.g. design of company’s LS where method of multi-parameter analogy - benchmarking will be used [1] [2].

Benchmarking is a technique where processes and methods of company’s functions are compared and differences of efficiency are discovered. Reasons for found differences are investigated and improvements are identified. Usage of benchmarking in logistic processes means process oriented way of thinking where value added logistic processes of designed LS $x_i(p)$ and matching logistic processes in gauge form $x_i(e)$ are compared and their differences $\Delta x_i$ are analyzed.

Problem is to find the etalon company. Such company must be similar and in that case it is from a group of competitors. To be able to gather information means to make the same analysis also in the gauge company, which means to gather information from it as well. This company is not motivated to provide their own information such benchmarking purposes.

In case of study approach, new methods, techniques and solutions are not created by used and applied a solution from analogy case. However, there might be cases when problem - case or situation necessary to be solved is relatively isolated but solution requires a creation of a model - heuristic, simulation, analytical. Borders between individual paradigms and approaches are not strictly defined (black and white) but in many case they are blurred (grey).

**b) Analytical model application**

Analytical models applied for LS are mostly models of operation analysis and manufacturing process modelling e.g.:

- Models for calculation of capacity and machine configuration.
- Models of bulk service.
- Markov chain.
- Network methods.
- Sequential methods.
- Linear optimization (simplex models).
- Dynamic optimization (dynamic, programming, calculus of variations).
- Allocation and lay out methods.
• Neuron networks.
• Forecasting methods (quantitative and qualitative) etc.

Each of these analytical models is suitable for a solution of a specific problem, e.g.:
• If we need to solve allocation of the distribution centre or stores, we apply Cooper iterative model.
• If we need to design a project of the maintenance big furnace, network analysis CPM and PERT can be applied.
• If we need to find an optimal product sequence, sequential methods Branch and Bound or an enumeration method is used.

All these models have defined usage in their application for LS synthesis and all are problem-oriented.

c) Application of Simulation Models in LS Synthesis

Simulation is a synthesis method where designed LS is replaced by a simulation model, with help of which all experiments are carried out with the aim of achieving parameters that are later on applied back on examined and designed LS. Simulation is one of the last and most expensive alternatives for LS synthesis. Due to the complexity, stochastic and variety of processes; simulation is most of the time the only option for LS synthesis. E.g. in case of very complicated cross-roads (Figure 3):

For example, if an objective and task is defined: to find an optimal lengths of green lights in all directions so that cumulative cars waiting time of at the crossing as short as possible and so that the crossing has the maximal operating efficiency.

Density and conveyance flows are different during the peak, during night of weekends, during holidays or during different seasons. Particular crossing could be observed and set directly on the real crossing but that would be unrealistic.

However the crossing can be modelled - we create a physical model with cars and lights, which is a possible task but only visionary for calculation of essential parameters \((T_n, T_s, T_e, T_w)\) - times of green lights from the north, south, east and west). This is a possibility to create a mathematical model based on systems for bulk service.
The task is feasible but a model of four or six systems for bulk service interactively excluding each other activities is extremely complicated.

Figure 4 Sequences of steps during the LS synthesis according SM

In this case simulation would be the only solution. A simulation model for particular crossing will be created and on this model, experiments will be performed (different lengths of green lights). Status of each of the cases
will be carefully monitored. From several variants the only one - optimal will be selected and applied to the real crossing.

Nowadays only computer simulation models play an important role in the real praxis. Simulation models are functional models which copy the functions, activities and processes of real LS. In our case we are not modelling a crossing but its functions, e.g. cars come to a crossing, if there is a red light, they wait, if there is a green light, they pass, etc. Such creation of a simulation model requires a specific analysis described during creation of simulation model.

Simulation models of LS are mostly discrete, respectively can be defined as discrete systems.

The methodology is based on Dahls definition of simulation (Figure 4).

d) LS synthesis based on heuristic model

Heuristic approach assumes modelling of process principles as processing of information carried out by a person on various phases of his / her activities and while solving various tasks. This approach then bases on a principle of heuristic model creation.

Sequences of steps during creation of such heuristic model:

(a) Definition of initial situation (problem definition).
(b) Creation of possible variants for further situations (possible solutions).
(c) Rule creation - criteria for solution selection.
(d) Heuristic model synthesis.
(e) Heuristic model verification.

The sequences of steps for creation of such heuristic model are illustrated on a Figure 5. Definition of rule group is performed as the result of analysis, technological processes, machines, equipment, organization and manufacturing process management, economy, capacity and optimality criterion.

![Figure 5 Creation of heuristic model](image)

Particular process, e.g. planning, has particular entry file of orders and by its analysis the rules were defined, which need to be fulfilled by the planning process.

The synthesis objective is to create an algorithm or model from these rules and from the definition of entry files structure.
\[ R \in \{ H, TP, EP, O, CO \} \]

Group of rules comprise of following groups:

- Heuristic - $H$
- Technological rules - $TP$
- Expert rules - $EP$
- Restrictions - $O$
- Optimality criteria - $CO$

4. CONCLUSION

LS synthesis is a process of creation of new innovated LS. Development of synthesis methods directs to unified type systems, partially valid and well algorithm (finance, transport, purchase). Though just as difficult it is to find two same companies, it is also difficult to find two same manufacturing processes, distribution networks, planning systems, etc. That is why for parts like procurement, manufacturing, distribution, transport, main material flow, etc we have to create “at-hoc” tailored made logistic systems. And there are approximate synthesis methods applied through:

- Case studies- benchmarking- multi analogy
- Analytical model- deduction
- Heuristic models - induction.
- Simulation models - imitation.

All these synthesis methods can be applied only by a designer who knows sufficient scheme of mathematical methods, information technologies and tricks of operative analysis and has satisfactory experiences and praxis because all these skills and knowledge create the background for simulation, heuristic model and for case studies.

REFERENCES

SESSION A:
SUPPLY CHAIN AND NETWORKS
SIMULATION OF THE BEHAVIOR OF LOCAL EXTREMA IN THE DISTRIBUTION

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Abstract

Distribution chains can change their parameters. There are changes in the final quantity and the final destinations too. This paper deals with searching of local maxima. There is analysis of the quantity of goods delivered to customers in time and space. We have simulated distribution of selected goods in the segment of specific pharmacies. We have recorded information about capacity of the deliveries according to the time and customers. It was evaluated distribution of the amount of delivered goods. There are using the precedent matrix to found places with larger supplies than the immediate surroundings. We have monitored the changes of maxima and their distribution of in space and time. There were also analyzed dependencies in this distribution of maxima. We have used the method of precedents matrices and we compared the results with the simulation based on the Simul8 program. Results can be used for the allocation of vehicles on the basis of knowledge of the behavior of the distribution. The benefit is that the simulation is performed on a specific real business process.

Keywords: Simulation, distribution, precedence, model

1. INTRODUCTION

Methods of analysis of flow variables are quite often used, especially in logistics systems. In the context of modelling and simulation is a priority choice and design of infrastructure, then the analysis of the motion of the observed bodies after this infrastructure. The most commonly used methods include distribution problems of linear programming, especially transportation problem, assignment problem, the problem of circle transport and general distribution problem. Research in this area were carried out in the context of major infrastructure projects (in the CR example BBMRI, CESNET, CzechCOS / ICoS, CzechGeo / EPOS, CzechPolar, CZERA, ESS, ESS - survey etc.). The claimed methods are particularly concerned with monitoring the absolute values (quantity of distributed entities, the duration of activities) and statistical processing. The paper deals with an innovative approach, analyzed the changes are monitored, thus are the dips and rises in the variables of space and time. The claimed methods have been presented in the past such as [6] or [7]. The method is applied to a specific subsystem of the distribution process of the selected portfolio of products the pharmaceutical companies and pharmacies in selected municipalities of the CR.

1.1. Distribution chains

The starting point for the analysis is a distribution logistics, that is support in the implementation of the decisions of the summary tasks and measures for the preparation and execution of the distribution. Whereas the role of distribution logistics is to provide manufactured goods as defined per type, the quantity of space and time so that they can be either complied with specified delivery time, or that it could be possible, most successfully met the expected demand, deals with the analysis of distributed product quantity as a factor of demand prediction.
1.2. Research, the research question, hypothesis, scientific goal

Priority objective of the distribution is therefore satisfying the demand. In this context, the emerging research questions. Is there a time dependency between the local extrema in the distribution traceable on a specific timeline? The spatial movements of local extremes can be mathematically describable? You can use a mathematical model and simulation of the program to predict future demand? Of these questions and the distribution of the objectives of the research goal resulted to create a model for tracking the extremes, to model a specific behavior of an existing distribution process and identify the dependencies. The extremes have been studied the distribution process, such as extreme was marked with the pharmacy, in which delivery was higher than in the surrounding pharmacies, available through the distribution infrastructure. In this context, have been made the hypothesis that deliveries to individual pharmacies characterized as extreme are cyclically dependent over time, this means that in time the position of the extreme moves by using a distribution function.

2. PROCEDURE, MODEL, METHODOLOGY

To answer questions and confirmation of the hypothesis was defined a distribution infrastructure. It was created by the model that defines the minimum distance between the monitored nodes. The model was defined as a generic, enabling the definition of any of the network based on real physical infrastructure (transport distance, network bandwidth, transport capacity, etc.) or a virtual infrastructure (defined based on the availability and accessibility of using geographical location, regardless of the physical infrastructure). The criterion is to create a contiguous infrastructure with "sufficient" density based on defined criteria. For creating the infrastructure has been used multiagent system. Custom modelling infrastructure is made up of a search based on the geographical coordinates of lows, for each node (end node distribution chain pharmacy) is based on a random passage network to find the nearest "appropriate" around. The model allows you to search a predefined number of bindings. The model also allows resolution of found links between points A and B in terms of the orientation of the AB or BA. To ensure an even distribution of links can be supplemented with an infrastructure based on triangulation, to ensure the continuous system can be used as the default infrastructure minimal skeleton. Infrastructure is further optimized by repeated passes. Infrastructure is recorded by incidental binary matrices. For a defined infrastructure to further model compare values of specified factors. Based on the values of the factors are determined the directions of increase or decrease the tracked variables. Changes are tracked between consecutive elements on a defined infrastructure. This leads to the creation of the infrastructure-oriented, are used to capture the case matrix (matrix precedential). For modelling and simulation has been used software MS Excel.

2.1. The data distribution infrastructure

Data used for the analysis of the distribution of specific companies in the period up to February 2015 July 2016. The data file contained almost 6500 records of more than 1200 pharmacies in about 550 villages. Were 55 products portfolios. The time scale was one day. In the context of data inconsistencies, it was necessary to simplify the model, for the initial research were as endpoints defined in the distribution chain of the municipality, not the pharmacy. Referenced post summarizes daily distribution to monthly intervals.

2.2. Modeling of the infrastructure, the selected models, the description of the method

Infrastructure has been defined for the village with the localization of registered pharmacies. For the village in pharmacy data were summarized (in the case of dislocation more pharmacies in the village). For the selection of the village was selected as a criterion for the zip code (there are more municipalities with the same ZIP CODE but also the municipality with more zip).
Table 1 illustrates parsed sequentially models of infrastructure. In the left column is the infrastructure created 10 cycles, 3 edges are defined, uniform distribution is secured by Triangulating the bindings, the edge of BA is not identical with the edge AB. Generating it took 5 hours 42 minutes. In the first row are captured by the identification of links, green is binding with the identification of 10 percent, then the red with the identification of 100 percent. In other rows is then defined by the infrastructure when 90 percent and 100 percent of passes. The right column then shows simpler models, when either is not required of triangulation, the edge AB is understood as a BA or the accuracy of the model is limited to a smaller number of passes. Black and white structures are 100 percent records identified, color model once again distinguishes the appropriate percentage of the identification.

2.3. Simulation, precedence, changing local extremes

For the determination of local extremes has been used a model defining the 3 edges, 10 cycles, triangles, edges enabled the calculation of the looping lasted 2 hours 57 minutes. The structure has an acceptable density, the model is continuous, the edges were 100 percent identified. For each of the nodes (modified end points of distribution) were compared using the first precedence (more about the method e.g. [6]) distributed a summary value range. Table 2 shows the selected infrastructure of the CZECH REPUBLIC and in red marked the first precedence - local maxima - in the period of May 2016. The next cell of Table 2 show for demonstration of selected segment of the municipalities and the movement of the extremes in your watch months (presentation segment is determined by the scope of the contribution; the comparison of the entire infrastructure would not be unreadable). The red circles indicate the extremes, the Red arrows indicate links between adjacent nodes on which delivery occurred, however, it is less than the value in the extreme. In the selected segment are shown municipalities - see Table 4.

Table 3 shows the then-year comparison in models with different density infrastructure. For a demonstration of the expanded selection is displayed, the area that is shown in Table 2 is highlighted in this area shading.

3. DISCUSSION - EVALUATION OF METHODS, EVALUATION OF A SPECIFIC MODEL OF RESEARCH, RECOMMENDATIONS

Method and model provides an accurate picture of the distribution of the local maxim. In a similar way, you can identify local minima. Based on the multiplication of matrices (closer to the case e.g. [6]) can be identified increases or declines in the distributed product quantity between the end points of distribution in the larger distances, not only between neighboring points.

Table 1 Different density distribution infrastructure

| 10 cycles, 3 edges, triangles yes, no repeat, 5 hours 42 minutes | 4 cycles, 3 edges, triangles, without overwriting the edges |
The model also allows defining the capacity options, not limited by distinguishing the level of transport infrastructure. Model to further assess the real distances that can be identified for example, based on the length of the road network. The model also allows defining the capacity options, not limited by distinguishing the level of transport infrastructure (limited processing power of the computer). The versatility of the model has been proven not only for modelling distribution channels but also in manufacturing processes and systems modelling and regional analyses.

**Table 2** Local extremes - development in months

<table>
<thead>
<tr>
<th>Simulated infrastructure - modeling precedence</th>
<th>Selection of distribution. May 2016</th>
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<tbody>
<tr>
<td><img src="image1" alt="Map of simulated infrastructure" /></td>
<td><img src="image2" alt="Map of selection distribution" /></td>
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Table 3 Local extremes - different density infrastructure-year comparison

|-----------|-------------|----------------|--------------|---------------|

Figure 1 Local extremes - the segment for comparison
Whereas, in this phase of the research were not examined other factors for example the absolute value of the supplies, cannot be in the present define dependencies. Not found clear distribution function applicable to simulate the Simul8 simulation program, it was not possible at this stage of the research predict the distribution. Similar research abroad (exploring the circularity in the economic phenomena, respectively. in the distribution) recommend tracking statistics quantities, layout, slope, and so on, which recommends for example: When the examination of the impact of cyclical wage model and the efficiency of Park and Choi [2] at the same time influence is debated monetary and fiscal instruments to the behavior of the market, which may significantly affect the fuel consumption and thus also distribution, regarding the cyclicality of the use of these tools. Circular and cyclical factors specify for example Strawczynski [3].

Further, as points out for example. Sosa et al. [4] would be similar research should consider the analyses related to the distribution and qualitative factors.

### Table 4 Extreme and Precedence

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### 4. CONCLUSION

Not found a clear answer to the research question, whether there is a time-dependency between the local extrema in the distribution, traceable to a specific timeline. It can be stated, that have been identified the end of the distribution chains, returning a low frequency of extremes and low frequency of deliveries, while these extremes do not depend on the number of the population in the region (Pelhřimov, 1 extreme x delivery). Additionally, you can identify the end of distribution chains, which have a very low the frequency of extremes, but have a high density of the supply of goods (Chýnov, Ledeč nad Sázavou, 1 extreme, supplies almost every month). Distribution It shows seasonal fluctuations, however, does not copy the character of the seasons, vacations or holidays (such as fluctuations in the months of April, May).

Can be traced from the geological occurrence of extremes (Vlašim, Zruč nad Sázavou, Světlá nad Sázavou, etc.), but differs in the cyclicality of the endpoints Per the capacity of supply. Can be traced back for changes the direction of cyclicity (for example, precedence. Humpolec, Pacov). The annual changes to show an increase in the density of links, fail to conform distribution of endpoints fail to conform the direction precedence. Year on year comparison shows the conformity in the occurrence of extremes and precedence. Increase the density of the network does not lead to the identification of new extremes, only identifies the new binding, as shown in Table 3 - comparison of interannually increases the selected segment.
The research objective, to create a model for tracking the extremes, model the specific behavior of an existing distribution process, and to identify addiction has been satisfied, the model is a flexible, extensible, model was used in the analysis of the distribution of the drug companies. On the specific the case has been partially confirmed the hypothesis that the supply to the individual pharmacies, characterized as extreme, are cyclically dependent, in time This means that in time moves the position of the extreme of using distribution function. This distribution function, however, failed to find. Of the previously mentioned studies for finding the distribution you need to consider the wider context, at the same time but the question further research, whether in the long run proves referenced model percentage sufficient results. In this context, as appropriate appears to be a possible extension of the stochastic method. Similar extensions are used, for example, in the model of real-business-cycle as such Andolfatto [5].

ACKNOWLEDGEMENTS

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REFERENCES

LSP COLLABORATION ON MULTIMODAL TRANSPORT IN CHEMICAL LOGISTICS

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Abstract

One of the most prominent targets of the EU Transport Whitepaper is the ambition to shift 30% of road freight, transported more than 300 kilometers, to multimodal by 2030 and 50% by 2050. Transport and logistics industries are working on achieving this goal with a strong commitment and contribution from chemical companies. The critical factors for success are the interconnectivity and interoperability of European transport systems in terms of infrastructure, processes and law, as well as logistics collaboration between supply chain partners. The purpose of this article is to introduce the concept of multimodal transport in chemical logistics with its key challenges, and to show the role supply chain collaboration plays on logistics when shifting road transport to multimodal ones. Vertical and horizontal collaboration with logistics service providers (LSPs), in order to develop quality multimodal service delivered at a good price, will be investigated. The research problem is analyzed using a survey conducted among chemical companies operating in Poland, as well as logistics companies serving them. The research is part of the “Promotion of Multimodal Transport in Chemical Logistics” project within INTERREG Central Europe Programme.

Keywords: Sustainability, multimodality, intermodality, horizontal and vertical collaboration, chemical logistics

1. INTRODUCTION

Freight transport is critical to successful operations of any supply chain, including chemical ones, as it ensures efficient movement and timely availability of raw materials, processed goods and finished products. The growing demand for freight transport is related to globalization, and on one hand, the dispersion of sources of supply and places of consumption, on the other hand, the concentration of production in fewer sites in order to secure reductions in scale. These economic practices result in the growth of the distance as well as the volume of freight transport, and cause problems when it comes to accommodating product flow in an efficient and sustainable way.

In most countries, one of the biggest challenges is a very high share of road transport within inland flows. According to Eurostat, in European Union countries in 2014 (EU-28) almost 75% of total inland freight transport was done via road, i.e. four times more than via rail (18.3%). [1] The European Commission (EC) warns that this imbalanced modal split with road haulage domination has its negative effects, which cost the EU more than 250 billion EUR annually, of which almost half relates to congestion and longer delivery times. Additional causes of this problem are environmental deterioration (by CO2 and NOx emissions) and the inefficient use of energy, as well as social costs of road accidents and noise. [2]

Thus, when deciding about the EU transport policy for the 21st century, the Commission focused on the need to integrate transport in sustainable development, i.e. development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. Among others, the policy includes: controlling road transport development, revitalizing rail transport, improving short-sea and inland waterways, and promoting multimodal transport. [3]

One of the most prominent targets of the EU Transport Whitepaper is the ambition to shift 30% of road freight, transported more than 300 kilometers, to multimodal by 2030 and 50% by 2050. [4] Transport and logistics
industries are working on achieving this goal with a strong commitment and contribution from chemical companies.

The purpose of this article is to introduce the concept of multimodal transport in chemical logistics with its key challenges, and to show the role supply chain collaboration plays on logistics when shifting road transport to multimodal ones. The research problem is analyzed based on literature and documents reviewing the topic, and a survey conducted among chemical companies operating in Poland as well as logistics companies serving them. The research is part of the “Promotion of Multimodal Transport in Chemical Logistics” project within INTERREG Central Europe Programme.

2. THE CONCEPT OF MULTIMODALITY IN EUROPEAN FREIGHT TRANSPORT

In order to facilitate the use of multimodal transport in European freight transport in general, and chemical logistics in particular, it is essential to explain the complexity of such a shift. That is why firstly - the concept of multimodal transport is introduced, secondly- the process and actors are described, and finally - the challenges are presented.

2.1. Definition and scope

Many terms are used to describe the phenomenon of transport using more than one mode. The most popular ones are: multimodal, intermodal, and combined transport. Very often they are used interchangeably, but according to European Conference of Ministers of Transport (ECMT) and United Nations (UN) Convention on International Multimodal Transport of Goods they differ and they should be understood as follows. [5]

**Multimodal transport** is the broadest term, which is defined as the carriage of goods by at least two different modes of transport. It is done on the basis of a multimodal transport contract from a place where the multimodal transport operator takes the goods in charge to a place designated for delivery. If these places are in different countries, we deal with international multimodal transport.

**Intermodal transport** is a type of multimodal transport organized in one and the same loading unit or vehicle by successive modes of transport without handling of the goods themselves when changing modes.

**Combined transport** is intermodal transport where the major part of the European journey is by rail, inland waterways or sea, and any initial and / or final leg that is carried out by road is as short as possible. According to UN recommendation, combined transport is a combination of means of transport where one (passive) transport means is carried by another (active) means, which provides traction and consumes energy.

Besides the terms defined above, concepts of co-modal and synchro-modal transport have been introduced into multimodality recently. Their focus is on efficiency.

2.2. Process and actors

A multimodal transport system may be described by its core activities such as pre- and post-haulage (generally completed by road), transshipment, rail haulage, coordination activities, and where applicable, sea transport. In some cases rail haulage could be changed for inland waterborne transport. In addition, infrastructure and supporting activities such as lease of equipment, inspection, cleaning, mending and empty stacking of intermodal loading units are needed for the system to work.

Although multimodal transport by definition involves at least two traffic modes, the focus is on the core part of the process that embraces rail haulage and transshipments. [6] The actors who participate in the core part of multimodal transport on the demand side are: shippers, forwarders and shipping agencies. The role of **shippers** is largely determined by the size of their shipment. Shippers sending full intermodal loading units, take interest in the system, while customers sending general cargo typically do not know or care how their consignments are forwarded. The role of **forwarders**, more and more often referred to as **LSPs**, is to act as
an intermediary in the transition of transport services between shippers and operators supplying physical transport and transshipment services. Traditionally forwarders perform activities such as the physical and administrative consolidation of small consignments, documentation, warehousing, and supplying intermodal loading units. Their ties to carriers have a history of close connections to road hauliers and use multimodal transport as some regular services, as reserve capacity or on customers’ request. Large forwarders such as DB Schenker, DHL, Kuhne and Nagel attempt to offer all types of transport between all geographical areas. Mergers and acquisitions in order to form players with large geographical and service scope have created a new landscape of the transportation market. [7] Besides, the other actors participating in multimodal transport are shipping agencies, which have shown particular interest in extending their control to port operations and hinterland transport.

The supply side of the multimodal market is traditionally divided between companies based upon rail and road transport respectively. The classic role of the rail operators has been to sell rail haulage between intermodal terminals. They also operate terminals and supply rail wagons, and nowadays they have become interested in all other categories. The new intermodal operators are found in the large market for the hinterland transport of maritime containers related to the ports of Hamburg, Bremerhaven, Rotterdam and Antwerp.

2.3. Barriers to modal shift

On the list of the chief obstacles to efficient multimodal freight transport in Europe is interconnectivity between modes, and interoperability within the modes. [8] In terms of interconnectivity, a lack of multimodal terminals with loading and unloading technology, as well as an absence of railway connections or their insufficient frequency or capacity, are the barriers most cited. The problem concerns mainly connections between Central Europe and France, Spain, Balkan countries and Turkey. Regarding interoperability, the most challenging is European rail, which was designed hundreds years ago, partly for national defense purposes, and has been incompatible between countries. [9] The other reasons for unsatisfactory development of multimodal transport is its time and cost handicap, low flexibility and responsiveness to demand changes, which is partly because of rigidity of government-owned railways, as well as high complexity related to extended planning and organizing of multimodal operations. The latter also relates to difficulties in changing the mentality and habits of transport planners who are used to road transport.

3. SUPPLY CHAIN COLLABORATION ON MULTIMODAL TRANSPORT

To overcome barriers to multimodal transport, on the base of game theory, resource based view (RBV) and social exchange theory, the thesis that supply chain actors’ collaboration on logistics can help to address the challenges related to modal shift, was formulated.

3.1. Towards supply chain collaboration - literature review

In the paper the concept of collaboration is understood, according to Soosay and Hyland [2015], as: “two or more companies working together to create a competitive advantage and higher profits than can be achieved by operating alone”. [10] It is widely accepted today that supply chain collaboration enables superior performance in firms due to the capitalization on resources, capabilities, processes and routines residing in their partners’ firms. [11] Thanks to it, supply chain partners could increase customer satisfaction, shorten lead times, improve information visibility and enable a clearer division of responsibilities among partners. [12]

The competences of LSPs make them an attractive partner for logistics collaboration. Collaboration with LSPs has a positive effect on the efficiency of logistics performance, which translates into the increased competitiveness of the supply chain. The supply chain collaboration of LSPs and their partners may have two directions, i.e. vertical and horizontal. The vertical collaboration refers to collaboration between adjoining businesses i.e. LSP vs. customers and shippers on the demand side, as well as vs. suppliers, rail and port
operators on the supply side. The **horizontal collaboration** refers to partners with a similar business profile, which operate at the same tier of supply chain. According to Barrat [2004], they could be competitors or non-competitors. [13] This form of relationship is often called coöpetition (cooperation plus competition). Wallenburg and Schaffler [2016] emphasize that horizontal collaboration is a common practice among LSPs who form partnerships to increase the productivity of their assets or extend their geographical coverage by combining network of LSPs. [14]

### 3.2. Intensity of collaboration

It should be emphasized that not all activities performed together by companies could be considered collaboration. Świtała [2015] admits that inter-firm relationships can take various forms from cooperation (basic level of supply chain integration), through coordination (with a higher level of integration), to collaboration (when companies treat each other as an “extension” of their organization). [15]

Lambert et al. [1999] identified three types of cooperation depending on the level of integration of partners (Figure 1). **Type I** consists of mutually recognized partners that cooperate to a limited degree within short time horizon. **Type II** - participants that do not merely coordinate, but also integrate part of their business planning. The horizon is longer, and multiple divisions or functions of the companies are involved. **Type III** is when participants have integrated their operations to a significant level and each company regards the other(s) as an extension of itself. This business relation is based on mutual trust, openness, shared risk and shared rewards. Typically, there is no fixed end date for such a collaboration. This spectrum is completed on the left side by arm’s length (transactional) relationship and on the right side by full integration. [16]

![Figure 1 Cooperation and the level of integration](image)

### 4. COLLABORATION ON MULTIMODAL TRANSPORT WITHIN EU CHEMMULTIMODAL PROJECT

Collaboration on freight transport in chemical logistics could be vertical and horizontal as well. It can also be diversified by its intensity. To analyze it, the survey within ChemMultimodal project was prepared and conducted.

#### 4.1. ChemMultimodal Project

The general objective of the ChemMultimodal project is to promote a shift to multimodal freight transport in chemical logistics by the coordination and facilitation of cooperation between chemical companies, specialized LSPs, terminal operators and public authorities in chemical regions in Central Europe (CE). The consortium of 14 partners from seven CE countries is responsible for delivering it. [18]

The goal for the first stage of the project was to analyze multimodal transport of chemical goods in the countries and regions of project partners, while focusing on identifying main routes, barriers and opportunities to improve the usage of multimodal transport in chemical logistics. Collaboration between chemical companies, specialized LSPs, terminal and port operators was investigated.
4.2. Research method and the structure of sample companies

At the first stage of the project a questionnaire-based survey was conducted among chemical and logistics companies in seven CE countries. Forty-nine questionnaires were sent out to companies across Poland and 21 answers were collected: 12 from chemical companies (producers and distributors as well) and nine from logistics companies (LSPs, carriers, rail and port operators). Most questionnaires were followed by interviews. Both groups of respondents are rather diversified, 58% of chemical companies are big players with more than 250 employees, 25% are medium sized players, and 17% is considered as small chemical companies. The split of logistics companies is as follows: 45% - big, 22% - medium, and 33% - small players.

4.3. Logistics collaboration on multimodal transport in chemical industry - survey results

The results of the survey regarding collaboration on freight transport were analyzed from two perspectives: a vertical and horizontal one.

Regarding **vertical collaboration**, all respondents from logistics companies admitted that they cooperate with their customers, however the intensity of the cooperation between companies differ. Big logistics players have a few significant customers with whom they integrate selected processes, work on new routes, new packaging or extra services tailored to their needs. This cooperation has elements of collaboration. However, it is the minority. The logistics market is very fragmented and the majority of logistics companies are small players with very limited market power. That is why they generally cooperate with their customers at arm’s length with very limited trust. In the case of arm’s length cooperation, partners are not ready to allocate risk related to shift from road to multimodal transport.

Regarding chemical companies, two out of 12 respondents decided to outsource their freight operations to LSPs, three out of 12 prefer to organize the freight transport on their own, three work in cooperation with LSPs, and the last four apply the mixed model with few routes managed by chemical companies’ transport departments on their own, and the others are managed by LSPs. The share of operations managed on their own against these managed by LSPs differs from company to company.

On the other side, the LSPs’ **horizontal collaboration** is very limited in Poland. Respondents from logistics companies admitted that their cooperation with competitors and non-competitors operating at the same tier of supply chain is extremely difficult. The biggest challenge is openness and trust, and fair gain and risk sharing. Shortages in these aspects make transport services organized by several providers not transparent to customers. This type of cooperation needs improvement, as LSPs are aware of the advantages of horizontal collaborations. LSPs understand that, individually, it could be difficult for them to shift transport from road to rail but when consolidating shipments from different LSPs it could be possible to fill the train. Horizontal collaboration could also be a good solution for extending geographical coverage by combining the network of other LSPs.

5. CONCLUSIONS

In order to be able to increase modal shift from road to multimodal freight transport, more international harmonization at a technical, legal and organizational level is needed, in terms of the interconnectivity and interoperability of the European transport system. It is critical to invest public money in developing better multimodal infrastructure, creating equal market conditions for every transport mode, and preventing distortion of competition. These are prerequisites for augmenting the collaboration between chemical companies, specialized LSPs, rail, and terminal operators on an efficient quality multimodal freight service. The role of chemical companies in this process should be noticed. They are important players in evaluating transport solutions and they should be more active in demanding the most sustainable and efficient transport solutions.
ChemMultimodal is a platform which aims to promote multimodal transport by coordination and facilitation of the collaboration of different stakeholders engaged in chemical logistics in Central Europe. The objective of the project is to improve sustainability of chemical logistics, increase multimodal transport of chemical goods and facilitate collaboration of multimodal stakeholders.

ACKNOWLEDGEMENTS

This paper is the result of research carried out for ChemMultimodal Project (Promotion of Multimodal Transport in Chemical Logistics) and co-founded by INTERREG Central Europe Programme.

REFERENCES


COOPERATION IN A SUPPLY CHAIN ON THE EXAMPLE OF JAPANESE COMPANIES LOCATED IN POLAND

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Abstract

For an efficient and effective management of a supply chain a significant impact has a cooperation undertaken by companies establishing communications with other entities forming the common supply chain. The emphasis is both on the relationship established in various areas of a functional supply chain and at different stages of its development. This cooperation may include areas such as: planning and integration processes in the supply chain, transport and storage, shopping and inventory management, distribution and customer service, logistics of production and waste and personnel and corporate social responsibility. The purpose of the article is a comparative analyze of the scope of cooperation undertaken by Japanese companies located in Poland in selected areas of the supply chain. The paper presents the results of research carried out in the form of focus interviews with representatives of the Japanese companies. The research shows that despite a similar range of organizational culture cooperation undertaken in the different areas of the supply chain is various.

Keywords: Cooperation, supply chain, Japanese companies

1. INTRODUCTION

Cooperation of companies and organizations within the supply chain is becoming increasingly important. In the conditions of globalization it can be seen that individual companies no longer compete with each other but the entire supply chains. The desire to increase the ability to compete is one of the factors affecting decisions about the cooperation and they include: the desire to reduce uncertainty and risk in the supply chain, the growing importance of fulfilling needs of customers’ requirements in terms of flexibility of supplies or the desire to acquire knowledge and new competence [1]

The purpose of the article is a comparative analysis of the scope of cooperation undertaken by Japanese companies located in Poland in selected areas of the supply chain. The result of the study is a ranking of selected Japanese companies located in Poland in terms of the scope of their cooperation undertaken in different areas of the supply chain. In order to rank the surveyed companies Multiple Criteria Decision Making / Aiding Electre III/IV has been used. The work has been divided into several thematically related sections. The theoretical part presents the essence and areas of cooperation in the supply chain. In the empirical one the material, method and the results of completed studies are presented. In the last part, the authors formulate conclusions and presented further research directions.

2. COOPERATION IN A SUPPLY CHAIN

One of the first definition of cooperation was that developed by Mead according to which cooperation is understood as mutual work for a single goal [2]. Applying this definition to the supply chain can be assumed that cooperation in the area of the supply chain is understood as mutual work of entities having a direct or indirect impact on meeting the needs of the final customer. In the literature many publications concerning cooperation in the supply chain can be found. Most of them concern the cooperation in a selected area of the supply chain, e.g. between a supplier and a buyer [3], [4], [5] or long-lasting cooperation in a strategic
However, there are few studies that show a broader approach to the entire supply chain in terms of undertaking cooperation in different areas with different entities. Verduijn and van de Loo identified four areas of cooperation in the supply chain related to the integration of information flow [8]. However, developed by them classification indicates areas of cooperation in which there is an integration of the flow of information through the implementation of a variety of solutions in the field of ICT, but it does not show other areas of cooperation, which cannot be integrated using such systems. A slightly different classification of areas of cooperation presented Piltan and Sowlati, who focused primarily on identifying the components of cooperation influencing their success or not. Among these components they distinguished: “information sharing, joint decision-making, risk/reward sharing and relationship-specific assets” [9]. The above classification shows only components of cooperation, but not functional areas of the supply chain within which there may be cooperation. According to a study by Frohlich and Wesbrook supply chains, where organizations work closely with their suppliers and customers, function much better than those in which this cooperation does not occur [10]. While according to Cao and Zhang for the success of the supply chain provides the cooperation of all the partners [11]. However, a necessary condition for cooperation is mutual sharing of information [12] and trust [13].

On the basis of the literature concerning a supply chain management [14], members of the project team implementing the research project called “Management methods in Japanese supply chains in Poland and Great Britain” have identified the functional areas of a supply chain, within which cooperation can be established. Among them there can be distinguished: 1) Planning, organization and control of processes in the supply chain, which relates primarily to taking action for the integration of the supply chain, 2) Transport and warehousing, which consists mainly of business cooperation with companies from the TSL sector, 3) Purchase and inventory management, which relates to cooperation with suppliers and thus the scope of the mutual transparency of information and trust, 4) Distribution and customer service, which relates to cooperation with customers in the field of sharing data about forecasts, customer surveys or building a strategic partnership based on the principles of mutual trust and information flow, 5) Production logistics, which concerns cooperation with customers in terms of production planning, organizing and controlling, 6) Research and development, including cooperation in carrying out mutual research on product development, improving processes or market research, 7) Waste logistics, which includes any kind of undertaking mutual actions with the co-operators in the logistics of waste, 8) Human resources and social responsibility, which relates primarily to the management of social capital in the supply chain, as well as cooperation with the cooperators in the implementation of the concept of corporate social responsibility. This classification is certainly not exhaustive of all functional areas of the supply chain but includes those affecting its smooth functioning.

3. RESEARCH METHOD

3.1. Multiple Criteria Decision Making / Aiding - Electre III/IV

In the work to analyze the way and extent of areas of cooperation in the supply chain of Japanese companies operating in Poland one of the methods of multiple criteria decision making / aiding was used, which belongs to the family of ELECTRE methods (fr. Elimination Et Choix Traduisant la Realia) - method ELECTRE III/IV. This method was created in the 60s of the twentieth century and its creator is B. Roy.

The basic principle used in the ELECTRE methods is to compare each option with all other decision-making, which allows you to check whether there are grounds for recognition of the option as having an advantage over others. ELECTRE family method is used in a variety of decision-making problems which are: a) issues related to selection of the best (distinctive) decision variants, from the point of a view of a set of criteria, b) ranking decision variants in terms of a set of adopted criteria, b) classification, which is the division of the set of variants classes (categories), organized among themselves in terms of preferences [15], [16]. Due to
the agreed objective of the presented work the main direction in the work of the research was to rank the analyzed companies due to the area of cooperation undertaken within the supply chain.

Applied in this paper Electre III/IV method focuses on the so-called an analysis of variants (V) or objectives - F) with respect to the family defined criteria (C). The input data are the weighting of the criteria (a) and thresholds: indifference (q), preferences (p) and veto (v). Use of the method ELECTRE III/IV is related to the performance of a series of tests (compliance and non-compliance) [17], whose aim is to compare each option with all the decision-making criteria. Decisions about whether a given variant exceeds the adopted profiles taken as a result of testing a variety of hypotheses. The calculation procedure used in the ELECTRE III/IV method comprises the following steps [18]:

1) Definition of objectives F and a family of criteria C combined with an evaluation matrix and the DM's preference model. During this phase the following thresholds are defined: \( w_i \) - weights, \( q_i \) - indifference, \( p_i \) - preference and \( v_i \) - veto (where: \( q_i < p_i < v_i \)).

2) Development of: the outranking relation \( S(a,b) \), which shows the extent to which "a outranks b" overall, the global concordance indicator \( C(a, b) \) created in the concordance test weakened by the discordance indexes \( D_j(a,b) \) built in discordance test.

3) Computation of the outranking relation \( S(a,b) \). On the basis of the computation of \( d(a,b) \) two preliminary rankings (complete preorders) using a classification algorithm (distillation procedure) has been established.

The final ranking has been obtained in the form of the ranking matrix as well as the outranking graph presenting complete preorders. Four options can be observed in the obtained ranking: indifference (I), preference (P), lack of preference (P') and incomparability (R).

3.2. Research material

The basis of the analysis presented in the paper was the information gathered during focus groups (study completed in early 2016.) carried out with the representatives of Japanese companies located in Lower Silesia in Poland. The study involved 6 production companies representing the automotive sector (in the study named F1, F2, F3, F4, F5 and F6), which are in the supply chain first tire suppliers for final producer (mainly cars).

The source of information about practices of studied Japanese companies concerning ways and extent of building relationship with the environment was a questionnaire survey that allows you to gather information from different areas of functioning of these enterprises in the supply chain. This information was used to determine the list of criteria and sub-criteria, covering the areas of cooperation of selected companies in the supply chain (Table 1).

<table>
<thead>
<tr>
<th>Table 1 Description of criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>C1.Planning, organization and control of processes in the supply chain</td>
</tr>
<tr>
<td>C2.Transport and warehousing</td>
</tr>
</tbody>
</table>
### Criterion (continue) | Sub-criterion
---|---
**C3. Purchasing and Inventory Management** | C3.1 cooperation in building a strategic partnership on the principles of transparency of information and trust - the percentage of suppliers with whom it such partnership is built (2 - over 50%, 1 - 10-50%, 0 - 10%),
C3.2 the implementation of the development program suppliers (1 - to undertake such actions, 0 - no such action),
C3.3 the use of the support of suppliers or customers to improve their own systems, purchasing and inventory management (1 - to undertake such actions, 0 - no such action).

**C4. Distribution and Customer Service** | C4.1 sharing data about estimates, sales, inventory, etc. in the information systems of key suppliers and customers (1 - to undertake such actions, 0 - no such action),
C4.2 the number of clients with whom a strategic partnership is built on the principles of transparency of information and confidence (4 - with all 3 - over 50%, 2 - 10-50%, 1 - 10, 0 - no),
C4.3 study the opinions and preferences of customers (1 - to undertake such actions, 0 - no such action),
C4.4 having a strategy of customer service (1 - yes, 0 - no).

**C5. Production Logistics and Waste and Research and Development** | C5.1 production control in collaboration with customers based on actual demand (1 - yes, 0 - no),
C5.2 liaising with co-operators in the field of research and development (2 - yes, on a large scale, 1 - yes, on a small scale, 0 - no),
C5.3 the frequency of the action in the field of logistics of waste in cooperation with co-operators (5 - all the time on an ongoing basis, 4 - once every few weeks, 3 - once every few months, 2 - once a year, 1 - less often than once a year, 0 - they are not undertaken).

**C6. HR and Corporate Social Responsibility** | C6.1 using social concept of business responsibility - CSR (1 - yes, 0 - no),
C6.2 taking into account when selecting or assessing the cooperator, his realization of CSR concept (2 - so this is the most important criterion, 1 - yes, but it is not the most important criterion, 0 - no),
C6.3 management of social capital in the supply chain (1 - yes, 0 - no).

### 4. STUDY RESULTS - COMPUTATIONAL EXPERIMENT

In order to make the ranking of enterprises in the areas of cooperation in the supply chain software Electre III/IV was used. The computer experiment required prior normalization of all the sub-criteria and their aggregation on a weighted average. In the next stage a model of Decision Making (DM's) preferences was developed. For the individual criteria there are specified weights (the sum of weights for all criteria was 1) and the thresholds: $q_i, p_i, v_i$ (Table 2).

As a result of the computer experiment a final ranking of the analyzed companies was obtained. Taking into account the specific weights and the results of research conducted among companies it is shown that the highest ranked company was F2. The company achieved the highest results in four areas (C1, C3, C5 and C6), including inter alia such sub-criteria: participation in the largest number of projects for the integration of the supply chain, conducting the measurement results of cooperation, building a strategic partnership with both suppliers and customers and the using the concept of CSR in relations with co-operators in the supply chain. The next ranking achieved the company F4, which stood out in the cooperation in the areas of transport and storage purchases and inventory management. Further two (F3 and F6) obtained the third position in the ranking. The lowest ranked was the enterprise F1 and F5. These companies also received the lowest assessment in the relation to most of the criteria. The company F1 received the lowest marks for criteria such as: C1 (planning, organization and control of processes in the supply chain), C3 (purchasing and inventory
management) and C6 (HR and CSR). In contrast, F5 also obtained a very low score in the relation to three of the same criteria as the company F1 (C1, C3 and C6).

**Table 2** The model of the DM’s preferences characteristic for the Electre III/IV method

<table>
<thead>
<tr>
<th>Criterion</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>waga</td>
<td>0.2</td>
<td>0.15</td>
<td>0.15</td>
<td>0.2</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Indifference (qi)</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Preference (pi)</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Veto (vi)</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

In the Electre III/IV method in the final ranking the following relationships between companies (objects) can be distinguished (see Chapter 3.1.): preference (P) - one company F is placed above another (e.g. F2 and F4), indifference (I) - companies are positioned in the same box (e.g. F1 and F5) and incomparability (R) - firms are not interconnected (e.g. F3 and F6).

![Diagram](image)

**Figure 1** The final ranking of the computational experiment

**CONCLUSIONS**

Discussed in the article an issue concerning areas of cooperation between enterprises is very important from the perspective of supply chain management. Enterprises cooperate in various functional areas of the supply chain in order to obtain the efficient and effective functioning. However, some of these relationships result from the specifics of an enterprise (such as cooperation with a parent company). The survey carried out among Japanese companies shows that the widest range of cooperation undertaken by them in the supply chain applies to mutual research and development of products. This is due to the fact that the surveyed enterprises are in the supply chain "I-tier suppliers" and thus they produce components for final producers on their behalf and according to their specifications. The fewest surveyed companies build with both suppliers and customers a strategic partnership on the principles of transparency of information and trust. This is certainly an area that needs further improvements. Perhaps the facilitation of establishing such a close and long-term co-operation would be a segmentation of the supply chain, based on which key suppliers and customers would be selected to establish closer cooperation.

Presented in this paper the results of research do not exhaust the issue of the cooperation between enterprises in the supply chain. Undoubtedly, this subject requires further in-depth studies that would identify the factors influencing the scope and way of partnerships in the supply chain.

**ACKNOWLEDGEMENTS**

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REFERENCES


COOPERATION BETWEEN JAPANESE COMPANIES AND LOCAL AUTHORITIES IN TERMS OF LIFE CYCLE OF ORGANIZATION

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Abstract

The aim of the paper is the identification of the cooperation areas between Japanese companies located in Poland and local governments in terms of particular stages of life cycle of an organization. The paper presents the results of the study conducted among Japanese enterprises and local governments located in the region of Dolny Śląsk in Poland. The research shows that the analyzed companies higher appreciate creating beneficial relations based on early stages of a life cycle of an investment. The local governments in turn, much more appreciate creating relations based on activities at the stage of a well-grounded operation of an enterprise in a region.

Keywords: Local authority, Japanese companies, cooperation, life cycle of organization

1. INTRODUCTION

Local government plays an essential role in the economic development of a city [1]. Thanks to the application of legal instruments, administrative procedures and financial means it may significantly influence its socio-economic situation [2]. One of the key tasks of local government regarding economic development is attracting external investors [3], including the foreign ones - connected with so called foreign direct investment (FDI). The most foreign investors concentrate within or around an urban area. It brings many advantageous for a city such as: economic and regional growth [4]. Local authorities are aware of the benefits therefore they try to attract investors offering them attractive plots, property tax exemptions, etc. However, such actions, in order to be profitable both for the city and for the investors, require a close cooperation of local government with foreign investors.

The aim of the paper is the identification of the cooperation areas between Japanese organizations located in Poland and local governments in terms of particular stages of life cycle of an organization. The structure of the paper is as follows: the first chapter presents the nature of the cooperation between foreign enterprises in all stages of a lifecycle and local authorities. The following chapter describes research methods used in the paper. The last chapter contains the findings of the study. The last part of the paper presents the conclusions.

2. COOPERATION BETWEEN FOREIGN INVESTORS AND LOCAL AUTHORITY IN TERMS OF ORGANIZATION’S LIFE CYCLE

In the literature there are many definition of cooperation mainly related to the business field ([5]; [6]; [7]; [8]). One of the first definition was developed in 1937 by Mead according to whom cooperation “it is the act of working together to one end” [5]. Bearing in mind this definition the cooperation between foreign investors and local authority can be understood as process of working together throughout the life cycle of an organization established in the city by a foreign investor in order to obtain mutual benefits. Thus, it can be assumed that the cooperation begins when the investor makes the decision concerning the location of a given organization / enterprise and finishes at the point of its liquidation or renewal according to the life cycle of an organization.
Reference literature contains numerous classifications of a life cycle of an organization ([9]; [10]; [11] and [12]). However, four phases appearing one after another are distinguished most commonly, namely: formation, development, maturity, and recession [13]. In the paper also four stages of a life cycle of an organization were indentified but in terms of scope and area of cooperation between foreign investors and local government. As a result, the following phases were indentified: an initiation phase connected with the decision on locating the investment in a given region (city), the phase of formation and early development, the phase of operation (connecting the phase of growth and maturity) and the recession phase (closure or renewal). The areas of cooperation between enterprises and local government in terms of the four stages of a life cycle of an organization are presented in Table 1.

<table>
<thead>
<tr>
<th>Stages of life cycle of cooperation</th>
<th>Areas of cooperation</th>
</tr>
</thead>
</table>
| 1. Initiation - before a foreign company will be founded in a city (I) | • cooperation with starting an investment in a given city (in terms of offering an attractive purchase price / acquisition of the plot)  
• the help of local government for example in negotiations with the representatives of special economic zone |
| 2. Formation and early development (F) | • cooperation in terms of recruiting employees  
• cooperation regarding the organization of public transport commuting possibilities for employees to get to the facility  
• local government’s help at formal requirements connected with starting an investment in a given city  
• cooperation in terms of building transport infrastructure around the newly arising investment |
| 3. Operation of the company (O) | • cooperation with the enterprise regarding the preparation of city development strategy  
• cooperation with the enterprise at the implementation of the city development strategy  
• inviting the representatives of enterprise (s) to social consultations, city development meetings, participate in committees / working groups, etc.  
• cooperation regarding investment in terms of improving of developing the infrastructure in the city  
• cooperation in terms of organization of cultural, sport and other events  
• cooperation regarding vocational training of students from a given area  
• cooperation in terms of organization of freight transport in a city  
• cooperation regarding joint promotion of the city and the enterprise (for example at international fair)  
• cooperation in terms of solving social problems and increasing social capital of a region |
| 4. The closure of the company (C) | • Cooperation regarding employees’ outplacement  
• Cooperation regarding the liquidation of assets of a company, etc. |
The scope of cooperation between a local government and a foreign enterprise is affected by many factors. Among them one can name: the amount of financial means available within the budget allocated to the cooperation with business, the location characteristics of a city (geographic and infrastructure conditions), the size of a city, and consequently the access to qualified employees and first of all, the mutual openness and willingness to commit.

3. RESEARCH METHOD

In the paper the following stages of the research methods have been applied:

- a critical analysis of the literature related to the direct foreign investments, cooperation, Japanese management methods, the life cycle of organization
- the development of research tools, namely two questionnaires on the basis of relevant literature, one questionnaire was created to examine the cooperation between enterprises and local governments from the point of view of local government and the second one from the point of view of a foreign company
- conducting a survey and focused interviews. The questionnaires were sent by electronic mail to towns and cities in the province of Dolny Śląsk, where companies with Japanese capital are located. Among 12 selected towns 6 sent back completed forms. The research in companies with Japanese capital was conducted on the basis of focused interviews. Five companies participated in the research.
- the analysis and interpretation of results. The analysis was performed with the use of Excel spreadsheet. The data was compiled in terms of the phases of a life cycle of an organization, however without the phase of recession (in the province of Dolny Śląsk there were no such cases).

4. RESULTS

The results of the conducted research concern two aspects of cooperation between local governments and companies with Japanese capital. The first one includes the information on the frequency of cooperation between foreign investors and local governments in terms of the previously defined stages of a lifecycle of an investment and the types of activities assign to them (Table 1). The second one presents the assessment of the extent in which the specific activities influence beneficial relationships between a local government and enterprise(s) with Japanese capital.

In the first case, 14 activities were indentified, in terms of which local governments and companies had a possibility to select answers from 0 to 6, where 0 - means no cooperation, 1 - one-time cooperation concerning one undertakings / event; 2 - very rare cooperation (once in 5 years or less often); 3 - rare cooperation (once in 2-3 years); 4 - moderate frequency cooperation (once a year); 5 - frequent cooperation (every 3-4 months); 6 - close cooperation (every month or more often). Table 2 contains the summary of results for particular activities and phases of a life cycle of an organization, calculated as:

- the number of responses confirming the cooperation (divided into the groups of entities),
- the frequency of cooperation calculated as a median of responses given by local governments.

In the case of the frequency of cooperation only the results for local governments are presented, as they refer to the cooperation of local governments with all Japanese entities in their area. According to the authors, it comprises a more comprehensive picture and offers a more reliable result in terms of establishing the frequency of cooperation than the presentation of results from the point of view of single entities.
Table 2 The frequency of cooperation between the local governments and Japanese companies in terms of selected activities and phases of a life cycle of a foreign investment

<table>
<thead>
<tr>
<th>Stages of cooperation with foreign company</th>
<th>Areas of cooperation</th>
<th>Number of responses</th>
<th>The frequency of cooperation of local government</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Local government (max 6)</td>
</tr>
<tr>
<td>1. Initiation - before a foreign company will be founded in a city (I)</td>
<td>cooperation with starting an investment in a given city (in terms of offering an attractive purchase price / acquisition of the plot)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>the help of local government for example in negotiations with the representatives of special economic zone</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2. Formation and early development (F)</td>
<td>cooperation in terms of recruiting employees</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>cooperation regarding the organization of public transport commuting possibilities for employees to get to the facility</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>cooperation with the enterprise regarding the preparation of city development strategy</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>cooperation with the enterprise at the implementation of the city development strategy</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>inviting the representatives of enterprise (s) to social consultations, city development meetings, participate in committees / working groups, etc.</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Operation of the company (O)</td>
<td>cooperation regarding investment in terms of improving of developing the infrastructure in the city</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>cooperation in terms of organization of cultural, sport and other events</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>cooperation regarding vocational training of students from a given area</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>cooperation in terms of organization of freight transport in a city</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>cooperation regarding joint promotion of the city and the enterprise (for example at international fair)</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>cooperation in terms of solving social problems and increasing social capital of a region</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

According to the abovementioned data, among the analyzed areas, the greatest number of responses, both on the part of local governments and the companies concern: in the initiation phase (I) - the cooperation at the founding of the investment, in the formation and early development stage (F) - the help in recruiting employees,
in the operation phase (O) - the cooperation regarding the organization of cultural, sport and other events. The lowest number of responses concerns the activities taken up in the phase of operation (O) and these are: the cooperation in terms of organization of freight transport in a city and the cooperation regarding the preparation of city / commune’s development strategy.

However, the highest frequency of cooperation between local governments and Japanese enterprises exists in the case of activities regarding: cooperation in terms of organization of cultural, sport and other events (median 4.5) and cooperation regarding the organization of public transport commuting possibilities for employees to get to the facility (median 4.0).

The second area of research, concerning the assessment of the extent of stimulating beneficial relations between local government and enterprise(s) with Japanese capital, included a set of 9 defined activities. In this area also the local government and the enterprises had a possibility to select a response in the five-grade scale (where 1 - the lowest grade, 5 - the highest grade). A median was calculated for each activity (separately for local governments and enterprises), and then gaps in the level of assessments were indentified. The results regarding the identification of gaps are presented in Figure 1. A negative value of a gap means, that enterprises give a higher grade to the influence of a given activity shaping the relations than the local government. A positive value means a reverse interpretation. The lower the value of the gap the more correlated is the assessments of a given activity.

![Figure 1 Gaps in the assessment levels of the influence of particular activities on shaping the beneficial relations between the local government and an enterprise (calculated after the median)](image_url)

The biggest gaps regarding the extent of the assessment of the shaping beneficial relations between a local government and an enterprise (gap 2, 0) exist in the area: granting access to fix assets by local government, direct meetings and the participation of the representatives of the enterprises in boards and teams operating by local government. Those activities are perceived as more advantageous by local government than by the entrepreneurs. The most correlated results, on the other hand, regard the assessment of activities concerning joint promotion of the local government and the enterprise (gap 0, 5).
5. CONCLUSION

The suggestions presented in the theoretical part of the paper regarding the description of cooperation between Japanese enterprises and local government in terms of the life cycle stages of an organization are based on the experience. The results of the conducted research allow to draw the following conclusions regarding the cooperation:

- Higher frequencies of cooperation between local governments and enterprises with Japanese capital refer to those activities, which may directly translate into benefits for the companies, either shaping their positive image in the region or using the regional human resources in the best possible way.

- In terms of the life cycle of an investment, the highest frequency of cooperation for this group of entities concerns the phase of formation and early development (F). It most probably results from the fact that the investors try to make the maximum use of the relation created during the initiation phase with local government in order to secure as fast as possible their position on the local market. The lowest frequency was observed at the initiation phase (I), which in turn, results from the characteristics of activities realized in this phase, for example one-time meetings at transferring plots or signing agreements concerning the tax release.

Pursuant to the conducted research it is possible to formulate a conclusion that the analyzed enterprises appreciate in a greater extent building beneficial relations on the basis of activities taken up in the early phases of an investment’s life. Local governments, in turn, appreciate much more building relation on the basis of well-developed operation of a company in a region. It is predominantly a consequence of different perception of the effects of the realization of such an investment. In the case of companies they have a strictly business-like, financial dimension, however in the case of local governments they are directed at the achievement of long-term socio-economic effects.

The authors are aware that, the presented research results do not include all entities with foreign capital, and they refer only to the cooperation of local governments with a selected group (Japanese companies). It is a kind of a case study comprising a fragment of the discussed issue. To obtain a full picture of the described cooperation it is necessary to conduct a wider research in this area with an attempt to establish not only the frequency but also the effectiveness of the activities.

ACKNOWLEDGEMENTS

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AGRICULTURE AS A FIELD FOR LOGISTICS ACTIVITIES DEVELOPMENT

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Abstract

Agriculture is the sector with strong specificity of production processes. This results from the use of the forces of nature (earth, solar, biological processes) and live organisms. Similarly as in the whole economy, the modernization of agrarian sector influences on growing importance of logistics. Modern agricultural enterprises must transport and store not only huge amounts of inputs (e.g. feed, fertilizers, pesticides, energy, seeds, etc.) but also the final plant and animal products (grain, tubers, forage, live animals, meat, milk, wool, etc.). Apart from that, the relationship between companies and their environment is becoming more and more significant. There is a strong attention to well prepared and created communication channels providing reliable flows of information, goods, money and people. This paper presents the scale of the production and transport of major crops in Poland against the background of non-agrarian products (coal, liquid fuels). Moreover, author presents the classification of the products that are part of internal and external trade and storage process in a classic agricultural enterprise. Some trends in technical solutions and technology used to streamline manufacturing processes with their use in agriculture on the example of milk production cereals were also laid out.

Keywords: Agriculture, logistics, agricultural products

1. INTRODUCTION

Agriculture is an important sector of the national economy, both historically (as the oldest area of conscious human production) and in modern times. In 2014, 2.38 million people, that is 16.3% of the total labour force in Poland, were employed in this sector and its share in the gross value of fixed assets was 4.6%, while in terms of land-use it amounted to 52.1% of the country (agricultural companies farmed on a surface area of 16.3 million ha) [Own calculations based on: Rocznik Statystyczny Rolnictwa 2015 [Agricultural Statistical Yearbook 2015], GUS, Warsaw and Rolnictwo w 2015 roku [Agriculture in 2015], GUS, Warsaw, 2016 [9, 10]]. Its contribution to generating national income was lower (due to the lower work efficiency than other segments of the national economy and variable forces of nature) and amounted to 2.6%. However, in all highly- and medium-developed countries of the world, despite the declining share of agriculture in GDP generation, the sector is recognised as an important one, particularly due to its necessity in maintaining society's food security and its equilibrating role in times of an economic crisis. Moreover, it is also important as a source of income for residents of rural areas, a market for industrial products and services, and recently also due to its role in maintaining environmental, landscape or genetic (biodiversity) values.

In the case of this sector, just like in the economy as a whole, its modernisation leads to an increase in the importance of logistics [3]. Modern agricultural enterprises transport and store significant amounts of production means (feed, fertilisers, pesticides, fuels, seeds, seedlings, etc.) and final products - plants (grains, tubers, feed) and animals (live animals, meat, milk, wool, etc.). Their relationships with the environment are increasingly important, including communication channels (flows of information, goods, money, people).

The aim of the paper is to present the scale of products transported and stored in agricultural sector in comparison to non-agricultural products (e.g. coal or liquid fuels). This allowed to define the importance of logistics activities for agribusiness.
2. NATURE OF AGRICULTURE AS A FIELD FOR THE APPLICATION OF LOGISTICS SOLUTIONS

The role of logistics in agriculture (and the agribusiness as a whole) is of particular importance due to the nature of this sector, which manifests itself in, among other things [1], [4]:

1) a significant temporary imbalance of supply and demand for agricultural products (this applies to plant production, in particular); the fact that many agricultural products are obtained only once a year and during a particular season (strawberries - early summer, cereals - summer, apples - mainly autumn etc.); the fact that demand for vegetables, fruits and animal feed remains relatively constant, it is necessary to store many raw materials, which require warehouses, which in turn result in costs,

2) the necessity, in case of agriculture, of creating specific warehouses, as most of the products deteriorate when improperly stored; in the case of many products warehouses cannot be universal in nature (such structures are cheaper), as they must fulfil specific requirements, e.g. temperature, humidity and ventilation, so investments are quite significant,

3) conducting numerous transport activities on unpaved roads and fields, even ploughed, which results in considerable fuel consumption and increases transport costs, in addition to posing high technical requirements for agricultural means of transport;

4) the negative impact of many atmospheric factors such as rain, hail, thaws, snow, ice, snow drifts, etc., which also increases the cost of transport, as well as the risk of accidents and equipment failures;

5) the limited transport and storage possibilities of many agricultural products (e.g. milk, meat, fruit and vegetables), as they often contain 80 - 90% water, are less concentrated and require processing, e.g. into dried products, jams, cheeses, meats and breads;

6) the frequent economical and physical difficulties in transporting agricultural products; their economic sensitivity stems from a high water content, while the physical aspect - from the fragility of the products (e.g. in case of improper transport, raspberries or strawberries change into a compact mass, losing their commercial value for individual customers), as well as from the processes of fermentation, rotting, drying, etc. that occur,

7) the specific means of transport required by many agricultural products, e.g. milk tanks, vehicles adapted for transporting cattle, pigs, poultry or eggs; such means of transport are specialised and can rarely be used in a more universal manner,

8) a farm being a transport company “involuntarily”. For example, the production of potatoes on a 1 hectare field requires about 2 tonnes of potatoes, a few hundred kilograms of mineral-based fertilisers, hundreds (and in unfavourable conditions, even thousands) of litres of water for spraying against weeds, pests and diseases. Furthermore, it's necessary to harvest several tonnes of potatoes from the field and they must be standardised according to size, and delivered to the appropriate recipient. This means that transport and storage are the basic work of farmers and processors of agricultural products [2],

9) the fact that logistics management is made easier by the existence of a limited number of large entities rather than many small ones; in agriculture there is considerable territorial distribution and fragmentation in terms of farm size, which leads to relatively small batches of goods and generally small-scale (though growing) production, while processing plants want to acquire large portions of a single commodity, namely cereals, fruits, vegetables, animals, etc.; even though there are organised producer groups with one of their tasks being the merging of small batches of goods into large ones. However, in Polish agriculture their scale is insufficient, as farmers prefer to act alone, which entails significant complexity of logistics activities associated with the receipt of agricultural products and deliveries of agricultural production means,

10) the fact that the last two decades have led to significant changes in technology, as well as agricultural and related technology in particular within Polish agriculture and agribusiness; we are dealing with machinery and equipment of different generations, not always compatible, which makes it difficult to maintain a stream of technological and logistical processes,
11) the differing technological level is concurrent with various levels of producer's knowledge - not all of them appreciate and implement modern technological requirements. They are often very attached to traditional production methods, while modern recipients have specific requirements within the scope of product quality and uniformity.

12) agriculture and agribusiness featuring numerous and independent intermediary links in the supply chain leading “from the farmer's field to the consumer’s table”, which causes significant disruptions in the flow of information and difficulties in “coordinating” their operations, as well as the supply of raw materials and products to the subsequent links in the food supply chain.

3. PLACE OF LOGISTICS PROCESSES IN AGRICULTURE

Agricultural businesses, just like other sectors of the economy, operate by moving means of production and products between three areas:

1) on the “input” side, meaning arranging supplies of products necessary for agricultural production (and possibly non-agricultural, manufacturing and services) to an entity,

2) within the entity in several ways:
   a) storing own (self-supply) and external raw materials used in production, and means of production themselves,
   b) transport from a warehouse to the places of use (to the field, buildings for livestock, workshops, other warehouses),
   c) transport pertaining to the production process (in production buildings, including buildings for livestock, on agricultural land),
   d) transport from production areas to warehouses for internal purposes or to conduct a sale,

3) at the “output”, i.e. by organising transport of agricultural products directly to external customers (trade, processing, consumers).

According to this summary, agricultural production is associated in its entirety with the efficient organisation of logistics processes, although usually these are not described (named) as such within the enterprises. A systematisation of areas of activity and product groups related to logistics processes, with specific examples, is shown in Table 1.

Table 1 Systematic description of areas of activity that require logistics processes in the agricultural enterprise

<table>
<thead>
<tr>
<th>Area of activity and product group</th>
<th>Examples of products</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Supply</td>
<td></td>
</tr>
<tr>
<td>Construction materials and equipment</td>
<td>Bricks, cement, concrete mixer</td>
</tr>
<tr>
<td>Machines and devices</td>
<td>Tractors, combines, ploughs, cultivators, harrows</td>
</tr>
<tr>
<td>Spare parts</td>
<td>Ploughshares, tyres, machine components</td>
</tr>
<tr>
<td>Small appliances, working clothes</td>
<td>Pitchforks, spades, wheelbarrows, overalls, rubber boots</td>
</tr>
<tr>
<td>Energy carriers</td>
<td>Diesel fuel, coal, electricity</td>
</tr>
<tr>
<td>Fertilisers and pesticides</td>
<td>Urea, potash salt, ammonium nitrate,</td>
</tr>
<tr>
<td>Medication and others</td>
<td>Calem Plus, Dietan, Virkon S</td>
</tr>
<tr>
<td>Seeding material</td>
<td>Seeds of cereals, maize, seed potatoes</td>
</tr>
<tr>
<td>Breeding stock</td>
<td>Calves, piglets, lambs, chicks</td>
</tr>
<tr>
<td>Feed, supplements</td>
<td>Mlekopan, &quot;T-mix&quot; pigfeed, 926-Rarytas</td>
</tr>
</tbody>
</table>
### Area of activity and product group

<table>
<thead>
<tr>
<th>Examples of products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Supply (continue)</strong></td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td><strong>II. Storage and internal trade</strong></td>
</tr>
<tr>
<td>Storage and transport of purchased goods</td>
</tr>
<tr>
<td>Own feed</td>
</tr>
<tr>
<td>Own seeds and seedlings</td>
</tr>
<tr>
<td>Water supply, sewerage pipelines</td>
</tr>
<tr>
<td>Excrement and organic fertilisers</td>
</tr>
<tr>
<td>Moving employees</td>
</tr>
<tr>
<td>Cash</td>
</tr>
<tr>
<td>Means of internal communication</td>
</tr>
<tr>
<td><strong>III. Sale</strong></td>
</tr>
<tr>
<td>Animals</td>
</tr>
<tr>
<td>Products of animal origin</td>
</tr>
<tr>
<td>Plant products</td>
</tr>
<tr>
<td>Processed products of agricultural origin</td>
</tr>
<tr>
<td>Products of non-agricultural origin</td>
</tr>
<tr>
<td>External products for resale</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

Source: own drawing up the author

The presented examples of production processes and products subject to logistics activities, such as procurement, transport, storage and distribution, do not exhaust the entire issue, but they do indicate its wide scope and complexity. This means that the effectiveness of operations of agricultural companies requires efficient logistics management.

#### 4. SCALE OF TRANSPORT AND STORAGE IN AGRICULTURE AS A SECTOR OF THE POLISH ECONOMY

The amount of freight is significant in agriculture, although people from outside the industry are often not aware of this. It is due to the spatial dispersion of agricultural production over 1.4 million farms, covering an area of 16.3 million ha, on the one hand, and the fact that production occurs not only in buildings, but also in fields, meadows, pastures and orchards, on the other. The high tonnage of transport in agriculture is also a consequence of the high water content of agricultural products (For example, green fodder from grasses and legumes can contain 70 - 85% water, bulb and root plants 80 - 90%, while green fodder from maize to be used for silage should contain about 65% water. Fruits contain 80 - 95% water, while seeds and dried fruit 10 - 15%. Even wood comprises 40 - 50% water.).

In Table 2 we present the scale of production and consumption of selected agricultural products and production means.
Table 2  Scale of production of selected agricultural products and consumption of certain production means in agriculture in 2014

<table>
<thead>
<tr>
<th>No.</th>
<th>Product name or production means</th>
<th>Unit of measurement</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cereal harvests</td>
<td>Mt</td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td>- including basic</td>
<td>Mt</td>
<td>24.4</td>
</tr>
<tr>
<td>2.</td>
<td>Harvest of straw from basic cereals</td>
<td>Mt</td>
<td>25.0</td>
</tr>
<tr>
<td>3.</td>
<td>Hay harvests</td>
<td>Mt</td>
<td>13.7</td>
</tr>
<tr>
<td>4.</td>
<td>Sugar beet harvests</td>
<td>Mt</td>
<td>13.5</td>
</tr>
<tr>
<td>5.</td>
<td>Potato harvests</td>
<td>Mt</td>
<td>7.4</td>
</tr>
<tr>
<td>6.</td>
<td>Oilseed harvests</td>
<td>Mt</td>
<td>3.3</td>
</tr>
<tr>
<td>7.</td>
<td>Pulse harvests</td>
<td>Mt</td>
<td>0.5</td>
</tr>
<tr>
<td>8.</td>
<td>Production of animals for slaughter (calculated into meat)</td>
<td>Mt</td>
<td>4.4</td>
</tr>
<tr>
<td>9.</td>
<td>Cow milk</td>
<td>bn l</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mt</td>
<td>13.0</td>
</tr>
<tr>
<td>10.</td>
<td>Chicken eggs</td>
<td>bn pcs.</td>
<td>103</td>
</tr>
<tr>
<td>11.</td>
<td>Purchased seed stock:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- cereals</td>
<td>kt</td>
<td>74.4</td>
</tr>
<tr>
<td></td>
<td>- potatoes</td>
<td>kt</td>
<td>39.9</td>
</tr>
<tr>
<td>12.</td>
<td>Nitrogen fertilizers</td>
<td>Mt</td>
<td>6.0</td>
</tr>
<tr>
<td>13.</td>
<td>Calcium and magnesium fertilizers</td>
<td>Mt</td>
<td>2.4</td>
</tr>
<tr>
<td>14.</td>
<td>Multi-component fertilisers</td>
<td>Mt</td>
<td>1.7</td>
</tr>
<tr>
<td>15.</td>
<td>Phosphorous fertilisers</td>
<td>Mt</td>
<td>0.3</td>
</tr>
<tr>
<td>16.</td>
<td>Pesticides</td>
<td>kt</td>
<td>64.8</td>
</tr>
<tr>
<td>17.</td>
<td>Purchased concentrate feeds</td>
<td>Mt</td>
<td>9.0</td>
</tr>
<tr>
<td>18.</td>
<td>Water consumption for irrigation</td>
<td>bn m⁴</td>
<td>82.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bn t</td>
<td>82.1</td>
</tr>
</tbody>
</table>

Source: [9].

Please note One litre of milk weighs an average of 1.03 kg, hence production amounting to 12.6 billion litres is around 13 million tonnes.

The volume of transported goods and, in effect, stored goods, is very large in agriculture. In Table 3, for comparison, we present the scale of the largest non-agricultural production.

The scope of transport of agricultural products is similar in size or larger than for industrial products, but it is of a decidedly different nature. For example, cereals total about 57 million tonnes of grain and straw (slightly less than e.g. bituminous coal, and twice as much as copper ores and concentrates), but it is highly dispersed. Cereals are produced by all of the more than 1.4 million farms in Poland, while the mining and extraction sector had 4661 registered companies in 2014. Cereals, rapeseed, legumes flow through a (sometimes) long supply chain, which translates into numerous intermediate links in the chain and significant transportation, handling and storage needs, usually greater than in the case of industrial products. Moreover, a significant part of the transport takes place on fields or dirt roads, unpaved and rapidly deteriorating under unfavourable weather (especially rain). Many transport means exhibit limited efficiency, are not in good condition, old, already
depreciated, highly cost-intensive (frequent failures, high fuel consumption). On small farms, 30-, 40-year-old, or even self-built, tractors are sometimes still in use. Furthermore, warehouse facilities in agriculture, although quantitatively large, are in a significant part traditional, not mechanised, and frequently significantly worn down, in need of urgent repairs.

Table 3 Scale of production of selected non-agricultural products in 2015

<table>
<thead>
<tr>
<th>No.</th>
<th>Product name or production means</th>
<th>Unit of measurement</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bituminous coal</td>
<td>Mt</td>
<td>72.7</td>
</tr>
<tr>
<td>2.</td>
<td>Lignite</td>
<td>Mt</td>
<td>63.1</td>
</tr>
<tr>
<td>3.</td>
<td>Gravel, pebbles and similar raw materials for the purposes of construction, use as road and railway aggregate</td>
<td>Mt</td>
<td>37.7</td>
</tr>
<tr>
<td>4.</td>
<td>Calcium oxide and similar for construction purposes</td>
<td>Mt</td>
<td>36.5</td>
</tr>
<tr>
<td>5.</td>
<td>Copper ores and concentrates</td>
<td>Mt</td>
<td>35.0</td>
</tr>
<tr>
<td>6.</td>
<td>Silica and quartz sands</td>
<td>Mt</td>
<td>10.7</td>
</tr>
<tr>
<td>7.</td>
<td>Dolomites</td>
<td>Mt</td>
<td>3.2</td>
</tr>
<tr>
<td>8.</td>
<td>Chalk</td>
<td>Mt</td>
<td>3.0</td>
</tr>
<tr>
<td>9.</td>
<td>Gas</td>
<td>hm³</td>
<td>5623.7</td>
</tr>
<tr>
<td>10.</td>
<td>Petroleum</td>
<td>kt</td>
<td>927.7</td>
</tr>
</tbody>
</table>

Source: [8]

5. DIRECTIONS OF CHANGES IN AGRICULTURAL LOGISTICS

Agricultural logistics is an area of fairly rapid changes in terms of both the means of production and links within supply chains. There are several reasons for this.

1) After many years of stagnation, the surface area structure of farms is beginning to change. As a result of the privatisation of state farms (PGR) large-scale private enterprises emerged (particularly in western and northern Poland), which employ modern management techniques and apply advanced technologies for large scale production. The number of such larger farms in central and eastern Poland is increasing as well. Such companies, with large uniform batches of goods, prefer to sell to a food processing company rather than use the services of intermediaries.

2) Recipients give farmers increasingly precise guidelines for raw material quality, so the importance of direct contacts is increasingly important. They also prefer dependable and proven suppliers, ones able to offer the greatest amount of standardised goods, both for trade (e.g. fruits, vegetables) and for processing (e.g. potatoes, animals for slaughter).

3) The production means industry, including transportation, storage devices and structures, gives customers more and more technologically advanced solutions, although these are usually more expensive and require better management to be fully utilised. On the one hand, this leads users to increase the scale of their operations, while on the other it encourages better planning of relationships with suppliers and recipients of products.

The changing situation has some consequences for the relationships between links in the supply chain. This can be briefly presented on the example of selected agricultural products. In the case of cereals, oilseed rape and legume seeds, storage in own warehouses (barns) is still the dominant means of warehousing, but collection of products directly from the field is increasingly widespread, with transport straight from the combine to external warehouses (trade intermediaries or processing companies), and agricultural enterprises are more often using bins or similar, usually to store feed grain.
Roughage had been stored in barns or in open areas (as heaps, stacks) in the past, but now it is more frequently left on the field or placed in the yard (haylage, hay, straw, all under foil), without building costly barns (many of which are being used as sheds for machines) or silos for silage.

Supply chains in the dairy sector, which is experiencing rapid concentration, have become simplified in recent years. While milk was produced on a small scale by almost all farms (estimated to number nearly 2 million) before the economic transformation, in 2014 about 10.5 million tonnes of milk were supplied in bulk quantities by about 130 thousand farms [5] [9], [10]. Small-scale operations have virtually withdrawn (having been eliminated due to the small scale of production and high purchase costs) from milk production, while large farms are rapidly increasing the number and productivity of cows, milk production, as well as upgrading farm buildings, in particular purchasing fast milk cooling tanks (after milking), which is a condition for its receipt by dairy processing plants. Small (rural) milk collection points have practically disappeared. For decades after the war they received milk from individual farmers (even just a couple litres per day), while in the current system milk is taken directly from the farmers to dairy processing plants, without intermediaries. This serves to improve its quality and lower purchase costs.

In the production of beef, pork, mutton or poultry mainly warehouses for storage of fodder are needed, with small premises being sufficient for storing medications or tools. Live animals, in contrast to milk, do not require regular and frequent transport, so they stay in production buildings, not warehouses, until their sale.

6. CONCLUSIONS

1) A clear tendency to shorten supply chains can be observed in agriculture and its economic environment. This stems from concentration processes in the agricultural sector and the emergence of companies with large-scale production, on the one hand, and the fact that recipients prefer contacts with manufacturers offering a standardised product in large quantities, which makes it possible to skip intermediate links, on the other. This makes it possible to reduce the cost of purchasing and standardising products, while maintaining quality requirements. This process eliminates small producers, who, by abandoning farming, permit strong companies to further consolidate. A particular form, which would allow them to survive on the market and develop, is the creation of producer groups. This kind of cooperation has so far been employed mainly by fruit growers, although it could also be useful to other farmers with a smaller scale of production.

2) The growing scale of production and stronger relationships between companies that form subsequent links in the food supply chain encourage a particular type of outsourcing, which involves moving the transportation and storage operations from agricultural enterprises to external service or trade companies and end users. A farmer released from storage operations and some transport tasks not only foregoes a part of the associated costs, but can also concentrate on agricultural production and expand its scale.

3) In agricultural enterprises themselves, within the scope of technological processes associated with transport, combining transport and consumption of several means of production is becoming more frequent. An example of such activities is moving materials from farm buildings to the field, such as products for sowing (seeds), fertilising (mineral-based soil fertilisers) and plant protection products (pesticides, to protect seeds in the soil, for example).

4) In recent years there has been a breakthrough in the storage of some forms of roughage. Thanks to the introduction of balers and bale foiling machines it has become possible to forego the construction of drive-through silos for haylage production (although they are still needed in silage production). It can be therefore concluded that a switch is taking place - where possible - from expensive closed warehouses to open storage, with new security techniques, such as covering in foil.
5) Agriculture is a sector, in which logistics processes have been carried out from its inception. In the 20th century, both quantitative and qualitative changes have been occurring, which could be defined as the initial phase of industrialisation. Today, we are witnessing advanced changes associated with the replacement of transport, warehousing and communication means to more modern and efficient versions, as well as changes in the division of tasks between agricultural enterprises and their economic environment towards outsourcing to external transport and storage operations, with the functions being taken over by service entities or final customers. This market is not yet overly developed, but it seems quite promising for logistics companies.

REFERENCES
IMPACT OF THE CELLULAR PRODUCTION STRUCTURE ON THE ASSEMBLY OF REFRIGERATING EQUIPMENT

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¹,²AGH University of Science and Technology, Cracow, Poland, EU

Abstract

The complex manufacture of refrigerating equipment most often uses the cellular structure. The problem in improving the material flow is a correct planning of processes in the individual cells. The final assembly line receives streams of materials from cells and streams of other components from buffer stores. The production task (finished refrigerating equipment) is affected significantly by cutting and bending processes of stainless steel parts. The paper presents the impact of these processes on the assembly of refrigerating equipment.

Keywords: Production system, work center, assembly

1. PREFACE

The problem discussed in the paper concerns the correct execution of a production task carried out in the make-to-order system. In contemporary production systems such problems are solved using a series of methods known as lean toolbox [1]. In addition to the classic literature references which propagate the use of lean methods in production systems [2, 3, 4, 5], there are other innovative approaches based on classic queuing theory [6]. In this paper, Altendorfer analyzes in detail the impact of inventory and process effectiveness on the lead time expected by the customer in single- and multistage production systems. Bhasin in [7] proposes a holistic approach to the lean management problems. The discussion on quality - Lean Sigma - is of interest in this paper. The implementation of lean methods to production companies, particularly of a medium size, is difficult, and does not always bring about the expected profits. Liker and Frank dampen the optimism presented in many papers [8], writing that the studies have shown that the implementation of lean methods achieves the intended results still only in two percent of cases. The reason is usually a poor understanding of the organizational factors that allow a successful implementation and follow-up. In the context of small and medium enterprises (SMEs) in Poland, the implementation of lean methods is even more complex due to the lack of knowledge being even more predominant than the lack of understanding. Hence, the authors argue that it is easier to convince the managers to use selected quantitative methods that do not make up a complicated system, but which can help to improve the basic productivity ratios [9]. Examples of logistics engineering methods that can be used are given in [10, 11].

2. PROBLEMS IN THE MANUFACTURE OF REFRIGERATION CABINETS

The analyzed company belongs to the SME segment, employing 300 staff and selling its products in more than 30 countries worldwide. The product range includes a few dozen display refrigerators and refrigeration cabinets which need more than 2000 various parts and components. Some of them are made in-house, and the others are bought from external suppliers. A particularly important company product range is the refrigeration cabinets used in medicine - mainly for storing blood, blood-based preparations, and plasma and cryoprecipitate. The ULUF range has a few varieties and the most complicated to manufacture is the ULUF 450.
The quality and is certified by the ISO 13485 standard (Medical devices. Quality management systems. Requirements for regulatory purposes) and the CE0434 mark (for equipment conforming with directive 93/42/EEC).

**Figure 1** presents the manufacturing diagram of the refrigeration cabinets. The production process takes place in five production cells from which parts, components and subassemblies are sent to the main assembly line.

![Production system diagram](image)

**Figure 1** Production system diagram

Cell I is used for the operations of cutting, punching and bending of steel (stainless, galvanized and painted) parts. Welding, pressure welding and deburring operations are also carried out there. The manufactured subassemblies are sent to the buffer.

Cell II is used for painting operations of the metal parts (the majority of the parts are painted white, some are painted in other colors, some are not painted).

Cells III, IV and V are typical component-focused cells, and the processes include insulating some spaces with polyurethane foam (III), preparation and assembly of electrical subassemblies (IV) and refrigerating subassemblies (V).

There are buffers in some cells for storing the components needed in subsequent operations. The finished product - a refrigeration cabinet - is made on the assembly line. The current production pace of the cabinet is about 30 hours, and the final assembly takes about 3.5 hours. After assembly the cabinet goes to quality control and is then tested for several hours.

The production of the refrigeration cabinets is only according to “make-to-order” principle and causes specific difficulties in keeping to the deadlines. These difficulties include:

- the customer having a large influence on the customization. As a result the products are little repeated, and with low volume there are problems with supply of individual components (e.g. there is demand for 80 different compressors),
- the production of parts in technology and component-focused cells,
highly-skilled operators are required in the component-focused cells (a lot of manual operations), and as a result the exchangeability of operators is practically impossible.

production in cell I (the technology cell) is carried out together with other job orders, hence it often starts earlier than required for the final assembly, and as a result WIP grows excessively due to collecting many job orders to start the punching and bending (i.a. economically profitable series to start modern numerically controlled machines).

As many different job orders are performed in each cell (other refrigeration cabinets and also display refrigerators and open merchandisers), the planning of the processes in the individual cells and for individual machines is difficult and complex. An example of a hypothetical schedule of realizable various processes during the manufacture of a refrigeration cabinet is shown in Figure 2 (the average duration of the production task is 36 hours).

![Figure 2 Example of the production task schedule](image)

The studies have allowed identification of stoppages of which the most important are:

- stoppages due to delayed delivery of purchased parts,
- stoppages due to poor quality of supplies,
- stoppages due to the absence of correlation between production schedules in cells with the assembly schedule; this type of delays generates the biggest costs for the company because the ‘delays’ occur at the final stage, i.e. the assembly of a finished product.

The other delays are due to quality defects at various manufacturing stages, most often paint coat defects.

There is an overproduction at each stage in the company so the impact of these defects on delayed deliveries to customers is minor. The occurrences listed above present some problems which have to be minimized as they generate muda.
3. PROPOSALS TO SOLVE THE PROBLEMS

The most important difficulties relating to the performance of the job order include:

- determining the earliest and latest time to start individual operations for each process;
- ensuring an adequate high quality (required by the customer) of parts and components made in the manufacturing cells (usually there are no spare parts, so a non-conformity results in delaying subsequent operations);
- ensuring an adequate information flow between the manufacture in cells and the needs of the final assembly;
- coordination of material flows and limiting the buffer storage of prematurely manufactured parts to an absolute minimum.

Thus, the following task was formulated in order to improve the production system:

\[ T_{zi}^{UL} = \sum_{i=1}^{m} t_{ic}^{UL} \rightarrow \min \]  

(1)

where:

- \( t_{ic}^{UL} \) - the duration of operation in cell \( ic \),
- \( z \) - the number of the performed production task for ULUF cabinet (UL),
- \( i \) - the number of the manufacturing cell called \( c \),

The duration of individual processes (acc. to Figure 1) - simplified notation:

- for cell I (cutting, punching and bending);

The duration of the task of cutting, punching and bending of all the parts necessary to make the UL cabinet is the sum of the times of necessary operations (bending is not performed on some parts):

\[ t_{i}^{UL} = \sum_{ip}^{M} t_{ip} + \sum_{ib}^{N} t_{ib} \]  

(2)

where:

- \( M \) - the number of punched parts,
- \( N \) - the number of bent parts.

- for cell II (painting);

The duration of the painting process is the sum of the times of all operations of painting white and other colors (not all the parts are painted):

\[ t_{ii}^{UL} = \sum_{iw}^{P} t_{iw} + \sum_{ic}^{N} t_{ic} \]  

(3)

where:

- \( P \) - the number of parts painted white,
- \( N \) - the number of parts painted other colors.

- for cell III (foam insulating);

The duration of the foam insulating process of the set of parts is the sum of times for preparation of the moulds, filling the moulds and seasoning (cooling):

\[ t_{ii}^{UL} = \sum_{ix}^{N} t_{ix} + \sum_{iy}^{N} t_{iy} + \sum_{iz}^{K} t_{iz} \]  

(4)

where:

- \( K \) - the number of mould sets necessary to perform the task.

- for cell IV (assembly of electrical subassemblies);

The duration of electrical parts assembly is the sum of the times of all necessary operations (e.g., soldering) to prepare the subassemblies for the final assembly:
where: ME - the number of required operations for electrical subassemblies.

- for cell V (assembly of refrigerating subassemblies);

The duration of refrigerating parts assembly (e.g., the evaporator) is the sum of the times of all the necessary operations to prepare the subassemblies for the final assembly:

$$\tau_{UL}^{V} = \sum ME \cdot \tau_{UL}^{i}$$  \hspace{1cm} (5)

where: MC - the number of required operations for the refrigerating subassemblies.

- for the final assembly line;

The duration of final assembly is the sum of the times of all operations necessary to make a given type of refrigeration cabinet (casing, evaporators, compressor, shelves, castors, electrical wiring, control systems, etc.):

$$\tau_{UL}^{MA} = \sum MA \cdot \tau_{UL}^{i}$$  \hspace{1cm} (6)

where: MA - the number of operations for a given type of ULUF cabinet.

In order to verify the system operation, the system model was developed (acc. to Figure 1), and implemented in the WITNESS simulation software. The model structure is presented in Figure 3.

**Figure 3** System model implemented in the WITNESS simulation software

**Figure 4** presents a simplified VSM (Value Stream Mapping) for as-is state which represents basic information and material flows, manufacturing operations, and storage and warehousing processes.
4. SUMMARY

Production in SMEs can be carried out according to one of the basic principles: make-to-order or make-to-stock. Make-to-order, particularly when the customer has a lot of leeway to customize a typical product, is a difficult and complex task. In the case of complicated devices it is often necessary to order ready-made subassemblies and parts from external suppliers. The most important thing for the cellular structure (preferred in this case) is to make correct production time schedules for cells so that on the line assembly takes place without stoppages. In addition to a correct correlation of the assembly time schedules with the production time schedules, it is necessary to ensure adequate external supplies.

The solution of these problems requires using the lean production methods (5S, spaghetti diagrams, Yamazumi charts, identification of 7 muda, VSM, and quantitative methods offered by logistics engineering (ABC classification of materials, XYZ, Pareto charts, CPM, and PERT).
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THE ASPECT OF REVERSE LOGISTICS OF PLASTICS 
ON THE WASTE MANAGEMENT IN PACKAGING

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Abstract

The research concerns a very important area of management, namely, reverse logistics, as the ecological conditions of the transition from the traditional model of material flows to the modern approach of logistics, as a closed cycle of materials and energy. This subject is very timely in light of the strategy pursued by the European Union for sustainable development, based on the concept of the system of "Integrated governance" which consists of a triad: society - economy - environment (ecosystem). Logistics systems activities require the assurance of adequate economical and environmental efficiency levels on the demands of sustainable development. The main aim of the paper is to present the concept of reverse logistics and recycling in the context of sustainable development, and also focus on the economical and environmental optimization of reverse logistics processes in plastics packaging. The presented article is part of research on developing application methods for the settlement of environmental-economic support for reverse logistics processes aimed at reducing consumption of energy and raw materials by manufacturers of plastics, which ultimately translates into added value in terms of so-called environmental benefits. The process of waste disposal can be significantly boosted by logistics, and especially by reverse logistics, which is "fixed" in traditional logistics and yet is representative of the ecological orientation of logistics and therefore very well suited to the imperative of sustainable development.

Keywords: Logistics, reverse logistics, sustainable development, plastics

1. INTRODUCTION

The current thinking about supply chains is focused primarily on logistics flows from raw materials to finished products, therefore those processes which primarily lead to interest in creating and developing supply chains. The global market, technology improvement and sustainability development has involved new model of supply chain. A new trend in logistics is observed [1]. In recent years, in the context of sustainable resource management, there is a new concept, that of reverse logistics, for which there are synonymous terms such as: reverse logistics, Ecologistics, logistics in the field of recycling, or waste logistics. The problems of waste management are increasingly falling into the field of logistics - this is reflected in the growth of reverse logistics.

The assumptions of sustainable development clearly indicate that the search for new solutions to technical, technological and logistical resources, and rationalization of the economy, energy and waste should be a priority for all business sectors and services. The definition contained in the Act on Waste of 14 December 2012 should be noted - "waste is all articles or substances which the holder discards, intends to dispose of or is required to dispose of."[2]

It should be stressed that current knowledge on the relationship between resource availability and the implications generated by their use and subsequent recovery is still only partial knowledge, and these relationships are significantly changing under the influence of both technological and social development.
2. REVERSE LOGISTICS

In waste management, it must be recognized that the "substance", which for one holder is waste, for another, or even the same operator, at another place and another time can be a useful raw material or intermediate, and this means that waste should be recovered and used effectively, in accordance with the philosophy contained in both Polish legislation and in the framework of the European Council Directive on waste 2008/98/EC of 19 November 2008. A new definition describes the packaging as all the products composed of materials of any nature to be used to contain and protect certain goods, from raw materials to finished products, to enable their handling and their delivery from producer to consumer or user and to ensure their submission. The directive also specifies with details for each category, what can and cannot be considered packaging. The role of packaging is broadening and may include functions such as attracting attention, assisting in promotion, providing machine identification (barcodes, etc.), adding essential or additional information, and helping in utilization.

The process of waste disposal can be significantly boosted by logistics, and especially by the reverse logistics, which is "fixed" in traditional logistics and yet is representative of the ecological orientation of logistics and therefore very well suited to the imperative of sustainable development. Reverse logistics (recovery logistics) enables the realization of the idea of a circular economy, which is a departure from the linear model of raw material flow, to a model of closed material-energy cycles, which significantly reduces the high entropy of the modern economy while enhancing the overall utility rate.

One of the instruments for the comprehensive assessment of the environmental impact of plastics production, coupled with their recovery and recycling is the ecological balance. The popularity of this tool is shown by the methodology of unification in the global ISO standards 14000x - as art (LCA) Life Cycle Assessment - Life cycle assessment (ISO 14040 and ISO 14044) [3].

Reverse logistics is defined as the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal [4].

Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics. Reverse logistics is more than reusing containers and recycling packaging materials. Redesigning packaging to use less material, or reducing the energy and pollution from transportation are important activities, but they might be better placed in the realm of "green" logistics. If no goods or materials are being sent "backward," the activity probably is not a reverse logistics activity.

Reverse logistics also includes processing returned merchandise due to damage, seasonal inventory, restock, salvage, recalls, and excess inventory. It also includes recycling programs, hazardous material programs, obsolete equipment disposition, and asset recovery [5].

3. THE PACKAGING INDUSTRY

Over the past few years, production of plastic packaging has taken on a particularly dynamic character. The development of quantitative production of plastics has been accompanied by parallel changes in the development of quality and range, mainly in terms of individual packages.

The plastic packaging successfully competes with the other traditional packaging materials (sometimes even displacing them from the market - such as paper and cardboard, glass). The main drawback of plastic packaging is its non-biodegradability and the limited potential for recycling because of the variety of polymers (especially in the absence of selective waste collection). The largest share in the packaging industry is occupied by polyolefins, among them: polyethylene - PE, polypropylene-PP, and others: polyvinyl chloride - PVC, polyamide - PA, polystyrene - PS, polyethylene terephthalate - PET.
The value of packaging industry in Poland is still growing and is about (in euro currency) 7600 million (2013), 8130 million (2014) and 8620 million (2015). Of course, in the packaging industry as with any industry, the Polish market consists of manufacturers producing packaging based on plastics, but also based on paper and cardboard, glass, wood, metal and textiles. Due to the materials used, however, plastic packaging dominates production (37.3%), followed by paper and cardboard (32.7%), metal (12.2%), glass (11%), wood (6.6%) and textiles (0.2%) - for the year 2013. The forecast (2020) is as follow: plastics (39.3%), paper and cardboard (36.2%), metal (9.5%), glass (8.2%), wood (6.3%) and textiles (0.5%). [6]

The development of a dynamic packaging market has created a significant problem in ecological terms, associated with the management of packaging waste. In accordance with national regulation Article 3, paragraph 8 of the Act on Packaging and Packaging Waste of 13 June 2013, packaging waste is defined as all discarded packaging (withdrawn from re-use), which is waste within the meaning of the Waste Act (14 December 2012), except for waste generated in the process of packaging production.

As indicated by research conducted by the European Environment Agency (EEA), the increase in the amount of waste is now one of the most important environmental problems of the EU. The member states produce about 1.3 billion Mg of waste annually, of which 14% is communal waste. In 1995, the average European citizen produced about 460 kg of municipal waste; in 2004 this number increased to 520 kg per person, and it is expected that by 2020 it will reach 680 kg. Packaging waste accounts for around 50-60% of the volume of municipal waste, and its number increases proportionally to the increase in wealth and population of the EU, a continuation of current trends in consumption patterns. [7]

There are many different types of cartons, cups, tubes, bags, bottles, cans, jars, and so on. Bags constitute up to 60% of the European landfill. In Poland, the amount of packaging waste by weight of municipal waste is estimated at about 30% by weight and 50% volume [7], although some estimates say about 50% by weight and 70% by volume. Appropriate management of packaging waste is therefore a serious environmental problem within economic development, and requires more and more improved waste management systems. These systems apply to packaging waste collection, transport, recovery and recycling.

Mass produced and recycled packaging waste in Poland over the selected years is presented in Table 1. It can be seen that despite the technological advances in the field of packaging, consisting of, for example, significantly reducing packaging weight as a result of the requirement for enterprises to meet PN-EN 13428:2005 [8], in the projections for 2014 the weight of packaging waste is expected to increase to about 6910.17 thousand Mg in relation to previous years. By 2014 the dominant mass of packaging waste is paper and cardboard waste, glass, plastic, composite and metal packaging.

Table 1 Mass produced and recycled packaging waste in Poland over the selected years [7]

<table>
<thead>
<tr>
<th>No</th>
<th>Material Type</th>
<th>Amount of packaging waste in Poland [thousand. Mg / yr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Paper &amp; Textiles</td>
<td>1226.47</td>
</tr>
<tr>
<td>2.</td>
<td>Glass</td>
<td>956.59</td>
</tr>
<tr>
<td>3.</td>
<td>Plastic</td>
<td>473.54</td>
</tr>
<tr>
<td>4.</td>
<td>Composite Materials</td>
<td>137.74</td>
</tr>
<tr>
<td>5.</td>
<td>Sheet Steel</td>
<td>134.01</td>
</tr>
<tr>
<td>6.</td>
<td>Aluminium</td>
<td>39.11</td>
</tr>
<tr>
<td>7.</td>
<td>Wood &amp; Natural Materials</td>
<td>488.00</td>
</tr>
<tr>
<td>8.</td>
<td>Total</td>
<td>3455.46</td>
</tr>
</tbody>
</table>
In the near future, innovations will become available such as printable RFID tags that provide warnings of changes in temperature and humidity levels that might affect the integrity of the product. Absorbers and emitters of natural occurring gaseous substances that prolong shelf life are already entering the market. In the future, biosensors that detect bacteria and viruses will pave the way to safeguard the quality and safety of food for consumers whilst further reducing food waste.

According to the UK’s Advisory Committee on Packaging: [9]

- An unwrapped cucumber loses moisture and becomes dull and unsaleable within 3 days. Just 1.5 grams of plastic wrapping keeps it fresh for 14 days.
- Selling grapes in trays or bags has reduced in store waste of grapes by 20%. When buying a product, consumers like to see its appearance and to be sure it matches their expectations. Plastic packaging provides this transparency and helps reduce bruising and other potential damage caused when handling products such as strawberries.
- In-store wastage of new potatoes reduced from 3% when sold loose to less than 1% after specially designed bags were introduced.

Generally the relevance of the environmental impacts of packaging seem to be overestimated by far: Only 1.7 % of the total consumer carbon footprint is related to all domestic and commercial packaging materials used in the EU27+2. The use of plastic packaging is related to only 0.6 % of the average carbon footprint of the European consumer (the use benefits, which are at least 5 times higher than the production burden, are not included here). Only 1.5% of all oil and gas consumed in Europe is used as a raw material to produce plastic packaging whereas 90% of it is used for heating, transportation and energy generation. If food was packed using other materials than plastics, the related energy consumption would double and greenhouse gas emissions would nearly triple. This would also be accompanied by a 360% increase in the weight of the packaging.[10]

The plastics industry is committed to constantly reducing the amount of plastics used in its products without compromising performance and durability. Ten years ago, the average plastic packaging weight was 28 % higher than today and even more for some applications.

4. RECOVERY AND RECYCLING OF PLASTICS

Whilst overall consumption levels rose by 20% between 1999 and 2004, the total weight of plastic packaging consumed rose by 4%. This means that plastics help reduce the impact of a rapidly growing consumption. The character of the main findings (more energy demand & more GHG emissions when plastic packaging was substituted by other materials) is not changed by re-cycling scenarios. Current plastic recycling levels reduce life-cycle energy demand by 24 % and GHG emissions by 27 %. Even with no plastic recycling, plastic packaging would cause less GHG emissions than alternative materials. If plastic packaging was substituted by other materials [10]:

1) the respective packaging mass would on average increase by a factor 3.6
2) life-cycle energy demand would increase by a factor 2.2 or by 1,240 milion GJ per year, which is equivalent to 27 Mt of crude oil in106 VLCC tankers or comparable to 20 million heated homes
3) GHG emissions would increase by a factor 2.7 or by 61 million tonnes of CO2-equivalents per year, comparable to 21 million cars on the road or equivalent to the CO2-emissions of Denmark.

The directive of 9th March 2005 on packaging and packaging waste 2005/20/EC (Official Journal. L No. 70), replaced Directive 94/62/EC introduced in the Member States for the recovery and recycling of packaging waste. This obligation came in the wake of the requirements of the Directive entered into Polish legislation - in particular, the draft law on the management of packaging and packaging waste, which replaces the existing provisions of two laws: the Law of 11th May 2001 on packaging and packaging waste (OJ 2004. 011 097) and

**Table 2** Proposed levels of annual recovery and recycling of packaging waste from 2014 [7]

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of packaging, from which waste arises</th>
<th>2010 % level</th>
<th>From 2014 % level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>recovery</td>
<td>recycling</td>
</tr>
<tr>
<td>1.</td>
<td>Packaging (together) (2)</td>
<td>min. 60</td>
<td>min. 38</td>
</tr>
<tr>
<td>2.</td>
<td>Plastic Packaging</td>
<td>min. 18</td>
<td>min. 22.5</td>
</tr>
<tr>
<td>3.</td>
<td>Aluminium Packaging</td>
<td>min. 45</td>
<td>min. 50</td>
</tr>
<tr>
<td>4.</td>
<td>Steel Packaging, including Sheet Steel</td>
<td>min. 35</td>
<td>min. 50</td>
</tr>
<tr>
<td>5.</td>
<td>Paper &amp; Textile Packaging</td>
<td>min. 54</td>
<td>min. 60</td>
</tr>
<tr>
<td>6.</td>
<td>Recycled Glass packaging, excluding ampoules (1)</td>
<td>min. 49</td>
<td>min. 60</td>
</tr>
<tr>
<td>7.</td>
<td>Wood Packaging</td>
<td>min. 15</td>
<td>min. 15</td>
</tr>
</tbody>
</table>

1) does not apply to packaging materials in direct contact with medicinal products as laid down by the Pharmaceutical Law.

In the field of plastic packaging, the previously discussed new law will introduce a recycling fee on plastic bags, which would take effect from 1 January 2015. The relatively long period of grace for the introduction of the fee is intended to create opportunities for manufacturers of plastic bags to change the production profile. The primary objective of the introduction of this fee (maximum level of 40 / gr per piece) is the reduction of plastic bags, of which Poland consumes about 6 billion per year. These bags are an extreme burden to waste segregation stations and waste in landfills and to the environment; they pollute ecosystems, and are a threat to animals (especially birds) - a significant reduction in their number is also an important activity of the social point of view. Revenues from the fees will be used by the Marshal offices to finance waste collection and recycling systems, and education in this field.

5. CONCLUSION

Plastics seems to be more and more important for our daily life and also for economy. In the UK, plastic milk bottles currently contain up to 10% of recycled materials, and this share is expected to increase to 1/3 in the near future. According to the German federal environmental agency, new plastic carrier bags often contain up to 80% recycled material. Used plastics are also a very cost-effective and efficient way of providing heat and power in cities around Europe. Plastic packaging is essential for processing, storing, transporting, protecting and preserving products. Plastic packaging is not harmful to the environment if properly disposed of. Plastic packaging means more with less: less waste, less energy, less resources used, reduced cost and lower GHG emissions across the full life-cycle of the product. [9]

The need for action to effectively manage resources on an international scale was addressed during the Second World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, where it was agreed that “protecting and managing the natural resource base for economic and social development are overriding objectives of sustainable development and also the essential requirements of it.” The strategic objective of waste management planning is the handling of waste in accordance with the principles of the waste management hierarchy, i.e. firstly the prevention and minimization of waste generation and to reduce their hazardous properties and, secondly, maximum utilization of material and energy components of the waste, and where waste cannot be subjected to recovery processes, to be neutralised. [1].
This assumption has become an inspiration to undertake research on the use of natural resources in a sustainable manner, meaning not only ensuring long-term availability, but also taking into account the environmental effects of their use. At the same time, those effects should be analyzed in a full cycle of processing of resources (at all stages of the value chain) - from the extraction of raw materials and their use as a production factor, through to the processes of transformation in production, to consumption and followed by the logistics process of returning used goods in circulation in economic and / or environmental terms.

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THE POLICY INFORMATION AS A DETERMINANT OF SECURITY IN THE SUPPLY CHAIN

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Abstract

The article presents the outcomes of research concerning information security in the supply chain. The research has been based on the scientific observations and the analysis of the state of the enterprise that were performed in three metallurgical plants. The research has entailed the state of information security and information flows in the supply chain.

Keywords: Information security, security in the supply chain, business security system, information flows in the supply chain

1. INTRODUCTION

In the 20th century the flows of loads were exposed to different risk resulting from natural phenomena and human activity. However, the 21st century has brought new perils. Owing to the fact that we became information society, it is the information that is treated as the uppermost resource for a company. Hitherto, the companies have protected data against industrial spying by creating the isolating system. The developing international trade has facilitated supranational cooperation along with having made information and technology security difficult.

2. THE SYSTEM OF INFORMATION PROCESSING

In the companies performing nowadays, a large amount of information is generated. Even the owner or management do not have the complete knowledge of each piece of information arising in a company. At the present time the validity of information is so low and changes so rapidly, that the models of management and systems are created which major aim is to protect data [1, 2]. The development of companies to a large extent causes information paralysis and 90% of decisions are made by 5% of the staff employed in a company [2, 3]. The solution to this situation is to create the policy of information management, delegating decisions to particular employees, building the conduct procedures in difficult or even crisis situations [6, 10]. Unfortunately, transferring the decisiveness to employees is frequently received by the management as a dangerous situation for a company's existing. The Figure 1 shows the amount of information processed by the company.

![Figure 1](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAgAAAADkCAYAAAAfC5NAAAABmJLR0QA/wDQ1JK9cR/ABXRUJQCHNIRuQ4ZCgAAAAABJRU5ErkJggg==)

**Figure 1** Data gathered in the analyzed companies
The Figure 1 shows the percentage structure of information in a division into the particular areas of activity taken in the company. It can be noticed that Huta HSJ Stalowa Wola gathers a large amount of information concerning its suppliers and rendered supplies, clients, and the manufacturing process. The remaining two companies gathers administrative and commercial data.

The excess of information can be the reason for losing the control by a company over generating, processing and taking advantage from the data. In this situation the methods for control and information classification should be elaborated [4, 9]. Therefore, the system of secure information processing should be created. The Figure 2 depicts the scheme of correct and incorrect information management.

The proper information management provides a company the opportunity for information processing, verification of its reliability, and if it is acknowledged as useful, it is included in the database. The useless data are destroyed. If information management fails, the flow and deletion of information are entirely uncontrolled, which may lead to information chaos or its lack.

3. INFORMATION SECURITY IN A COMPANY

In each company the selected elements of information security system are in force. More and more entrepreneurs are supervising the movement of people in a company via monitoring or using the antivirus or anti-spyware programs. Nevertheless, the implementation of information security system does not mean keeping to the selected safety rules. It is necessary to use the following rules for creating information security [8,11]:

- determining the requirements of information/data-handling system in a company,
- controlling activities currently taken,
- rating information,
- assessing weak points,
- establishing the budget of activities,
- defining the required security,
- organizing and creating the security.

The application of safety rules requires the collaboration of all employees in a company, pursuing the suitable internal policy, making the abandonment of the binding procedures possible, updating security system [5, 7].

The implementation and functioning of information security policy in a company is the assurance of physical security, as well as data-handling paper and electronic documentation [7], which is illustrated in the Figure 3.
The policy of information security should work in a company in two scopes, the physical and the data-handling ones. The first one comprises global environment, thus the area at which a company functions, the monitored site, entry gate, buildings, civil engineering works within a company and machinery. The second component of security policy is physical security. It concerns inter alia the security of computers, data carriers, paper current and archival documentation, security zones in buildings. Whereas data-handling security is provided inter alia by the security of information systems, security against cyber-attacks, surveillance of internal network and Internet traffic. The system of information security is shown in the Figure 4.

The system ensuring information security in the enterprise, but it does not influence the type of information that inflows or when passing the information outside it is received as the same piece of information, without distortions, errors and whether it reaches the addressee. The policy of information security does not provide, however, information security beyond the area that a company functions, which means that cooperating permanently with contractors, entrepreneurs are vulnerable to perils of the same sort as the self-existing...
company. It would be necessary, then, to create the common system of access to information in order to secure it. However, it is not feasible, because each company acts in its own interest and material profit.

4. SECURITY IN THE SUPPLY CHAIN

The issue of security in the supply chain is a complex issue and it should be considered in various dimensions. Information security is one of them. Information security of the system which is the supply chain may treat each company as one of the subsystems [8]. In order to discuss information security in the supply chain the sites of information flows in the researched chain should be considered (Figure 5).

![Figure 5 The supply chain considering information flows](image)

The manufacturing companies that are researched are the recipients of information from suppliers, and the information processed by them is dealt by wholesalers. The system of security in the supply chain should protect the data that are common for the components of the supply chain that work in close cooperation. (Figure 6). Having the common information requires taking steps in order to secure it. The researched companies took actions that have been necessary for protecting common data. The effects of these activities are shown in the Figure 7. The elements implemented so far have seen an increase in the indices that are the signs of a positive impact on information security in the supply chain.

![Figure 6 Information which should be protected by security system of the supply chain](image)
5. CONCLUSION

The article presents the outcomes of research concerning information security in the supply chain. The research has been made at the beginning of 2016. The analysis has entailed three elements of the supply chain which are suppliers, producers and wholesalers. Their system of information processing has been analyzed, which has enabled to create the model system of information management and indicate the errors that the entrepreneurs have made so far. Subsequently, there has been made the distribution of the processed data into the separate and common ones, which has enabled to determine which information should be under collective security. Implementing these solutions has allowed for making calculations whether the security had brought the expected results. It can be univocally acknowledged that creating the system of information security has contributed to the speed of information flows to the final recipient. It has also increased the efficiency of the conducted activities within information management.

REFERENCES

FACTORs INDUCING THE PROGRESSION OF INTERMODALITY IN BALTIC ADRIATIC CORRIDOR

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Abstract

The zones along the Baltic and the Adriatic have substantial geographical, economic and transport similarities. The strengthening of economic growth and the dynamics of the flow of goods has provided intermodality the utmost importance. The development of multimodal transport network and its connection with the TEN-T corridors represents a precondition for strengthening national economies. Baltic-Adriatic corridor connects the north and the south of Europe, with a more progressive intensification of the economic growth of Baltic and Central European countries. The intermodal transport system in the corridor has the ability to generate and intensify the economically sustainable growth. Without doubt, there is a true need for economic growth and transport system within which intermodal transport would have particular significance as a strategic program. Strategic planning of transport development must be in the service for the overall economic growth and it should be dynamically adjusted to the objective investment possibilities in the field of intermodality.

Keywords: Logistics, intermodality, Baltic Adriatic corridor, SWOT / TOWS analysis

1. INTRODUCTION

In today's modern era the freight transport is of immense importance. The transport volumes are ever growing and the issue to accommodate them in an optimal and sustainable way is of utmost importance. Due to this criticality it is often impossible to arrange just one modality for freight transport, making two or even three modalities necessary (intermodal freight transport) [1]. This article highlights the key aspects which influence the establishment and development of intermodality, in Baltic Adriatic Corridor. The Baltic Adriatic corridor is 2400 km long corridor connecting the Baltic ports in Poland with the ports of the Adriatic Sea. It starts at the ports of Gdansk and Gdynia, connecting via strong economic centres like Warsaw, Vienna and Venice to Trieste and Ravenna. The corridor has some branches from Szczecin to Katowice, from Graz via Udine to Trieste as well as via Ljubljana to Trieste / Koper. The corridor provides better access to Baltic and Adriatic seaports for the economic centres in Poland, the Czech Republic, Slovakia and Austria.[2]

The article begins with the thorough analysis of the various aspects (general and specific) making an impact on the flow of goods in the corridor, therefore urging the need for intermodality. The later part highlights SWOT / TOWS analysis and related recommendations to establish and develop intermodality in Baltic Adriatic corridor.

2. FACTORS CATALYZING INTERMODALITY IN BALTIC ADRIATIC CORRIDOR

This section provides an insight into the aspects, which catalyse the establishment and development of the intermodal platform. The aspects are divided into general and specific to highlight the importance.

The general environment for the network of multimodal platforms is related to the transport infrastructure in the considered area. For purpose of this article, the multimodal network is created by road, rail, air transport and inland waterways network. The overview of general environment of the network of multimodal nodes situated on the Baltic-Adriatic Corridor starts with identification, analysis and impact of various logistics
corridors and logistics axes on volume of goods in Adriatic-Baltic corridor. Each classified corridor gives a precise and important information about the infrastructure in particular corridor as well as main origins and destinations of the freight transported along with the volume in millions tones.

At the second Pan-European transport conference in Crete, 10 European transport corridors were defined. The corridors variously encompass road, rail and waterway routes. It worth to be mentioned that some of the given corridors entirely belong to the Adriatic- Baltic corridor. In such a case, the research is based on assumption that there is no outflow to the outside Adriatic-Baltic corridor.

The specific environment analysis moves the issues of business and infrastructure surrounding of the network of intermodal nodes. It is found that all the nodes in BAC are in the phase of more or less rapid development. Key success aspects is reasonable planning process. In the case of railway transportation, in most of the discussed node investments are needed to be adopted in order to fulfil future demand and eventual shifts of freight volumes from road to rail.

**Factors - General Environment**

As stated previously, the main aspects under general environment is directly associated with the impact of corridors on the freight flow. The **Figure 1** below shows the updated list of the core network corridors.

![Figure 1 Core Network Corridors](image)

The impact of selected core network corridors on the goods flows in the Baltic Adriatic corridor is highlighting in the upcoming section.

Warszawa - Berlin - Amsterdam / Rotterdam - Felixstowe - Midlands core corridor

The impact of corridor on Baltic Adriatic corridor is shown in **Table 1**.

**Table 1** Impact of corridor on BAC, Source: Own research

<table>
<thead>
<tr>
<th>No</th>
<th>Origin of goods</th>
<th>Destination</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UK, France, Benelux</td>
<td>CEEC via Berlin and Pan-European corridor 2</td>
<td>8.9 million tones</td>
</tr>
<tr>
<td>2</td>
<td>Russia</td>
<td>EU via Minsk, Warsaw, Berlin</td>
<td>11.2 million tones</td>
</tr>
<tr>
<td>3</td>
<td>Belarus</td>
<td>EU via Warsaw</td>
<td>3.4 million tones</td>
</tr>
</tbody>
</table>
As clear from the table, this particular core corridor propels 23.5 million tones into the BAC, thereby creating huge requirement for additional platforms.

Mediterranean core corridor

The impact of Mediterranean corridor on Baltic Adriatic corridor is shown in Table 2.

**Table 2** Impact of corridor on BAC, Source: Own research

<table>
<thead>
<tr>
<th>No</th>
<th>Origin of goods</th>
<th>Destination</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Austria, Slovenia, Hungry</td>
<td>Germany</td>
<td>0.42 million tones</td>
</tr>
<tr>
<td>2</td>
<td>Germany</td>
<td>Austria, Slovenia, Hungry</td>
<td>0.38 million tones</td>
</tr>
<tr>
<td>3</td>
<td>Italy, Slovenia, Austria, Hungry</td>
<td>Ukraine</td>
<td>0.62 million tones</td>
</tr>
<tr>
<td>4</td>
<td>Ukraine</td>
<td>Italy, Slovenia, Austria, Hungry</td>
<td>0.21 million tones</td>
</tr>
</tbody>
</table>

Hamburg - Rostock - Burgas / TR border - Piraeus - Lefkosia core corridor

The impact of corridor on Baltic Adriatic corridor is shown in Table 3.

**Table 3** Impact of Corridor on BAC, Source: Source: Own research

<table>
<thead>
<tr>
<th>No</th>
<th>Origin of goods</th>
<th>Destination</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Austria, Slovenia, Hungry</td>
<td>Balkans</td>
<td>0.25 million tones</td>
</tr>
<tr>
<td>2</td>
<td>Balkans</td>
<td>Austria, Slovenia, Hungry</td>
<td>0.18 million tones</td>
</tr>
</tbody>
</table>

Strasbourg - Danube core corridor

The impact of Strasbourg - Danube core corridor on Baltic Adriatic corridor is shown in Table 4.

**Table 4** Impact of Corridor on BAC, Source: Source: Own research

<table>
<thead>
<tr>
<th>No</th>
<th>Origin of goods</th>
<th>Destination</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Austria, Slovenia, Slovakia, Hungry, Czech Republic</td>
<td>Germany</td>
<td>1.1 million tones</td>
</tr>
<tr>
<td>2</td>
<td>Germany</td>
<td>Austria, Slovenia, Slovakia, Hungry, Czech Republic</td>
<td>0.6 million tones</td>
</tr>
</tbody>
</table>

Factors - Specific Environment

As a result of the increasing growth of the procurement, markets in the Far East and Middle East changes in the worldwide flow of goods were ascertained. The higher demand for goods from Asia led to a significant rise in the number and volume of trade flows to Europe. This structural change naturally affects the need for reshaping of the European economic area and its infrastructure. Whereas the northern ports are confronted with capacity bottlenecks through the return to their original transhipment volume, the southern ports are presented with an opportunity to strengthen their market position. For the Adriatic ports individual improvement measures - such as, increased attractiveness of hinterland connections to sales and procurement markets - represent a prerequisite that is decisive in terms of competitiveness. By routing Asian sea freight traffic through the southern ports, not only travel times can be reduced (by up to six days) but a substantial reduction in pollutant emissions can also be achieved. As capacity peaks have not yet been reached at the Adriatic ports, a high degree of flexibility in the provision of services can be ensured.
On the other hand, the increasing changes in the market situation and the resulting increased complexity of logistics systems have a considerable influence on the competitive situation of rail freight transport. The current deficit in competitiveness on the part of rail freight transport is caused on the one hand by the change from basic production to finished products production and on the other by increasing demands made on transport services by customers (such as, for example, just-in-time deliveries). In concrete terms, this means that currently customers’ needs and expectations with regard to rail transport are not sufficiently considered. The following deficits can be listed: In comparison to the road, the mean speed of rail transport is very low. The rail infrastructure limits the possibilities of providing service. The quality of service at terminals and shunting yards, for example, is inadequate. Overloading of the infrastructure leads to considerable delays of the entire transport process. The information systems employed in rail freight transport do not allow information transparency with regard to individual transport processes.

The possibility of improving efficiency by concentration, optimizing routes in joint journeys, and by increasing utilization levels in the pre- and post-carriage stages are fully exploited by the transport business, but the focus is on the individual economic interests of the transport business. In particular in areas where demand is split up in terms of space and time this means the de facto exclusion of potential customers for intermodal services. They will continue to meet their transport needs by means of trucks as long as it will allow them to completely cover the costs. The prices charged by many terminals at present (which are charged at least twice, for loading and unloading, without taking into account lifting during handling) are a further cost driver in the intermodal chain of routes “without recognizable customer benefits”. In the case of the large terminals, these prices do not fully cover costs. Investment in tracks (loading tracks, departure tracks, crane) cannot be amortized, or only in part. As a rule internal cross-subsidy from lucrative areas of the business (for example by realizing warehouse and real estate assets) are noted.

SWOT / TOWS dimensions and SWOT / TOWS Analysis - intermodality in BAC

SWOT / TOWS dimensions are part of the SWOT / TOWS analysis tool used for evaluating an organization and is used for analysing internal and external aspectss in order to attain a methodical approach and support for decision making. If it is used correctly, it can provide a good basis for successful strategy formulation.[4] It is an assessment technique structured to evaluate internal processes to identify strengths and weakness for improvement.[5] This particular section provides the insight into the results which were attained while performing analysis. The section includes, SWOT / TOWS dimensions, SWOT Analysis, TOWS Analysis, Strategy Matrix and profile of various strategies which can be undertaken.

SWOT / TOWS dimensions

SWOT / TOWS dimensions identifies Strengths and Weakness and examines the Opportunities and Threats for the identity under consideration. The dimensions suggests that the entity that use their internal strengths in exploiting environmental opportunities and neutralizing environmental threats, while avoiding internal weakness, are more likely to gain competitive advantages.[6]

Table 5 Opportunities, Source: Own research

<table>
<thead>
<tr>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional cooperation programs</td>
</tr>
<tr>
<td>Adaptation of best practices to develop multi modal nodes</td>
</tr>
<tr>
<td>Ambitious plans to improve transportation conditions</td>
</tr>
<tr>
<td>Incentives for environmental awareness</td>
</tr>
<tr>
<td>New Technologies for intermodal transfer</td>
</tr>
</tbody>
</table>

Total: 100%
Table 6 highlights the various strengths related to BAC.

**Table 6** Strengths, Source: Own research

<table>
<thead>
<tr>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong industrial potential of the region</td>
</tr>
<tr>
<td>Free movement of persons and goods in Schengen Zone</td>
</tr>
<tr>
<td>Strong export based economies</td>
</tr>
<tr>
<td>Good transportation conditions in old EU, new members catching up fast</td>
</tr>
<tr>
<td>High usage of modern technologies in logistics management</td>
</tr>
</tbody>
</table>

Total: 100%

Table 7 highlights the various Threats related to BAC.

**Table 7** Threats, Source: Own research

<table>
<thead>
<tr>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversification of the economic growth</td>
</tr>
<tr>
<td>Decrease in global trade share</td>
</tr>
<tr>
<td>Capacity constraints</td>
</tr>
<tr>
<td>Inefficiency leading to increasing lack of interesting intermodal solutions</td>
</tr>
<tr>
<td>Incompatible ICT and terminal standards</td>
</tr>
</tbody>
</table>

Total: 100%

Table 8 highlights the various Weaknesses related to BAC.

**Table 8** Weaknesses, Source: Own research

<table>
<thead>
<tr>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large diversity of countries</td>
</tr>
<tr>
<td>Lower quality of network in NE part of BAC</td>
</tr>
<tr>
<td>High emission impacts</td>
</tr>
<tr>
<td>Administrative barriers</td>
</tr>
<tr>
<td>Safety and security in transportation in some countries</td>
</tr>
</tbody>
</table>

Total: 100%

**SWOT weighted analysis**

This sub-section highlights the results of the SWOT weighted analysis. SWOT analysis pursues an integrated approach including key and environmental variables. [7] The results obtained after conducting the interactive operations are highlighted in **Table 9**.
Table 9 SWOT weighted analysis, Source: Own research

<table>
<thead>
<tr>
<th></th>
<th>Interactions number</th>
<th>Weighted number of interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths / Threats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can threats weaken strengths?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>7.05</td>
</tr>
<tr>
<td><strong>Strengths / Opportunities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can opportunities reinforce strengths?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>46</td>
<td>9.45</td>
</tr>
<tr>
<td><strong>Weaknesses / Threats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can threats multiple weaknesses?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>5.15</td>
</tr>
<tr>
<td><strong>Weaknesses / Opportunities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can opportunities combat weaknesses?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>8.35</td>
</tr>
</tbody>
</table>

TOWS weighted analysis

This sub-section highlights the results of the TOWS weighted analysis. TOWS matrix helps to systematically identify relationships between threats, opportunities, weaknesses and strengths, and offers a structure for generating strategies on the basis of these relationships.[8] The results obtained after conducting the interactive operations are highlighted in Table 10.

Table 10 TOWS weighted analysis, Source: Own research

<table>
<thead>
<tr>
<th></th>
<th>Interactions number</th>
<th>Weighted number of interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths / Threats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can threats weaken strengths?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>7.05</td>
</tr>
<tr>
<td><strong>Strengths / Opportunities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can opportunities reinforce strengths?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>46</td>
<td>9.45</td>
</tr>
<tr>
<td><strong>Weaknesses / Threats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can threats multiple weaknesses?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>5.15</td>
</tr>
<tr>
<td><strong>Weaknesses / Opportunities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can opportunities combat weaknesses?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>8.35</td>
</tr>
</tbody>
</table>
Set of outcomes - Strategy matrix

The strategy matrix which highlights the combined outcome of SWOT and TOWS weighted analysis. It plays an important part in determining the profile of various strategies which can be taken into account to have an efficient outcome. The strategy outcome is shown in Table 11.

Table 11 Strategy Matrix, Source: Own research

<table>
<thead>
<tr>
<th></th>
<th>OPPORTUNITIES (O)</th>
<th>THREATS (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRENGTHS (S)</strong></td>
<td>TOWS</td>
<td>TOWS</td>
</tr>
<tr>
<td>Interactions number</td>
<td>46.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Weighted number of interactions</td>
<td>9.45</td>
<td>7.05</td>
</tr>
<tr>
<td><strong>TOWS / SWOT</strong></td>
<td>TOWS / SWOT</td>
<td></td>
</tr>
<tr>
<td>Interactions number</td>
<td>80.0</td>
<td>62.0</td>
</tr>
<tr>
<td>Weighted interactions</td>
<td>16.25</td>
<td>12.7</td>
</tr>
<tr>
<td><strong>SWOT</strong></td>
<td>SWOT</td>
<td></td>
</tr>
<tr>
<td>Interactions number</td>
<td>34.0</td>
<td>28.0</td>
</tr>
<tr>
<td>Weighted number of interactions</td>
<td>6.80</td>
<td>5.65</td>
</tr>
<tr>
<td><strong>WEAKNESSES (W)</strong></td>
<td>TOWS</td>
<td>TOWS</td>
</tr>
<tr>
<td>Interactions number</td>
<td>40.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Weighted number of interactions</td>
<td>8.35</td>
<td>5.15</td>
</tr>
<tr>
<td><strong>TOWS / SWOT</strong></td>
<td>TOWS / SWOT</td>
<td></td>
</tr>
<tr>
<td>Interactions number</td>
<td>76.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Weighted interactions</td>
<td>16.0</td>
<td>11.15</td>
</tr>
<tr>
<td><strong>SWOT</strong></td>
<td>SWOT</td>
<td></td>
</tr>
<tr>
<td>Interactions number</td>
<td>36.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Weighted number of interactions</td>
<td>7.65</td>
<td>6.00</td>
</tr>
</tbody>
</table>

Profile of available strategies (TOWS / SWOT)

TOWS as the next step of SWOT in developing alternative strategies. TOWS matrix provides means to develop strategies based on logical combinations of aspects relate to internal strengths (or weaknesses) with aspects related to external opportunities (or threats). TOWS matrix identifies four conceptually distinct strategic groups: Strength- Opportunity (SO), Strength-Threats (ST), Weaknesses-Opportunities (WO), and Weaknesses-Threats (WT), for creating the alternative strategies. Table 5 highlights the various opportunities related to BAC.[9] As mentioned earlier, the output of strategic matrix is the profile of available strategies. Hence, it is completely based on the number of interaction and weighted interactions obtained during the analysis. The profile of available strategies is shown in Table 12.
Table 12 Profile of available strategies, Source: Own research

<table>
<thead>
<tr>
<th>Organization / Environment</th>
<th>OPPORTUNITIES (O)</th>
<th>THREATS (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Strategy (SO):</td>
<td>As clear from the analysis SO has got highest number of interactions and Weighted interactions, so main focal strategy revolves around SO. Base strategy highlights the following: 1. Strong industrial potential will increase the overall goods flow in the region and while maximizing the regional cooperation and improve the intermodal transportation 2. New EU members development as strength can directly make an impact in markets by adaptation of the best practices to develop multi modal Empiric Nodes.</td>
<td>Defense Strategy (ST): Threats can be mitigated by focusing on following strengths: 1. Strong industrial potential will mitigate threats viz. decrease in global trade and inefficiency 2. Free movement of goods overcomes threats viz. Diversification, Capacity constraints and incompatible ICT and terminal standards 3. Good transportation condition will eradicate the inefficiency</td>
</tr>
<tr>
<td>Expansion Strategy (WO):</td>
<td>Expansion Strategy goes in close view with the Base strategy and has got number of interactions closer to base strategy too. The Opportunities which will encounter weakness are as follows: 1. Regional cooperation programs will overcome weakness caused due to diversity in regions, lower quality network, administrative barriers, safety and security 2. Adaptation and Ambitious plans to improve and develop transportation will have a direct effect on the weakness created by the lower quality network in north eastern part of the BAC</td>
<td>Survival Strategy (WT): The major weakness viz. large diversity and lower transport quality will be exploited by the threat viz. inefficiency and incompatibility.</td>
</tr>
</tbody>
</table>

3. CONCLUSIONS AND RECOMMENDATIONS FOR STAKEHOLDERS
This section is structured according to the analytical themes of logistical structures, pattern of trading relations, scheduling of product and transport flow, and management of transport resources. It highlights the conclusions totally based on the article and will be followed by the recommendation for stakeholders. The conclusions are enlisted below:

- The European transport scene is characterized by a very dense network of road, rail and inland waterway links in the centre of the Union, gradually being less dense as the periphery is approached and population densities become less. Area of important development in terms of infrastructure is the Pentagon that is the area characterized by high GDP, population density and multimodal accessibility.
- The bigger part on B.A.C. good flows is referred to Italy and Austria. In Austria and Hungary, we have a general decrease in good flows. Import quantities are bigger than export.
Considering Eurostat, data it is possible to note that road transport is really the most important modality, gaining the level of about 87% in EU27 and 84% in B.A.C. Comparing these values with the one detected in the partnership studies is possible to note that the role of road transport is reduced.

Comparing this data with the TENCONNECT scenario it is possible to suppose that the increase of flows divided by modality will not depend only on general flows increase, but also on the development of multimodality in European countries.

One of the important aspects, which can be taken into consideration to elaborate the future transport modality, is Catchment Area development by new modes of transportation involving new additional transport infrastructure evolved in the network.

All core corridors have a massive impact on BAC network.

In accordance with the SWOT Analysis of the network, the logistics centres should follow the Base Strategy (SO) and Expansion Strategy (WO). There are certain special needs in the network and their development is of utmost importance.

Acceleration of the technology shift has been seen in the transport modes.

The recommendations for stakeholders is provided below. There are three key stakeholders considered in this particular case. They are as follows:

- Shippers including Manufacturers, wholesalers and retailers
- Freight carriers including transporters, warehouses and companies
- Administrators including administrators at national, state and city level

Each of the above-specified stakeholders has its own specific objectives, tends to behave in a different manner, and needs to be considered. The origination of the journey is from shippers and to the consumers. Freight carriers and administrators are the media of the delivery tasks. The characteristic of their relationships is that a slight move in one part may affect the whole situation. One of the important recommendations for the stakeholders is to focus on mobility and sustainability. Mobility is ease of movement, which is the basic requirement for transport of commodities. Goods are supposed to be delivered Just-In-Time. Therefore, the balance between sufficient network capacity and reduced traffic congestion is a main issue. Concerning sustainability, which is more and more important, environmental issues and energy conservation would need to be taken into account. Some of the directed recommendations are as follows:

Shippers and freight carriers:

- Develop regional hubs multi-modal transport nodes and sufficient port and intermodal terminal capacity together with sufficient hinterland network.
- Promote safety standards and measures on roads and railway.
- Accelerate technology shift towards cleaner vehicles including electric vehicles in connection with the replacement of imported carbon fuels by renewable fuels.
- Good relationships with local authorities as well as the representatives of local businesses.
- Investments in ICT systems.
- Harmonization of loading units and packaging sizes.

Administrators:

- Develop and promote the BAC intermodal network, especially when it goes beyond the TEN-T to obtain funding from the EU Commission, showing the special needs of the region and to also develop further funding in order to secure the fast development of the network.
REFERENCES


SESSION B:
RISK MANAGEMENT
PRODUCTION PROCESS RELIABILITY MODELLING BASED ON THE MARKOV PROCESS IMPLEMENTATION

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Abstract

The paper discusses a problem of reliable performance of production processes. Reliability analyses of production systems regard considering many different factors and requirements. Thus, based on the developed multidimensional definition of production process reliability the seven-state Markov model of production process performance is presented. Short sensitivity analysis of the developed model is also given. The work ends up with summary and directions for further research.

Keywords: Production process, reliability modelling, Markov process

1. INTRODUCTION

The manufacturing sector faces many challenges in the era of globalization at today’s highly competitive market. Complexity in taking decisions due to e.g. shorter life cycles of products, shorter delivery times, high product quality expectations, as well as immense availability of information, randomness in the system performance, or heterogeneity in occurred events all make that manufacturing system / process reliability modelling is a difficult task [1, 2].

The main target of the production system is to operate appropriately with the maximal production rate or capacity and acceptable quality of the products [3]. Following this, the main problems investigated in the area of production system / process reliability regard to maintenance optimization and inventory modelling issues. In this area the literature survey is quite vast and presented e.g. in [3]. There are also several studies related to reliability, availability and maintainability (RAM) of manufacturing systems (see e.g. [4, 5] for comprehensive literature review). Furthermore, another important problem in many industrial applications is the redundancy optimization aimed at system structure configuration designing taking into account cost or / and reliability criteria (see e.g. [6]). This issue may be also connected with reliability importance analysis implementation (see e.g. [7]). Moreover, the last problem in the analysed research area is the performance evaluation of production systems. The performance measurement of manufacturing systems is mostly focused on five types of performance objectives based on cost, flexibility, speed, dependability and quality [2]. The detailed literature review in this area may be found e.g. in [2, 8, 9].

Many different approaches and aspects of production process reliability which are under investigation in the analysed literature make this research area still demanding further and extensive investigation. Following this, based on the developed multidimensional production process reliability definition (see [9]), authors focus on the development of seven-stated Markov model for production process reliability assessment. The presented article gives the first attempt for development and investigation of production process reliability assessment method that helps decision managers in their every-day work.
2. PRODUCTION PROCESS RELIABILITY

Based on the literature review given in [9], authors propose the production process reliability definition as an ability of a production system to completely fulfill the production plan of fully valuable final products in a specified period of time under stated conditions. The given process conditions regard to the five main areas [9]:

- machines and equipment performance and their failures occurrence possibility,
- maintenance and logistic support infrastructure performance and their failures occurrence possibility,
- information flows and information reliability,
- possibility of the occurrence of unwanted random hazards / threats (internal and external type),
- processes of decisions making by policy makers and human factor reliability.

This definition is also compatible to maintenance theory, where the prime objectives are to ensure the system function, ensure system life, ensure safety, and ensure human well-being (see [10] for more information).

The complex reliability analysis should cover the investigation all of the mentioned areas providing a valuable contribution to processes performance improvement. To satisfy these requirements, the multi-state reliability theory should be implemented, where the process may assume many states ranging from perfect functioning to complete failure. Following [6] the stochastic process approach, based on Markov processes, may be used.

Let’s consider a manufacturing system under continuous monitoring. It’s production process may be in one of seven defined reliability states, depending on the production plan and process conditions performance (two states marked at grey are not possible to occur in the real-life systems and are excluded from the reliability analysis) (Table 1). In the Table 1 the production process state is given as a pair: the first give the possibility of production plan performance, while the second one the process condition state.

<table>
<thead>
<tr>
<th>State no.</th>
<th>Plan performance</th>
<th>Process condition performance</th>
<th>Production process state</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Perfect</td>
<td>Perfect</td>
<td>UP state</td>
</tr>
<tr>
<td>1</td>
<td>Perfect</td>
<td>Partially imperfect</td>
<td>UP state</td>
</tr>
<tr>
<td>2</td>
<td>Perfect</td>
<td>Imperfect</td>
<td>DOWN state</td>
</tr>
<tr>
<td>3</td>
<td>Partially imperfect</td>
<td>Perfect</td>
<td>DOWN state</td>
</tr>
<tr>
<td>4</td>
<td>Partially imperfect</td>
<td>Partially imperfect</td>
<td>DOWN state</td>
</tr>
<tr>
<td>5</td>
<td>Partially imperfect</td>
<td>Imperfect</td>
<td>DOWN state</td>
</tr>
<tr>
<td>6</td>
<td>Imperfect</td>
<td>Perfect</td>
<td>DOWN state</td>
</tr>
<tr>
<td>7</td>
<td>Imperfect</td>
<td>Partially imperfect</td>
<td>DOWN state</td>
</tr>
<tr>
<td>8</td>
<td>Imperfect</td>
<td>Imperfect</td>
<td>DOWN state</td>
</tr>
</tbody>
</table>

The perfect performance of the production plan means that there are manufactured fully valuable products in right quantity and without any delays. Partially imperfect plan performance may regard to some time delays or problems with right quality and quantity. Imperfect performance of production plan means that based on the available resources there is no possibility to fulfill the defined plan in the defined period of time. The production process conditions performance perfectly if there is no occurred problems in machines, human factor, and support asset performance, the information is perfect (available and reliable), and there is no additional unwanted hazard events identified. Partially perfect performance of production process conditions regards usually at least to have reliable production machines and available human and information resources to fulfill the production plan. These three resources are usually critical for any manufacturing system flexible and reliable performance.
Let’s also assume that production process experiences random failures in time and each failure entails a random duration of repair before the manufacturing system is put back into service. System after repair is as-good-as-new. Let’s also assume that any information about failures in the system is reliable and comes immediately.

3. SEVEN-STATE MARKOV MODEL

For the analysis of the production process performance, we can associate its performance to a Markov seven-state model, on the basis of the defined set of states (Figure 1).

![Markov seven-state model](image)

The graph describes behaviour of the production process with two successful (0, 1) and five mutually exclusive failure states (3, 4, 5, 7, 8) as shown in Figure 1 and Table 1. The modelled process is repaired from the states: 3, 4. Moreover, to make the model more understandable there is presented its detailed interpretation.

Let’s make an assumption that the production process at the beginning is operable. This means, that it is in UP state and can perform production plan perfectly in any time when called. This also means, that there are all necessary production process conditions satisfied. In the next moment, one of the necessary resources may fail (e.g. the supply delivery will be delayed but there are available spare raw materials), but there still may be possibility to perfectly fulfil the production process (transition from the state 0 to the state 1). The state 1 is defined as the UP state of the production process, taking into account the its presented reliability definition.

In the next moment, process may pass from the state 1 to the state 0 - when the necessary process conditions recovery is finished. On the other hand, process, being in the state 0, may pass to the state 3, which means that the production plan is performed partially imperfect despite satisfying all the process conditions. This state is the DOWN state of the production process.
In the next time moment, production process may pass from the states 1 or 3 to the state 4 - when both, production plan and production conditions are partially imperfect. The state 4 is the DOWN state of production process. Later, when the process conditions are imperfect (e.g. lack of human resources or machines and support infrastructure failure), process may pass from the state 4 to the state 5. The transition from the state 4 to the state 7 means that the partially operable process conditions are not enough to perform production plan, so there is no possibility to produce the right quantity of fully valuable products in the defined period of time.

In the situation, when process conditions and production plan are imperfect, at first the necessary process resources has to be restored. This is connected with the necessity of necessary maintenance assets supply to failed production system. This situation is reflected by the transition from the state 8 to the state 7, and the lack of transition from the state 8 to the state 5.

Following [11] we can formulate the probability expression for the model. Thus:

\[
\begin{align*}
P'_6(t) &= -(\lambda_{10} + \lambda_{30})P_6(t) + \mu_{10}P_1(t) + \mu_{30}P_3(t) \\
P'_7(t) &= \lambda_{14}P_7(t) - (\mu_{43} + \mu_{41} + \lambda_{45} + \lambda_{47})P_4(t) + \mu_{54}P_5(t) + \mu_{74}P_7(t) \\
P'_8(t) &= \lambda_{34}P_3(t) + (\mu_{30} + \lambda_{34})P_3(t) + \mu_{43}P_4(t) \\
P'_7(t) &= \lambda_{45}P_4(t) - (\mu_{43} + \mu_{41} + \lambda_{45} + \lambda_{47})P_4(t) + \mu_{54}P_5(t) + \mu_{74}P_7(t) \\
P'_8(t) &= \lambda_{54}P_5(t) + \lambda_{58}P_8(t) - (\mu_{54} + \lambda_{58})P_5(t) \\
P'_8(t) &= \lambda_{47}P_4(t) - (\mu_{74} + \lambda_{78})P_7(t) + \mu_{87}P_8(t) \\
P'_8(t) &= \lambda_{58}P_5(t) + \lambda_{78}P_7(t) - \mu_{87}P_8(t)
\end{align*}
\]

Where the following notations are used:
- \(\lambda_{ij}\) - failure rate associated with states \(i\) and \(j\)
- \(\mu_{ji}\) - repair rate associated with states \(j\) and \(i\)
- \(P_i(t)\) - probability of being in state \(i\) at time \(t\)
- \(P'_i(t)\) - first derivative of \(P_i(t)\) with respect to \(t\)

Taking into account steady-state solutions, there is possible to estimate the steady-state availability ratio \(K\):

\[
K = \lim_{t \to \infty} K(t) = \lim_{t \to \infty} [P_6(t) + P_7(t) + P_8(t)]
\]

4. SENSITIVITY ANALYSIS

Sensitivity analysis of the developed model was made using Markov Graph module of GRIF 2011 Software [12]. For the purposes of preliminary analysis performance, it was assumed that:
- Mean Time Between Failures for all states is the same and MTBF = 1 [time unit],
- Mean Time To Repair for all the states is the same and it changes: MTTF = 1; 10; 100 [time unit].

Thus, the parameter \(\rho = \mu / \lambda\) obtains the following values: \(\rho = 1, \rho = 0.1, \rho = 0.01\).

The performed analysis mainly focuses on the calculation of availability function \(K(t)\) of the system (Figure 2) and probability of being in the state 4 - \(P_4(t)\) (Figure 3) - please note the different scales of time and values for each version a, b, c. The presented analysis results are obtained when all \(\lambda_{ij}\) parameters and all \(\mu_{ji}\) parameters are the same.
The influence of mean production process down time on the availability ratio is characterized by the level of repair rates $\mu_j$. The longer the process plan and conditions are inoperable, the greater is the probability, that the production system will not be ready to perform its main functions, in its specified environment, when called for at a random point in time. As a result, the availability ratio decreases from the value of 1 to $K = 0.25$ for $\rho = 1$, by $K = 0.91$ for $\rho = 0.1$, to $K = 0.99$ for $\rho = 0.01$.

The second interesting issue is the possibility of being in the state 4 (partially imperfect plan and conditions performance). Here we also may see the same dependence - the Steady-state probability of being in the state 4 decreasing from $P_4 = 0.125$ for $\rho = 1$, by $P_4 = 0.043$ for $\rho = 0.1$, to $P_4 = 0.0047$ for $\rho = 0.01$.

Also time to reach steady state depends on $\rho$ and is from $T^\infty = 12$ for $\rho = 1$, by $T^\infty = 0.8$ for $\rho = 0.1$, to $T^\infty = 0.05$ for $\rho = 0.01$. The following examples show only the possibilities of the model sensitivity analysis.

5. **SUMMARY AND CONCLUSIONS**

The paper presents the preliminary step in the definition of production process model. It focuses on the developed by the authors in work [9] multidimensional definition of production process reliability. The main
reason of such paper’s target identification is connected with the lack of distinct definitions of production process reliability that adhere to the real-life complex manufacturing systems performance requirements.

The presented article shows the first attempt for development and investigation of production process reliability assessment method that helps decision managers in their every-day work. Taking into account the subjectivity of expert opinions, lack of information, and the variety of approaches to reliability assessment problems, authors conclude that this research area still demands further investigation and development of new complex framework for production system reliability measurement.

REFERENCES


SUSTAINABLE PURCHASING SYSTEMS BASED ON DEMAND FORECASTING - SUPPLY CHAIN SUSTAINABLE GROWTH A CHALLENGE NOWADAYS

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Abstract

In consequence of growing international business volume and supply chain management importance, the purchasing as one company’s functional part has gained strategic role to be successful in the current business markets. (Paulraj, Chen, & Flynn, 2006) Contemporary supply chains of particular industrial branches are getting, in consequence of business markets globalization, still more complex and material flows streaming in them are getting still more bulky. The bulky material flows in inner or in outer supply chains should be effectively planned, managed and controlled in context of long-term sustainable socio-economic development and living environment protection. Well, enterprise management systems - one of them is also purchasing management system; should be designed in the way to be possible to reach required level of stability and simultaneously to reach required level of flexibility.

Keywords: Sustainability, purchasing logistics, supply chain, methodology, methodics

1. INTRODUCTION

Supply chain management or the approaches to manage material flows is getting the most important part of company’s management. (Ashenbaum & Terpend, 2010) Progressive enterprise management system or its innovation is necessary regarding contemporary supply chains, their parts, thus for effective material flows management. (Rebovich & White, 2010) First-rate planning, management and control of input material flows is fully necessary to assure consequential entire company run in the sense of forward and also backward material flow. In a company are primarily two functional parts which are responsible for material flow into the company. (Ashenbaum & Terpend, 2010) The management systems of a purchasing should be based on the prognostic sub-system of independent demand or a consumption with the aim of the superior managerial decisions making at the given functional company level, so that they reflect as good as possible the business market demands. Thus, to make high-quality managerial decisions it’s necessary to have well developed prognostic system. (Kačmáry & Malindžák, 2010) In the article it’s presented created methodics to design the logistics management system of a purchasing and the methodology to design prognostic sub-system. The methodics and the methodology are universally applicable in any industrial company or tertiary sphere organization. Further they are interpreted essential notions such as: demand forecasting, supply chain definition and the definition of purchasing logistics management systems.

2. DEMAND FORECASTING

A creation of forecasting models and scenarios of the future business development are the crucial business task. Still few companies have got effective demand forecasting system designed in their structures. (Gilliland, 2017) The independent demand forecast creation is for the company very important and that in terms to make superior managerial decisions at all functional levels of the company, thus at purchasing department too. In the first phase of the independent demand or a consumption forecast making process, it’s done basic statistical analysis of the demand or a consumption character - average, standard deviation, maximal and minimal value determination of the analysed time series. The statistics methods of time-series analysis are very useful in the
first phases of demand pattern character analysis. (Kačmáry et al., 2014) Further it’s made the analysis of the
time series seasonality and essential study of time run of independent demand pattern, see Figure 1.

![Essential Demand Patterns](image)

**Figure 1** Essential types of demand patterns (Hart et al., 2016)

From the analysed time series time flow point of view it’s possible to classify the analysed independent demand
or consumption as it follows:

- regular (basic pastry, milk, meat),
- seasonal (ice cream, vitamins, pharmaceuticals in flu season),
- irregular (spare parts),
- leap (a crisis situation - health requirements, an epidemic - pharmaceuticals).

As soon as it’s done the essential statistical analysis of the time series of the demand or a consumption and
also the analysis of the demand or a consumption pattern in the given time horizon, so it’s starting the process
to choose suitable forecasting model.

3. **SUPPLY CHAIN DEFINITION**

The supply chain can be described as a network integrated by flows among manufacturing companies,
warehouses, distribution sheds, retail and wholesale units and customers. The integrated flows are material,
information and financial flows and freight transportation - e.g. road, railway, air, belt, etc. The material flow
management or supply chain management should be run in any company within company management. The
design of sustainable supply chain networks or innovation the supply chains in such way are topical issues
nowadays. (Grant et al., 2013)

Further it’s possible to talk on inner or outer supply chain. First-rate design of supply chain structure is
determining to reach required level of efficiency and effectiveness in context with long-term sustainable socio-
economic development and living environment protection. The general example of the supply chain is stated
in the Figure 2.
The scientific field or profession „supply chain management” includes the issues regarding the manufactures to effectively buy, transform and distribute items and also it includes the issues of wholesalers and retailers to effectively manage good flows in their networks. All those issues must be properly solved in the context of particular firm’s functional silos. (Wisner & Tan, 2000) The business performance can be enhanced thru innovation of supply chain - e.g. its integration or new integration design; which should be included in the company’s strategy in highly competitive business environments. (Narasimhan & Das, 2001)

4. PURCHASING AND PURCHASING LOGISTICS MANAGEMENT SYSTEMS

In contemporary competitive environment, there are rising strategic importance of all functional silos including purchasing. Purchasing plays important role regarding input's material flows. (Ashenbaum & Maltz, 2017) The procurement of the company or tertiary sphere organisation represents 1st functional level within the frame of forward material flow. The fundamental aim of the purchasing department is the provision of the required amount of the raw materials, the parts or the services to guarantee a run of the subsequent functional levels, especially a run of manufacturing department and consequential final products distribution into business destinations. There should be running collaboration and some kind of interaction between purchasing and logistics employees in a company. Such kind of integration must be also enhanced in a company by executives. (Ashenbaum & Maltz, 2017) Proper information, e.g. demand level development should be gained by demand forecasting system for effective business management - functional silos management, which should be also integrated. (Rockley & Cooper, 2012) The purchasing department of the company is the one of the essential element of the company’s inner supply chain and it should be therefore for it to be designed progressive logistics management system.

The logistics management system of a purchasing is composed by the following sub-systems:

a. data, b. forecasting, c. planning, d. inventory management, e. suppliers and deliveries, f. setting of the logistics processes, g. personal, h. economic, ch. purchasing administration, i. control.

More detailed description of the single sub-systems of the purchasing logistics management system is stated in the article, see references no. 21.
For the purposes of the purchasing logistics management system design in the practice, it was created universal methodics to design, namely there are the following design steps:

1) The analysis of current state of purchasing management
2) The creation of particular sub-systems
   a) Data sub-system
   b) Forecasting sub-system
   c) Planning sub-system
   d) Inventory management sub-system
   e) Sub-system suppliers and deliveries
   f) Sub-system to set the logistics processes
   g) Personal sub-system
   h) Economic sub-system
   i) Sub-system of purchasing administration
   j) Control sub-system
3) The integration of created sub-systems
4) The putting into operation

More detailed description of the mentioned methodics is stated in the article, see references no. 21. Among important logistics activities or functions can be covered purchasing, warehousing, inventory management, transportation and packaging. Logistics activities should be integrated in a system to reach first-rate management of material flows within and between organizations. (Lewis & Talalayevsky, 1997)

5. CASE STUDY

The case studies are important to develop a deeper understanding of how and why processes emerge and evolve over time inside the analysed systems. (Eriksson, P. E., 2014) Any firm needs a management system to plan, manage and control its activities. The system which ensure required alignment of firm’s operations to its business needs and strategy. It also related to functional part of purchasing. (Forrest & Breyfogle III, 2008)

The engineering industrial company innovates its company’s management system within the context of contemporary requirements of the global market economy. After primary analysis within the frame of the project of company management system innovation, it was firstly decided to create new sub-system of independent demand forecast creation and subsequently to innovate company’s purchasing system. For the purposes of the above mentioned, it was applied created methodology to design prognostic system of the independent demand and the methodics to create purchasing logistics management system.

The methodology to create the prognostic system, it’s possible briefly described thru the 8 points, see:

1) **Company description** or more precise specification of production plants for which a forecasting system of demand or consumption is to be created,
2) **Visualization of supply chain** - inner and outer flows,
3) **Determination of order penetration point** or points within the scope of a company supply chain - identification of a demand with independent or dependent character,
4) **Segmentation of extensive inventory portfolio** (e.g. final product, semi-finished product, raw materials) accumulated in order to penetrate a point or points,
5) **Analysis of existing systems** for independent demand forecasting,
6) **Determination and statistical processing of input data** for a demand forecasting (demand, consumption, sales),
7) **Essential analysis of demand pattern** - trend, seasonality, increase, decrease,
8) **Finding a process of the best-fit models to forecast** independent demand for single inventory segments accumulated in order penetration point or points of a company supply chain. (Hart, 2010)
The more detailed description of the above mentioned methodology is stated in the dissertation thesis, see references no. 17. After the creation of the new prognostic sub-system of the independent demand, it was subsequently innovated the purchasing system with the usage of the methodics to create purchasing logistics management system. Thus, it was gradually innovated or designed particular elements of purchasing management system from the logistics system management point of view. Namely, there were following sub-systems: data sub-system, forecasting sub-system, planning sub-system, sub-system of inventory management, sub-system of suppliers and deliveries, sub-system to set the logistics processes, personal sub-system, economic sub-system, purchasing administration sub-system and control sub-system.

Well, the foundation of the innovated purchasing system is the prognostic sub-system of the independent demand, when entire managerial decisions in all purchasing management sub-systems are realized on the basis of created accurate forecasts of the independent demand future development - the scenarios of the development in the short-term, middle-term and long-term time horizon, see Figure 3.

![Figure 3](image)

**Figure 3** Forecasted data as an input to first-rate purchasing decisions (Hart, 2016)

It’s appropriate to point out, that the logistics and purchasing functions are considered in a different manner. But the purchasing and logistics department should collaborate to meet requirements on fluent material flow management in supply chain. That should be considered thru a design of management systems. (Fabbe-Costes & Nollet, 2015).

6. **CONCLUSION**

An important business outcome for a state economy is enterprise performance which is widely presented in the management literature. (Chinomona, 2013) Contemporary global business environment and shaping single market of the European Union put high demands on the enterprise management systems, which should meet especially requirements such as:

- stability, flexibility, efficiency, effectiveness, resistance against crises situations and security.

Above stated requirements are also regarded to management systems of the procurement in a company or tertiary sphere organisation. The modern purchasing systems should be based on logistics management principles of the material flows and especially then on prognostic sub-system of independent demand or a consumption. In the article, it was briefly presented the methodology of independent demand forecasting system creation and hereafter the methodics of purchasing logistics management system design. The stated methodology and methodics are universally applicable in the practice, when they can contribute to enhance enterprise management systems. Thereby they can also contribute to long-term sustainable socio-economic development of society and living environment protection.

REFERENCES


COMBINED USE OF SIMULATION AND OPTIMIZATION MODELS AS A DECISION SUPPORT TOOL FOR ROBUST INVENTORY ROUTING PROBLEMS

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Abstract

The combination of decisions regarding inventory management and vehicle routing decision leads to complex combinatorial optimization problem called the Inventory Routing Problem (IRP). Several heuristic algorithms for solving IRP were proposed in recent years. A lot of them are based on static and deterministic versions of IRP. Based on our management experience we identified a lot of situations where the VMI approach is used but the dynamic version of the IRP has to be considered. Such situations occur in case of LPG supplies to fuel stations. There are some proposals of heuristic policies which can be used in above mentioned circumstances. In our proposal after each delivery the optimization models are applied in order to optimize routes and delivery dates. In our paper we presented the combined use of optimization models and discrete event simulation to evaluate the influence of different variability of selected models’ parameters on the final plan. Simulation models have proved very useful as an aid to build dynamic and robust plans for considered inventory routing problem. We presented results of extensive simulation analysis of randomly generated cases for comparison our proposals and some policy solutions.

Keywords: VMI, VRP, IRP, DSS

1. INTRODUCTION

The fuel stations supply problem belongs to the major transportation and logistics problems with very strong economic impact. Autogas deliveries to fuel stations is a particular case of this problem. As a repetitive distribution of a homogenous product by a homogenous fleet of tank trucks it can a priori be considered as a very good research area for IRP solutions. Deliveries of petrochemical products to the fuel stations in most European countries are performed by highly specialized hauliers under centralized planning and scheduling conditions. The successful implementation of VMI (Vendor Managed Inventory) strategy can lead to high productivity results, high customer service level and efficient organization. One of the key factors for this approach is the adequate DSS (Decision Support System) for deliveries planning and scheduling. This paper focus on some logistic aspects of this complex and important problem basing on real-life data from the transportation company and develops some specific methods in order to increase the competitiveness of transportation operations.

The research method presented is an attempt to use time-discretized integer programming models to solve a real life IRP. The proposed formulation is based on location based heuristics (LBH) introduced by Bramel and Simchi-Levi [1]. In comparison to the primary formulation in this approach more than one item was considered. Additionally, based on empirical observations the seed sets technique was simplified and the decision model was slightly changed. The considered algorithm was also implemented by Hanczar [2] to solve the fuel distribution problem.
Until recently, optimization and simulation were kept pretty much separate in practice, even though there was a large body of research literature relevant to combining them. In the last two decades, however, optimization routines have prominently worked their way into and with simulation packages (Fu [3]). The combined use of optimizing methods of mathematical models (MIP) with discrete event simulation models can contribute to the formation of more accurate and more robust plans. Developed simulation models will allow to study of the impact of demand variability on distribution results.

2. SCOPE OF RESEARCH

The specificity of the transport services market of petroleum products and autogas in Poland indicates the possibility of the use of decision support models (in particular IRP approach) for delivery planning. The main key factors are (1) product homogeneity (in case of autogas / LPG we’re dealing in fact with only one product, in the case of fuels with a maximum of 6 products); (2) existing infrastructure including telemetry systems that provide information about the inventory level of gas and fuels at service stations several times a day; (3) increasing frequency of application of Haulier Managed Inventory (HMI) approach by fuel suppliers, according to which the transport company is responsible for ensuring the availability of fuel at the station. On the other hand, important variations of daily demand on fuel stations is a significant factor to be considered for application of IRP models. In vast majority of theoretical papers concerning IRP, demand is considered deterministic even within the whole planning horizon.

The authors of the present study decided to implement the following research tasks. It was assessed in the first step how advantages of IRP application for fuel distribution can be affected in real life by fuel stations demand variability. In the first stage it was verified whether the variability of real data of consumption allows the use of IRP at all. In the second stage it was verified for which patterns of demand variability IRP models can be applied and the length of the planning horizon was determined.

Implementation of the second stage was related to proposal of a method of solving the present problem of fuel supplies that would be robust against high demand variability. Although the literature on the subject begin to provide some proposals concerning these issues, they are based in most cases on the use of simple supply rules heuristics or forecasts application. Unfortunately, none of these approaches apply for the case of Polish LPG deliveries market where consumption variability arrive to 40% or even more. The proposal provided by the authors of this paper, which in such conditions can significantly improve the performance of algorithms used, consists in launching the route optimization executed after each delivery. Combined use of the optimization approach (for IRP solutions) and simulation approach (to verify the effects of planning in stochastic conditions) allowed to point out the advantages of such an approach.

3. LITERATURE REVIEW

The paper by Beltrami and Bodin [4] may be deemed a pioneering work regarding IRP problems. This work focused on modeling and simple solution techniques. In the following papers by Fisher et al. [5] and Bell et al. [6] mixed integer programming was used first to obtain a solution for the IRP instance. Subsequently, the first approach to solve a large IRP instance was made by Golden et. al. [7] and by Dror [8], they investigated the large distribution system of liquid propane to residential and industrial customers. Burns et al. [9] try an analytic approach to solving IRP. They considered the optimal trade-off between inventory and transportation costs. The two distribution strategies are taken into account: direct shipping (i.e. shipping separate loads to each customer) and peddling (i.e., dispatching trucks that deliver items to more than one customer per load). The presented results indicate that the cost trade-off in each strategy depends on shipment size. For direct shipping, the optimal shipment size is given by the economic order quantity (EOQ) model, while for peddling; the optimal shipment size is a full truck. In the latter case, trade-off also depends on the number of customers included on a peddling route.
Parallel to the deterministic IRP, the large area of research where the stochastic version of the IRP is considered. This field started with papers by Dror and Trudeau [10] and Dror Laporte and Trudeau [11], where authors consider the VRP with stochastic demand. However, due to the fact that in this paper stochastic formulation is not considered, a more detailed review of the paper has been omitted. A complete review of methods and algorithms for solving stochastic IRP problems may be found in Schwarz et al. [12] or Cordeau et al. [13]. Concerning simulation and optimization combined approach, one of the recent reviews that can be considered is Figueira and Almada-Lobo [14].

4. METHODOLOGY OF COMBINING SIMULATION AND OPTIMIZATION MODELS FOR THE ROUTES AND DELIVERY DATES

In our approach, we consider combined use of simulation and optimization models for robust solving of inventory routing problem of LPG deliveries to petrol stations within one region in Poland (one depot, multiple vehicles, several dozen customers). Starting from the optimisation model in order to determine an optimal or suboptimal MIIRP solution of the problem, our approach proceeds with application of discrete event simulation tool (DES), which is able to provide information about whole system behavior and its reactions to LPG demand variations at petrol stations (see Figure 1). The solution generated by optimization model is used as input for simulation model to verify the feasibility and robustness of the computed solution through the generation of different scenarios which consider different levels of demand variability typical to real life systems.

The results of the simulation experiments, allowing an evaluation of the system performance, can support the detection of the current solution weaknesses and limitations of the initial problem MIIRP solution. The feedback loop is then realised going back to the optimisation phase with the new information generated by the simulation model. This information is used to improve the initial optimal or suboptimal solution. This approach allows to evaluate the relevant system performance in case of different levels of demand variations and indicate weather re-planning during the day is necessary and possible.

In order to describe the demand variability at the stations we apply coefficient of variation (CV) which is defined as the ratio of the standard deviation $\sigma$ to the mean $\mu$:

$$CV = \frac{\sigma}{\mu}$$

(1)

It shows the extent of variability in relation to the mean of the population. In our model each node shall represent each petrol station with specific coefficient of variation $CV_i (i = 1, ..., n)$. Final demands at the petrol stations are assumed to be random variables (stochastic in nature) and no assumption is made about the inventory policy at an individual station. The inventory position of each station shall be analyzed and joint
inventory and routing decisions shall be made to avoid any stock-outs and minimize the total expected cost of transportation in each scenario (which is considered as linear function of total travelling distances). The inventory cost of LPG at stations shall be neglected as the cost of LPG is rather low (comparing e.g. to other liquid fuels) and usually stations’ vessels capacities are relatively low.

5. NUMERICAL EXPERIMENTS

For the computational experiments real data has been taken into consideration. In our approach we first performed VRP computations applying optimization model for the 1st day, than we performed stochastic demand simulation for the 1st day, then we performed VRP computations for the 2nd day again and stochastic demand simulation for the 2nd day and again the same sequence for the 3rd day (see Figure 2).

In the second step we performed IRP computations applying optimization model for the first 3 days, than we performed stochastic demand simulation for the 1st day, then we performed IRP computations for the days 2-3-4 and stochastic demand simulation for the 2nd day and again we performed IRP computations for the days 3-4-5 and stochastic demand simulation for the 3rd day (see Figure 3).

Our computations were performed on real-life data of LPG distribution within one region in Poland for a given gas supplier. The region consists of one depot and 36 gas stations 24/7 open. Traditionally the customer uses from 2 to 3 truck to organize deliveries to the stations during 7 days per week and considers cost efficiency (number of kilometers per 1000 L delivered) as key point.

All computations were performed according to the following data:
- number of customers n: 36;
number of depots: 1;
planning horizon: 3 periods;
demand distributions: mean demand is generated as an integer random number following a discrete triangular distribution with lower limit 10% and upper limit 85%;
product availability at the depot: always;
maximum inventory level: 85% due to LPG distribution specific limitations;
starting inventory level: randomly generated;
vehicle capacity: 36000 l.

The key performance indicators (KPI’s) of our model are:
number of kilometers per 1000 L of LPG delivered - $\alpha$ [km / 1000 L]
number of stock-outs occurred at any station within the distribution period - $\psi$.

Our aim is to minimize number of kilometers per 1000 L of LPG delivered and avoid any stock-out at any station. Simultaneously we control the aggregated volume of LPG in whole distribution network of stations: we compare the total daily sales of all stations with the volume of gas delivered to the stations within one day. Our aim is to avoid situation when the aggregated volume of LPG in whole distribution network would drop below a certain critical level which shall oblige to use much higher number of trucks and drivers to prevent the supply chain from general inefficiency. For our computations we first consider small number of trucks (2) to perform the deliveries to all stations. However shall the number of trucks used be insufficient (an integer solution to optimize not existing), we increase number of trucks (e.g. to 3) to run our optimization. For each of data sets we have generated simultaneous computational experiments of joint usage of proposed optimization and simulation models. We first provide results for combined use of simulation and VRP optimization models for planning horizon of three days. For different coefficient of variation levels we present number of stock-outs, solution of costs / travelled distance and number of vehicles used to perform deliveries.

Table 1 Results of optimization / simulation experiments for planning horizon k=1 for three days (VRP variant)
Some conclusions can be drawn from Table 1. For coefficient of variation values below 30% we do not observe any stock-outs and number of stock-outs grows for higher values of CV.

In Table 2 we provide results for combined use of simulation and IRP optimization models for planning horizon of three days. For different coefficient of variation levels we present number of stock-outs, solution of costs / travelled distance and number of vehicles used to perform deliveries.

### Table 2: Results of optimization / simulation experiments for planning horizon k=1 for three days (IRP with rolling horizon variant)

<table>
<thead>
<tr>
<th>CV [%]</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Distance travelled [km]</th>
<th>Sum</th>
<th>Liters of LPG delivered</th>
<th>Sum</th>
<th>No. of routes / vehicles</th>
<th>α [km / 1000 L]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1087</td>
<td>1179</td>
<td>3059</td>
<td>68400</td>
<td>68400</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1095</td>
<td>1177</td>
<td>3065</td>
<td>68400</td>
<td>68400</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1332</td>
<td>1451</td>
<td>3576</td>
<td>68400</td>
<td>72000</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1095</td>
<td>1410</td>
<td>3298</td>
<td>68400</td>
<td>72000</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1432</td>
<td>1089</td>
<td>3314</td>
<td>68400</td>
<td>104400</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1080</td>
<td>1490</td>
<td>3363</td>
<td>68400</td>
<td>72000</td>
</tr>
<tr>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1623</td>
<td>1060</td>
<td>3476</td>
<td>68400</td>
<td>107434</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1452</td>
<td>1163</td>
<td>3408</td>
<td>68400</td>
<td>104400</td>
</tr>
<tr>
<td>45</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>793</td>
<td>1456</td>
<td>1044</td>
<td>3293</td>
<td>68400</td>
<td>108000</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>793</td>
<td>914</td>
<td>1542</td>
<td>3249</td>
<td>68400</td>
<td>72000</td>
</tr>
</tbody>
</table>

Some conclusions can be drawn from Table 2. For coefficient of variation values below 45% we do not observe any stock-outs and number of stock-outs grows for higher values of CV.

### 6. CONCLUSIONS AND FURTHER RESEARCH DIRECTIONS

We can now evaluate the impact on number of stock-outs and the final solution cost of usage of the two approaches (i.e. VRP method and IRP with rolling horizon method). Considering results of our computational experiments we observed important reduction of stock-outs in case of applying IRP with rolling horizon method. It was caused by additional (non-standard) condition to the model applied which allows high level of trucks utilization (i.e. 90% of truck capacity to be used). Thus deliveries in case of IRP with rolling horizon method were performed also to the stations that were not far from the distribution trip and allowed reasonable unloading in order to avoid any backhaul of LPG to the depot. This practice is common in real-life applications of LPG deliveries in Poland.

The KPI ratio number of kilometers per 1000 L of LPG delivered is the second element to be considered. In our computational experiments for 20% level of CV we observed better results for VRP with rolling horizon approach but for higher values of CV we observed more efficient distribution for IRP with rolling horizon approach. We can draw conclusion that short planning horizon (only 1 period for VRP method) provides
positive results only for low values of coefficient of variation. One of the most interesting parameters is number of trucks used for the distribution. For the VRP with rolling horizon model we needed more than 2 trucks only in 1 case however for the IRP model it occurred 8 times. In our model we analyzed impact of stochastic variations of only one parameter: demand. In real-life systems stochastic variations concern many other factors like:

- service time at the station
- travel time (due to congestion, technical failures, traffic inspections etc.)
- waiting time at depots (queues, product shortage), etc.

For further research our aim is to perform computational experiments of combined use of simulation and optimization models for simultaneous variations of different distribution parameters.

REFERENCES

SELECTED ASPECTS OF THE DISRUPTIONS RISK IN THE IMPLEMENTATION OF JIT

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Abstract

In the paper will be presented the way performing the studies, particularly the selection and characterization of the survey sample and the analytical scheme of research. The results of this study will enable to answer the following questions: whether the use of JIT (Just In Time) increases the likelihood and consequences of disruption and whether JIT has been applied in an appropriate way. The main objective of the conducted research was an assessment of the relationship between the use of selected management instrument – JIT and the risk of disruptions in the supply chain. While the scientific aim is to enrich the knowledge of the issues on the risk of disruptions to supply chain management.

Keywords: Disruption risk, just in time, supply chain

1. INTRODUCTION

In modern enterprises searching for a competitive advantage, undertakes to cooperate in the supply chain and an integration of suppliers with buyers, which is expressed in the use of appropriate instruments for managing supply chains. A certain category are instruments whose use as far integrates the supplier and the buyer that follows specific role reversal – the activities and management areas traditionally belonging to the buyer, they shall be transferred to the supplier. These instruments include among others – JIT.

The risk of disruptions, which has been present for a very long time, is currently becoming more meaningful in the context of integration within supply chain defined as “the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer” [1]. Not without significance is the fact that supply activities take place on a global scale – in various legal, political and social environments. The literature on the subject stresses the fact that in the last decade there have been several factors which increased the vulnerability of supply chains [2, 3, 5]. These include: natural disasters, terrorist attacks, the rapidly changing and unpredictable demand, shorter product life cycles, a reduction in the number of basic products components, reduced supplier bases, a reduction of buffers, e.g. in store levels and in delivery terms, more integrated and intertwined processes ongoing amongst businesses, more demand for JIT supplies, in shorter time windows, technological changes, cost pressure, the necessity to increase leanness and agility, increased use of outsourcing and off-shoring, dependence on suppliers.

2. RESEARCH PROBLEM

Some authors believe that higher vulnerability of supply chains defined as “exposure to serious disruptions resulting from the risk within the supply chain as well as from internal risks for supply chains” is a consequence of the application of lean supply chains strategies that has been taking place in recent years. In particular, it has become a general practice to keep inventories at extremely low levels which prevents buffering the breaks in the supply flow and causes disruptions. The above is stressed by Handfield, Blackhurst, Elkins and Craighead [5] who notice a conflict between the need to decrease the frequency and minimize the effects of disruptions in supply chains as well as a strive for cost reduction by implementing global economy strategies.
Similarly, Zsidisin, Ragatz and Melnyk [6] point to "the dark side", i.e. to the threats for supply chains based on such instruments as TQM (Total Quality Management), Six Sigma, Just-in-Time or lean management. The above results from the fact that on one hand the integration of supply chains and the use of lean management tools brings obvious profits, but on the other it affects such elements of supply chains which are believed to increase the risk of disruptions.

Considering the fact that the evaluation of risk level is based on two elements, i.e. the probability of its occurrence and its effect, following the analysis of literature on supply chain strategies, one conclusion seems to be obvious: perhaps the strategies of lean supply chains - just in time in this - have a positive effect on the probability of disruption, however, if and when it happens, the effects of such disruption might be much more unfavorable than in the situation when the just in time is not applied. To justify the need to take up research into the disruption risk of supply chain instruments an assumption was made that there is a relation between the level of risk and the applied supply chain instrument - for example Just in time.

This manner of formulating the research problem leads to the following thesis that the use of such supply chain management instrument as JIT affects the risk of disruption and 2 hypotheses.

H1. The application of JIT increases the probability of occurrence of disruptions;
H2. The application of JIT increases the negative effects of disruptions.

This research aims to enrich the knowledge of the issues on the risk of disruptions to supply chain management.

In the theoretical aspect, the research aim involves defining the notion of “disruption risk” especially in the contexts of its synonyms such as interruption, delay, deviation. Furthermore there is a need to identify the characteristics of disruptions in supply chains. Another theoretical aim includes defining the fundamental determinants of the selected supply chain strategies.

The research calls for providing answers to the following questions which are relevant to the management of supply chains and the development of knowledge on the subject:

- Does the use of JIT increase the likelihood and consequences of disruption?
- Has JIT been applied appropriately?

3. METHODOLOGICAL BASES AND LITERATURE REVIEW

The methodological aim includes operationalization of variables used in the analytical scheme and defining the method of measurement of the variables related to the disruption risk in supply chains. The finally aim is to verify hypotheses formulated based on a constructed simulation model and the performed simulations to research methods with which achieved the answers for this questions and verification of hypotheses, include: literature studies, empirical research with the use of statistical methods.

The source data for statistical analysis was obtained from questionnaires as it is impossible to use exclusively the data from secondary sources. The sample consisted of 195 enterprises, the use of JIT was declared by 84 companies (43.3%).

Risk has recently become the subject of Polish publications not only in the area of finances and insurance, but also logistics and supply chains. The risk of disruptions is a particularly meaningful and frequently stressed category of risk in supply chains. The issues of risk of disruptions are discussed by such authors as Świerczek [7], Kramarz [8]. Świerczek [7] pointed to the transmission of disruptions, i.e. the expansion of the negative effects of risk to a higher number of supply chain participants in the contexts of becoming mutually dependent on the companies which act within supply chains. Kramarz [8] built a model of strengthening resilience of supply chains from the point of view of material division within the supply chain of steel products. The literature
on the subject of disruptions on the world scale written in English primarily includes articles and scientific publications [9].

Marley [9] pointed to lean management, integration complexity, and their relationship with respect to the effects of disruptions and that the use of lean tools can create problems in the supply chain that have not occurred on such a large scale. Closer cooperation within a single supplier, while reducing the level of buffer stock and flow times, causes more frequent occurrence of disruptions. Sinha et al. [11] - the need to control the effects of disruption in the process of planning, controlling and monitoring the relationship between the organization and its partners. Zsidsin [6] – lean process should lead to a reduction in losses and in inventory levels, which in turn reduces costs, but these activities - regardless of the positive conditions for the application - can increase the risk of disruptions as well as their severity. Handfield and McCormack [5] saw a conflict between the need to take action to reduce the frequency and impact of disruptions in supply chains and the aspirations to reduce costs by the strategies of the global economy. Hendricks and Singhal [12] - an increase in the number of large and costly supply chain disruptions resulting from the introduction of lean management. Moreover, there is no publication that contains an analysis of the just in time in view of the risk of disruption.

Secondary research carried out in economic environments points to the fact that the managers approach the eventuality of supply chain disruptions as one of the most important threats for businesses. The industry data prove that 85% of global supply chains suffered from at least one disruption in one year. The negative effect of supply chain disruptions on the price of shares was also confirmed in a report published by PricewaterhouseCoopers [13]. The research carried out in 2005 [14] pertaining to risk management in Polish organizations (250 most dynamically developing companies) concludes that the most threatening factors for companies are disruptions in supply chains (34% respondents) and strengthening of the competitors (43% respondents). Also the result of the companies’ own research on risk factors in supply chains showed disruptions to be a valid factor in everyday practice.

Viewing strategies in the context of single organizations, however, shall not be adequate as complete supply chains compete with each other on the market. When considering the tendencies in the development of supply chains, it is advisable to study supply chain strategies in the contexts of possible risk of disruptions. The current knowledge points to the fact that the subject of research itself, i.e. the risk of disruptions, is a new research area. The studies of the subject become even more innovative if the risk of disruptions is viewed in the contexts of the applied supply chain strategy.

Based on a literature review the concept of disruption in the supply chain was defined as unplanned event leading to a break in the normal flow of goods and information, which has a negative impact on the supply chain. The most general notion is a disruption in the supply chain. Considering the problem of disruption from the perspective of the company and not the entire supply chain, we are talking about disruption of supplies. On the other hand, when we estimate the probability of occurrence of an identified potential disruption and its possible effects, then we can talk about the risk of disruption.

4. THE ASSESSMENT OF THE IMPACT OF JIT ON THE PROBABILTY AND EFFECTS OF SUPPLY CHAIN DISRUPTIONS

JIT impact on the likelihood and consequences of disruptions, rated on the basis of the results of quantitative analyzes responses given to the question:... "Do you think that the use of a JIT, as opposed to the situation that this instrument is not used, causes: [...]"

- a higher likelihood of a supply disruption,
- a situation when a disruption that occurs at our supplier’s end would affect us sooner,
- a situation that if the source of risk was external (e.g. a natural disaster) and it affected our supplier, it would be more difficult for us to deal with its consequences etc.(see Table 1)
Each of these questions contain the same set of statements respondent could agree with them or not. By checking in accordance with their feelings - on a scale of 1-5: 1 - "definitely not" 2 - "probably not", 3 - "neither, nor so", 4 - "rather yes", 5 - "definitely yes". Given the questions, which used a five-point Likert scale, benefited from higher statistics measurement. The mean, standard deviation, and median.

When analyzing the JIT instrument and considering a question whether the probability of a supply disruption is greater when JIT is applied, one cannot see any prevalence of either - "yes" or "no" answers. The average of indications amounts to 3.13, and the standard deviation is 1.14. Thus, the use of JIT does not increase the likelihood of disruption. When assessing the increase in potential impact of disruptions, it may occasionally be seen - when analyzing the median - that half of the respondents agreed with certain statements. This was the case in the following variables: disruption that occurred at our suppliers’ end, would affect us sooner if the source of risk was external (e.g. a natural disaster) and if it affected our supplier, it would be more difficult for us to deal with its consequences, if there were a supply disruption, the sales losses would increase. In the case of the use of JIT the average of all potential negative effects is higher than 3, therefore the respondents tend to answer: 4 - "rather yes", 5 - "definitely yes".

Table 1 The answers for the question: Why did you decide to implement the JIT in your organization?

<table>
<thead>
<tr>
<th>Q: Why did you decide to implement the JIT in your organization?</th>
<th>Average</th>
<th>Median</th>
<th>Standard deviation</th>
<th>Min.</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our competitors enforced the implementation of JIT on us.</td>
<td>3.1205</td>
<td>3.0000</td>
<td>1.17284</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>JIT was imposed upon us by our client (we did not want to lose them).</td>
<td>2.9036</td>
<td>3.0000</td>
<td>1.15415</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>The use of JIT was our idea, we imposed certain conditions for the good of both parties.</td>
<td>3.3704</td>
<td>4.0000</td>
<td>1.03010</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We would not have implemented the JIT, if there had been no trust between us with respect to information sharing.</td>
<td>2.7284</td>
<td>3.0000</td>
<td>1.16203</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We would not have implemented JIT without the support of integrated IT systems.</td>
<td>3.2410</td>
<td>3.0000</td>
<td>1.13256</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We have successfully implemented the JIT because the supplier fulfills their quality management duties.</td>
<td>3.3494</td>
<td>4.0000</td>
<td>1.17321</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Long term financial profits from using the JIT are higher that possible losses that might be caused by disruptions.</td>
<td>3.4699</td>
<td>3.0000</td>
<td>0.95429</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Before we implemented the JIT deliveries we had considered the threat of increased risk of disruptions.</td>
<td>3.5663</td>
<td>4.0000</td>
<td>1.09536</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We had protected ourselves against the effects of disruptions within the JIT by introducing penalties for failing to meet the terms of deliveries.</td>
<td>3.0602</td>
<td>3.0000</td>
<td>1.17234</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Thanks to the application of JIT we cope much better than our competitors with external disruptions.</td>
<td>3.6024</td>
<td>4.0000</td>
<td>1.02338</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Since the time, we have been relying on the supplier within the JIT, the disruptions in their deliveries occur less frequently.</td>
<td>3.5293</td>
<td>4.0000</td>
<td>0.98200</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We apply the JIT but we simultaneously monitor our supplier and support them in case external disruptions occurred.</td>
<td>3.3614</td>
<td>4.0000</td>
<td>1.00703</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>JIT is used only for the goods in regular and continually controlled demand.</td>
<td>3.2289</td>
<td>3.0000</td>
<td>1.02797</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We use the JIT if the scale of flow from the supplier is substantial enough.</td>
<td>3.4819</td>
<td>4.0000</td>
<td>1.02839</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We have not decided to use the JIT without standardization.</td>
<td>3.1446</td>
<td>3.0000</td>
<td>1.06075</td>
<td>1.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>
Q: Why did you decide to implement the JIT in your organization? (continue)

<table>
<thead>
<tr>
<th>Question</th>
<th>Average</th>
<th>Median</th>
<th>Standard deviation</th>
<th>Min.</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within the JIT we plan the purchase of product ranges with no guarantee of their quality.</td>
<td>2.8554</td>
<td>3.0000</td>
<td>1.19074</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>We would not be using the JIT if we could not be sure that we could eliminate the possible disruptions.</td>
<td>3.5060</td>
<td>4.0000</td>
<td>1.05198</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>In order to ensure the demand, we have set up a warehouse in the vicinity of our recipient so that we could meet their JIT requirements.</td>
<td>3.3049</td>
<td>3.0000</td>
<td>1.00233</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Whenever there were disruptions within the JIT deliveries, it caused substantial financial losses to our organization.</td>
<td>3.3614</td>
<td>4.0000</td>
<td>1.03096</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>If we use the JIT deliveries, it is only for the standard components for which replacements may easily be found.</td>
<td>2.9398</td>
<td>3.0000</td>
<td>1.16189</td>
<td>1.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

However, the deviations from these values are large enough (about 1.0), thus a conclusion that the use of JIT increases the negative effects of potential disruptions would be an overstatement.

5. CONCLUSION

Based on the statistical analyzes, the hypotheses have not been confirmed. The present studies show that the use of JIT which is one of the basic tools of lean management does not increase the risk of disruptions in the supply chain. The analysis of the median suggests that a representative sample might prove that the use of this instrument increases the negative effects, yet it does not affect the increase in the likelihood of disruptions. The analysis should be based on conditions of the application of lean tools as well as on the correctness of their implementation. Therefore, it is suggested that risk analysis should constitute the starting point for the implementation of lean tools. Despite the falsification of hypotheses, achieving it is a contribution to enhancing knowledge of the disruptions risk in supply chain management.

The above data undoubtedly prove the relevance of supply chain disruptions and thus the relevance of theoretical studies on such disruptions. What is missing is a theoretical basis for the analysis of disruption risk. There is literature which points to theories that can be applied to explain the operation of companies within a supply chain, among others the theory of agency, the theory of transactional costs, the theory of key competencies, Porter’s cluster theory, the theory of branch structure and the chain of value as well as the chain approach. As risk is a notion that is discussed by many types of sciences, especially the social science, mathematics, natural science or technology, the contemporary knowledge on the risk is cross-disciplinary, although each type of science only uses its part, one may point to certain theories or concepts which create a common foundation to all of them. In the economic sciences, the first elaboration on risk was presented by Willet in The Economic Theory of Risk and Insurance, which was followed by the expected utility hypothesis or the prospect theory. However, most analytic work on the risk of disruption itself includes the reports of consulting companies or standards defined by practitioners. Thus the lack of theoretical foundations with respect to the risk of disruptions of supply chains is an area that needs to be tackled upon by scientific research. Based on preliminary survey, there are a couple of theories which might be used in this area. These include the dynamic theories and follow the leader traffic flow models, loose coupling, normal accident theory, reliability theory, or the theory of black swan events. These theories, however, call for a detailed discussion, and their exact applicability for explaining the phenomena related to the risk of disruptions of supply chains is yet to be defined.

The current knowledge points to the fact that the subject of research itself, i.e. the risk of disruptions, is a new research area. Needless to say, this notion must not be simplified down to the phenomenon of demand
acceleration or to the notion of bottleneck. The studies of the subject become even more innovative if the risk of disruptions is viewed in the contexts of the applied supply chain strategy.

ACKNOWLEDGEMENTS

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SUSTAINABILITY INDICATORS AT THE COMPANY LEVEL: FRAMEWORK AND METHODOLOGY

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Abstract
Sustainability is a hot issue, implemented at different levels, including whole world, regions, countries, cities / villages and companies. In the presented paper authors are focused on sustainability at the company level, which may be seen as a source of the competitiveness. Running a sustainable business requires appropriate system of measurement, supplying useful information for the decision-makers. Authors choose indicators as a tool for sustainability measurement. In the study, there is presented the method of sustainability indicators system determination at the company level, considering theoretical background of sustainability indicators as well as experts' knowledge.

Keywords: Sustainability indicator, sustainability measurement, sustainable development

1. INTRODUCTION
Sustainability has become recently an essential topic in many areas. It results in making an effort in translating the theoretical goal of sustainable development (hereafter: SD) raised from Brundtland Report into practical usage at different levels of application. In accordance to the literature review, authors claim that SD has been introduced at five different levels, depending on the scope of impact (Figure 1).

Figure 1 Levels of SD policy application

There are close relationships between levels from the Figure 1. The top-level of SD introduction is the global one. All goals defined at this level should be treated as a guide to the activities undertaken at lower levels, in order to meet needs of humanity (material and immaterial) with the use of environmentally friendly technologies what will not stop the development. The first source of guidance in the implementation of SD on a global level was a program document established during the United Nations Conference in 1992, Rio de Janeiro, called Agenda 21. It was intended to involve actions at international, national, regional and local levels, what corresponds with the proposed levels in the Figure 1. At the national level, in Poland the SD become included into constitution, gaining the valuable significance. Considering Agenda 21, authors added the unit level. It includes company’s dimension of SD implementation. According to the literature review, authors claim that researches spent significant effort on the SD issues from the macro-perspective, focusing on the global, national or regional level. Moreover in the global debate on the SD, the universal perspective is dominating,
what results in universal measurement systems for SD assessment designed for countries / regions, without considering the diversity in the field of economic development, the socio-cultural or political conditions. At the same moment it can be observed a positive relationship between company’s sustainability and competitiveness of the same enterprise. Sustainability is not a possibility to be more competitive, it becomes a requirement of competitiveness, what is a result of greater awareness of customers and entrepreneurs. Taking that into consideration, authors suggest to start thinking about SD and implementing appropriate activities at the company’s level. What is more it should correspond with local, regional and national solutions in order to fulfill global requirements. Nowadays, business success is no longer measured by traditional economy indicators, but sustainability indicators which consider people, economy and ecology aspects of running a business [9, p.132]. With appropriate indicators set, company is able to improve the sustainability. However at first, there should be established set of indicators which allow company to answer the following questions: What is the actual state? Have we achieved established goals? How do we compare to other companies in the sector? Selection of the right indicators for sustainability measurement is relevant, because it is better to measure right things approximately than the wrong ones with great accuracy and precision [12].

This paper intends to construct a comprehensive, compact and practical indicator framework for sustainability assessment addressed for company. The objectives are: (1) to identify existing indicator frameworks for companies (2) to define guidelines for company’s sustainability indicators development and (3) to establish an indicator selection method for companies.

The remaining part of this paper is structured in the following way. In Section 2 a review on existing sustainability indicator frameworks is introduced. Based on that review, the guidelines for company’s sustainability indicators development are proposed in Section 3. Section 4 introduces the recommended method of sustainability indicators determination. The last section summarizes findings and suggests future research directions.

2. EXISTING SUSTAINABILITY INDICATOR FRAMEWORKS

2.1. Indicators importance for sustainability measurement

The growing interest in sustainability worldwide during the last two decades, has resulted in a parallel growth in measures of sustainability, usually expressed as sustainability indicators, ratings and indices. Authors recommend to use indicators. First of all, they were identified in Agenda 21 as one of the guidelines to measure progress towards achieving sustainability targets and inform decision-makers as well as the public about the current state of sustainability state in a suitable and policy-relevant manner. Secondly, Meadows stated that “Indicators arise from values and they create values”, what fits well to the SD, the most significant issue worldwide, in authors opinion [7, p. 2]. The meaning of indicators is a result of their possibilities: tracking progress over time, identification of problems, planning future improvements, etc. As it was mentioned in the Section 1 it is problematic to provide a practical dimension to SD concept, although measurement of the sustainability is a great chance for that.

2.2. Review of existing indicator frameworks

In order to recognize existing indicator frameworks, authors have made the literature review with the use of scientific database - Web of Science Core Collection. The keywords used in the search were subject to the following logic sentence: (“sustainability indicator” OR „sustainability assessment“), the search was performed over the title of all publications in the database. Through this search 2033 articles published between till 2016 were found (state on 21.10.2016). Summary of the literature review is presented in the Figure 2 as a classification scheme for papers regarding sustainability assessment, including 3 levels.
The first level in the Figure 2 is related to the position of the SD policy application (answer for the question: where?), what corresponds with Figure 1. In order to achieve the goals of this article, obtained publications, were filtered according to their relevance to the sustainability assessment at the company level. Consequently, the second level in the Figure 2 concerns object of the assessment at the company level (what?) including company's characteristic determined by size, sector and type of the company. There are various objects of the assessment, including systems (whole company e.g. [1]), processes (e.g. [3]) and products (e.g. [8]). Considering available solutions, they are e.g. dedicated for Small and Medium Size Companies (e.g. [2, 9]), or for companies representing particular economy sector e.g. printing industry [5] mining industry [1], steel industry [6]. According to the Figure 2, at the third level, it was time to obtain the answer for question: How? That question is related to the following issues related to the indicators: total number of indicators, type, characteristic, issues which they should measure, coverage of SD dimensions (ecological, social, economic).

3. GUIDELINES FOR COMPANY’S SUSTAINABILITY INDICATORS DEVELOPMENT

Based on conducted literature research in Section 2, authors defined following guidelines for development of sustainability indicators at the company level:

- G1: Indicators should be dedicated for the company representing particular sector of a certain size and type, considering aspect of socio-economic terms in the region / country;
- G2: Compatibility with requirements of higher levels in application of SD policy;
- G3: Limitation of indicators’ number ensuring comprehensive approach of all SD dimensions and stakeholders of business;
- G4: Indicators’ diversification according to the type (quantitative, qualitative).
- G5: Use of expert judgement as well as theoretical achievements in the context of sustainability indicators.

Guidelines no G1 and G2 are related to the issues described in the Section 1. Authors pointed out that the number of used indicators should be limited and at the same time it should make possible to ensure comprehensive approach to all SD dimensions considering all business stakeholders. According to the studied papers, if a set of indicators consists of large number items, there are a lot of confusions regarding the importance of the indicators as well as the assessment becomes time-consuming. Consequently, entrepreneurs are not willing to make the assessment. Taking into consideration opinion of Veleva i Ellenbecker [11, p. 523], authors recommend to use 10-20 indicators. Examining guideline G4, it is suggested to diversify types of indicators in order to make it possible to use in various conditions. The last recommendation
(G5) is associated with use of experts’ insights on indicators because each system is specific as well as indicators available in the literature. In authors opinion, the most well-known and used by researches indicators sets are: Dow Jones Sustainability Index, Icheme Sustainability Metrix, ITT Flygt Sustainability Index, Global Reporting Initiative (GRI), Barometer of Sustainabaility, Ford Product Sustainability Index (FPSI), etc. They are briefly described and compared in [2, 3, 4, 6, 9]. Consequently, authors have developed a catalogue of sustainability issues (hereafter: CSI) (Table 1):

**Table 1 Catalogue of sustainability issues (CSI)**

<table>
<thead>
<tr>
<th>People</th>
<th>Environment</th>
<th>Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working conditions (health and safety, comfort at the workplace, Employee’s training and development, equal opportunities);</td>
<td>Materials (use, use of hazardous substances, recycling / direct reuse of products / raw materials);</td>
<td>Company’s equipment (accommodation, machinery, tools);</td>
</tr>
<tr>
<td>Customer satisfaction</td>
<td>Emissions (CO2, sewage);</td>
<td>Employment</td>
</tr>
<tr>
<td>Employees’ participation in decision-making process</td>
<td>Energy (consumption, use of renewable energy sources);</td>
<td>Investments (in technology, Employees, community development);</td>
</tr>
<tr>
<td>Support for the local community</td>
<td>Waste (3R scenarios, toxicity);</td>
<td>Quality (defects, customer service);</td>
</tr>
<tr>
<td>SD awareness</td>
<td>Water (consumption, re-use)</td>
<td>Economic results (income, expenses)</td>
</tr>
</tbody>
</table>

In the Table 1 there were presented all sustainability issues which should be covered by indicators used to assess sustainability at the company level, considering all dimensions of SD.

In the presence of the large number of sustainability indicators proposed in the literature, many authors have noted that there is lack of guidance on correct selection of indicators [10]. In order to complete consideration of guideline G5 and to meet mentioned requirement, authors have proposed the following criteria for indicators’ selection (Hereafter: CIS), which are creating indicators’ characteristic:

- **C1:** Accessibility of required data for indicator (easy to identify, without creating demand on additional data)
- **C2:** Comparability of the indicator’s results over time (trends) enabling benchmarking
- **C3:** Reliability of supplied trusted and useful information about sustainability state-of-art for decision-makers.
- **C4:** Simplicity in the construction and interpretation of indicator to enable a non-expert the understanding and interpreting it for future decisions
- **C5:** Relevance - indicator is related to an aspect of sustainability that is significant for stakeholders and purposeful for the company with a particular specific.
- **C6:** Resistance against confidential data - indicator should not concern data considered as confidential.
- **C7:** Support for application of SD policy in region / country.

4. **SUSTAINABILITY INDICATOR SELECTION METHOD FOR COMPANIES**

Considering results of the Section 2 and Section 3, authors have proposed an universal methodology of sustainability indicators determination at the company level (Figure 3).
Authors recommend in the **Figure 3**, the method of sustainability indicators determination dedicated for a company representing a particular specific, in accordance to guideline G1 from Section 3. The method consists of two stages: preparation (1) and indicators determination (2). Introduction of the guideline G5 is manifested by use of set of indicators from the literature (IL) as well as indicators obtained from brainstorming session (IB) with academic and business experts (2.1) (minimum 10 experts). The key step in the procedure is 2.2, where all ideas of indicators (from literature (1.2) and from creativity phase of brainstorming (2.1)) are evaluated with the use of: requirements expressing adaptation of SD policy application at higher level (region / country) and criteria for sustainability indicators (CSI). Positively verified indicators are creating the set of recommended SI, which should be specified with the following data: formula (quantitative indicator) or assessment base (qualitative indicator), unit, reference value and range of values. Authors suggest to use a Focus group interview (FGI) in order to determine those characteristics of selected indicators. As a result there should be obtained a set of 10-20 indicators appropriate for the company's type, size and sector supporting SD policy application in the region / country.

### 5. CONCLUSION

To conclude, this paper presented a method for determination sustainability indicators for companies, which provides clear and effective decision-support for sustainability assessment, supporting SD policy application in wide scope of impact. Authors recommend the use of following methods and techniques, including: literature analysis, brainstorming and FGI, although there are no contraindications for use of different experts methods. The most important is to combine theoretic background with experts knowledge and business requirements to make the set of indicator and whole method not only useable but useful. Research will be continued by applying the method of determination sustainability indicators for polish recycling companies. In the next step authors are going to develop a procedure of aggregation indicators into index of sustainability presenting the level of
sustainability of the company. Searching for compromise solution in the proposed method it is also considered an application of stochastic multiple criteria decision aiding procedures (Sawicka [9], Sawicki and Sawicka [10]) as an exemplary application in the field of logistics.

ACKNOWLEDGEMENTS

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INTERDISCIPLINARY MODEL OF OPERATIONAL RISK MANAGEMENT FOR THE URBAN TRANSPORTATION SYSTEM - RESEARCH BASIS

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Abstract

On the study basis the authors found the presence of a gap in the research area of a risk management of urban transportation systems. There is relatively small amount of publications on risk analysis for the urban transportation systems. At the same time, the results already described concern the issues associated with the safety of infrastructure and the accidents. In the published results of researches conducted in Poland and around the world there is a lack of an interdisciplinary approach to risk management in urban transportation systems, in accordance with the holistic approach of ISO 31000. Therefore, it seems important to carry out interdisciplinary research related to the identification of risk factors present in the systems of urban transportation, including technical, economic and social aspects. Special importance has also the assessment of sensitivity of transport processes on the occurrence of defined risk factors and their impact on quality of inhabitants life. The main aim of the article is to present the assumptions currently initiated by the authors for the creation of an interdisciplinary model of operational risk management system for the urban transportation system including buses and trams, which improves the reliability and life quality of inhabitants.

Keywords: Risk assessment, urban transport system, holistic view

1. INTRODUCTION

The quality of public transport services depends on their efficiency of normal operations as well as their performance in case of minor disturbances and major disruptions. The causes of these disturbances can have very different sources: social, economic and technical. Public transport planning and operations are traditionally focused on travel time and costs, while overlooking aspects such as reliability and robustness. However, there is substantial evidence on the impact of unreliable service and service disruptions on passengers’ perceptions and costs of these impacts (e.g. [1, 2]). The impact of disruptions may extend beyond direct time losses due to their disproportional effect on travellers’ decisions [3].

There is relatively small amount of publications on risk analysis for the urban transportation systems. At the same time, the results already described concern the issues associated with safety of infrastructure and accidents. In the published results of researches conducted in Poland and around the world there is a lack of an interdisciplinary approach to risk management in urban transportation systems, in accordance with the holistic approach of ISO 31000. Therefore, it seems important to carry out interdisciplinary research related to the identification of risk factors present in the systems of urban transportation, including technical, economic and social aspects. Special importance has also the assessment of sensitivity of transport processes on the occurrence of defined risk factors and their impact on quality of inhabitants life. The main aim of the article is to present the assumptions currently initiated by the authors of the research project for the creation of an interdisciplinary model of operational risk management for the urban transportation system including buses and trams, which improves the reliability and life quality of inhabitants. For this reason, in the first place the authors will present an overview of the literature concerning risk management, with particular emphasis on the transportation risk. The next section will discuss the main directions of research conducted in the area of risk management in urban transport. On this basis, authors will define a research gap, which the authors want to
fill with the currently initiated research project. The concept of these studies will be presented in section 4 of the article.

2. RISK MANAGEMENT - REVIEW

In the literature one can find different definitions of risk, depending on the specialty, for which it is specified. A common definition is that risk is the probability of harm or damage occurring from exposure to a hazard, and the likely consequences of that harm or damage [4]. In the social sciences, the risk may be defined as a situation or an event where something of human value (including humans themselves) is at stake and where the outcome is uncertain [5]. Partnerships Victoria [6] claims that risk "is the chance of an event occurring which would cause actual project circumstances to differ from those assumed when forecasting project benefit and costs". The Project Management Institute [7] defines risk as 'an uncertain event that, if it occurs, has an undesirable effect on at least one project objective (e.g., time, cost, scope, quality).

Also, the risk in the area of transport itself is defined in different ways [8]. The first use of the word ‘risk’ is the probability of an unwanted event; as such, it is a pure number between 0 and 1. A slight variant of this is the probability per time unit, or frequency, of a class of events. The second use of the word is to mean some combination of the probability or frequency of an unwanted event and its outcome. The most common usage is to define risk as the expected or average consequence per time unit of a class of events, such as the mean number of fatalities per year. In that case, the units in which risk is measured implicitly include the units of the outcome, such as fatalities per year.

In the last few years one have seen significant growth and evolution of the concept of risk management. In the 70s of the twentieth century, the obligations of the person responsible for risk management in the enterprise was limited to hazard identification and purchase appropriate insurance [9, 10]. Today it is a complex management process, described as the concept of Enterprise Risk Management, whose aim is the holistic management of all risk groups in the enterprise [11]. This concept also has its own ISO standard (ISO 31000 Risk Management Standard). Thanks to several years in the study of risk prevailing view about the need for a holistic, interdisciplinary approach to the risk assessment and management [12]. This change has also resulted in the industry - it is particularly important to the idea of Operational Risk Management [13]. The Operational Risk Management - ORM helps organization avoid unexpected losses, improve their operational efficiency, promote more efficient use of capital, satisfy stakeholders and to comply with regulations [14]. Therefore the authors in their research will use the definition in line with the ISO 31000 standard [15]. According to it the aim of risk management is usually to assess the risk in terms of the likelihood that particular consequences (negative or positive) will be experienced flowing a defined event, taking into account the possible initiating sources and causes of harm (or benefit). That information provides a qualitative, and often quantitative, basis to develop controls to eliminate, reduce, or modify the risk in a continuous process of review and mitigation.

The risk is a subject of research in all transport systems (e.g. [16, 17, 18, 19]). However it should be noted, that the concepts of risk management methods in transport by rail, air and water are more developed than in road transport [20]. At the same time, analysis of the publications in the EBSCO database from years 2006 to 2016, concerning risk management in transport, allows to distinguish 5 dominant thematic groups, which relate to ongoing research in this area: (1) the risk of accidents in transport (including [21, 22, 23]); (2) the risk of transport of dangerous goods (e.g. [24, 25, 26]); (3) the risk of terrorist threats in transport (number of publications connected with it increased after the year 2001, (e.g. [27, 28])); (4) the risk of road infrastructure (e.g. [29, 30]); (5) the risk of delayed transport (e.g. [31, 32]). These studies were focused on a selected group of threats (typically: technical) occurring in the transport system. Thus it can be concluded that they did not meet guidelines standards of ISO31000. Because, according to the standard, the risk management should be holistic and should take into account not only technical factors, but also human and cultural [15]. The analyzed publications definitely lacked such a holistic approach. It can be concluded that in the current published
research in the area of risk management in transport research vulnerability exists a lack in the form of interdisciplinary risk management models which would be compatible with the concept of Enterprise Risk Management.

3. RISK MANAGEMENT IN URBAN TRANSPORTATION SYSTEM

There is a growing interest in recent years in the analysis of public transport vulnerability and measures to improve its robustness. While network unreliability refers to variations due to inherent uncertainty and recurrent perturbations, network vulnerability refers to exceptional disruptions with severe impacts on system performance [33]. This topic already attracted a lot of attention in road traffic research (e.g. [34, 35]) and in the last decade also entered the public transport research domain [36, 37]. Vulnerability is however limited to the consequences of disruptions on network functionality once they occur. Its antonym, robustness is defined as the capability of a system to absorb shocks and withstand disruptions [35, 38]. Network resilience requires robustness as well as a rapid recovery back to normal operations and performance [39]. Finally, risk integrates the extent to which the system is exposed to various disruptions (i.e. failure probabilities) and their respective impacts.

Among the research conducted in Poland in the area of risk management in transport systems, noteworthy is a project ZEUS, and subsequent projects strictly on urban transportation. The project ZEUS developed general principles of integrated risk management, which has been given the name of the TRANS-RISK [20]. Under the Integrated System of Transport Safety it has not been taken any specific actions related to risk management of hazards in urban transport. However, in the context inference conducted it indicated the need for individual transport modes specific procedures, models and risk measures for use in the context of the general principles of integrated risk management in transport. Continuation of the work initiated by the project ZEUS become a concept TRAM-RISK described, inter alia [40]. This method is dedicated to trams risk management. During the work on the development of the method, the authors took on to build a specific model, procedures and risk measures corresponding to the requirements of the tram. The authors in their first publications [40] pointed out that their study will combine the issue of the reliability of tram with the problems of management of its security. However, later publications [41] closely targeted are already on the implementation of this method in the field of security management, and presented the results of studies focused primarily on the risk of an accident. Omitted in these studies issues related to the reliability of transport, which covers three areas [42]: (a) reliability of any connection (terminal reliability) - meaning the probability that all passengers reach their destination; (b) reliability of travel time (travel time reliability) - probability of reaching the destination within a given period of time; (c) reliability of execution of transport network passengers’ demand (capacity reliability) - in relation to its capacity.

According to the authors of this article it is therefore necessary to initiate further research devoted to the concept of risk management in urban transport, which will be focused on both security issues and the problems of service reliability. It is reasonable to also extend these research and in addition to the tram, the bus system should be examined. Especially since this is the mode of transport most frequently used in public transport systems in Poland.

4. CONCEPTION OF RISK MANAGEMENT DEDICATED FOR URBAN TRANSPORT COMPANIES

Based on the analysis of literature and current achievements of Polish researchers, the authors of this articles found that it is essential to carry out interdisciplinary research related to the identification of risk factors present in the urban transport systems. These studies should take into account not only the technical aspects of the analyzed system, but also elements of economic and social conditions. The main objective of this study should be a widening of the current state of knowledge regarding risks associated with the organization of public passenger transport in large urban areas and the development of theoretical, interdisciplinary model of
operational risk management for the public transport including bus and tram, improving reliability and safety of transport, and quality of life.

The starting point of the analyzes should be process approach for the studied phenomena. This is due to the fact that, according to The Risk Management Association process, as risk category, has the largest share of operational risk (65%). Process approach also takes into account the fact that the transport services are carried out in a complex system which is characterized by behavioral, social, economic and technical factors. Perspective process will therefore identify the source of the risks associated with any resource of transport service process on the input. The scope of the proposed resources to be considered in the analysis is shown in Figure 1.

![Figure 1](image)

**Figure 1** The input resources in the service process of urban transport which are sources of potential risk

Process approach at the urban transport system will also reduce the phenomenon, which has been formulated in the form of one of its hypotheses. On the basis of observations and interviews, the authors found that often the risk management systems of urban transport is individually performed by different groups of stakeholders, in a limited way and does not take into account the existing relationship, which should be included in an integrated strategy to reduce the risk in urban transportation. The organization and implementation of transport involved several entities (organizations) - the organizer of public transport, infrastructure manager and the carrier. The lack of a coherent risk management strategy, common to all of these entities, limits the effectiveness of prevention activities. To verify this hypothesis, the authors provide as part of research to analyze the current risk management procedures applicable to the organizer of public transport, the owner of infrastructure and enterprises of urban passenger transport. It will be evaluated by the degree of formalization, mutual consistency and the scope of monitored groups of threats. These procedures should also be checked for their compliance with the standards defined by ISO 31000.

To the research, it was selected 5 largest agglomeration in Poland with communication of bus and tram: Warszawa, Wrocław, Poznań, Gdańsk, Kraków. This enables diagnosis of multifactorial risk inherent in the system of public transport in large cities. Identification of risk factors belonging to three main groups highlighted in studies (technical, economic and social) will provide a basis for assessing the sensitivity of the test of transport system and impact analysis on the transport processes. It will also examine the impact of the identified risk groups on the quality of life of residents surveyed agglomeration, comfort and communication behavior of people traveling.

The result of the proceedings of the research will be the concept of an integrated, interdisciplinary model of operational risk management systems in urban transport, in line with the standard ISO31000. The model of risk management should take into account the role and the specificity of functioning of public transport in large
cities. It will be focused primarily on the risk factors affecting the reliability and safety of the implementation of passenger transport, but also the source of the danger that determine quality of life will be identified.

5. SUMMARY AND CONCLUSIONS

Research carried out by the authors so far indicate the presence of vulnerabilities research in the area of risk management systems of the urban transport. Research reported in the literature relate primarily to the risks associated with damage of the infrastructure and the occurrence of accidents. There is no publication taking into account a broad analytical look, focused on interdisciplinary risk assessment. For this reason, there was an initiative to launch a study on the risk of urban transport taking into account the standards of ISO 31000.

The article guidelines provide an introduction to the study initiated by the authors. The need for such research arose on the basis of an annual internship realized in the public transport carrier in Wroclaw and detailed analysis of the projects implemented so far by the Polish scientists. It seems that the development of these will be important for management science, sciences of security and transport. The results will increase the current state of knowledge concerning the management of operational risk in the system of public transport in large cities.

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RATIONALIZATION OF LOGISTICS PROCESSES WITH THE USE OF MAPPING AND MODELLING IN BPMN NOTATION

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Abstract

A company is like its processes and process awareness is half the battle in case of implementing modern IT tools for process mapping and modelling. Thanks to modelling the processes can be seen in a very realistic way taking into account many real limitations and also including random parameters which illustrate random factors. The tool for process mapping and modelling is the BPMN notation which lets us model very complex processes, analyse and constantly improve logistics processes on the basis of analysed costs, time, bottlenecks, resources and relationships with other processes.

Keywords: Processes mapping, modeling, logistics process

1. INTRODUCTION

The constant quest for new ways of providing and maintaining a competitive advantage in the rapidly changing economic and social environment resulted in careful analyses of business processes of companies. They not only analyse the course of these processes but also look at them from different angles. Process improvement is difficult and complicated so wrong decisions are often taken. However, analysing individual operations of a process minimises the risk of making mistakes and accelerates effective changes. The growth of effectiveness can be achieved by implementing process management in company logistics. Process maps, factual descriptions of their course and actions provide a better understanding of processes. Individual people (organization units, departments) start to realise that they are a part of a larger entity and the effectiveness of logistics systems depends on the effectiveness of individual system units. The way logistics processes are organized in a company reflects its cooperation with other business entities. Being aware of the interactions between company departments you can understand the interaction between links in a supply chain. The better companies cooperate, the higher effectiveness of the whole supply chain is. There is also another consequence: the quality of service which is of a qualitative nature (very hard to measure) may become more of a quantitative nature thanks to making the service process similar to a production line [1]. The longer the supply chain is, the more time it takes to describe it but the more improvements, advantages and even savings it brings.

2. PROCESS MAPPING

Process mapping is a tool facilitating the improvement of existing processes and the implementation of a process structure in an organization. What is more, it enables a more complete comprehension of existing processes and elimination / simplification of those which require modifications [2].

Generally speaking, a process map is a tool which provides visualization of a set of tasks, an assessment of structures of all processes and subprocesses in the present stage [3]. It depicts all the functions in an organisation to produce the final product (or products). A map is a sequence of activities or tasks that present a work flow [4]. It is an organised presentation of the structure of processes, their relationships and connections. A process map takes into account the order of individual activities in a process. A well - produced
process map identifies the main connections of a process, the time needed to perform given tasks in a process as well as indicates any illogical, unnecessary and / or inefficient activities. A process map is a dynamic depiction of a company, unlike the organisation structure scheme which is static [5].

One of the most effective ways to understand current processes is marking them in a diagram. Its aim is a graphic presentation of processes in such a way which lets us follow and understand their course. Maps should be a “living” document prepared by teams responsible for the processes. Work flow diagrams ought to be a point of reference in a discussion about the employees’ work and stimulate understanding of the action models [6].

The main aim of creating process maps is describing business processes so that they can be simplified, eliminated and improved while products and services can become cheaper, better and achievable quicker [7].

Proper process mapping serves several purposes [12]:

- it enables careful understanding of the process components - activities, results and those who perform individual tasks,
- it defines the limits of a process,
- it is a point of reference (thanks to it process improvements can be measured).

As soon as the company managers understand the current process structure they can start identifying the areas that need to be improved. In process mapping the following procedure is often used:

- identifying the main process by means of relationship mapping,
- creating a detailed process map including all the process activities.

However, in many cases process activities must be considered more carefully. A process map identifies some activities which influence material, information and financial flows of a process. Thanks to such diagrams of sequences of activities quite often it is the first time managers are provided with a complete picture of the way the process takes place [12].

Here are some of the advantages of process mapping [6]:

- process mapping often tell more than words, therefore they should be commonly used in organizations and let us assess the work flow, the range of losses and situations to be improved,
- while creating maps the units that cooperate begin to understand tasks and problems of others and other workers’ contribution to the whole process. The process of creating maps often makes workers look for some improvements while imperfections of organizations are revealed and get eliminated.

3. LOGISTICS PROCESS MODELLING

Modelling is a process reflecting the most important features of an object (process, system) in a simple manner. Models illustrate the work flow and a value added, which stimulates a better comprehension of functioning of an organisation. Logistics process modelling involves describing the functional architecture of individual subprocesses by symbolic reflection of the reality [9].

By modelling we look for the final shape of processes that should be conducted as well as possible. Logistics process modelling can take place thanks to redesigning the existing process which helps us find the answer concerning the unity of actions, costs, using the resources, etc. The problem may be discussed in a broader sense and after creating a model it can be verified paying special attention to its potential implementation. However, it must always start with identification and analysis of processes [10].

Process modelling involves complicated processes and going into details at different levels. It establishes connections and relationships between processes so that one can focus on a chosen level without going into
subject in greater depth and allocate resources to logistics processes. Models reflect real systems that are studied to find out more about them [1].

When the desired model solutions are found they are compared to the existing processes paying special attention to modifications and improvements.

Models can be verified using information technologies to stimulate processes, which are very useful because making process maps is time-consuming.

Modelling can be treated in two ways:

1. diagnostic - focus on depicting the actual state, analysis of current solutions and making a diagnosis,
2. predictive - presenting a newly-adopted model process corresponding to the conditions of a company.

Models treated in a predictive way which uses processes based on many attempts, experiences and implementations of IT systems are called reference models. They take advantage of business solutions without creating new processes from the beginning. Such models usually refer to functional, organisation and information areas of logistics.

In practice in case of logistics process modelling, depending on the range and subject of works, either the diagnostic or the predictive approach can be used or even both of them (e.g. when the predictive approach is limited only to the design stage of logistics processes).

As for detailed rules in the stage of process modelling, we should follow the general rules. In literature there is a set of rules to obey during process modelling [11]:

1) Each process starts and finishes for a specified customer (receiver) who determines requirements and takes advantage of the effects of processes (process individualisation).
2) Each process consists of subprocesses, operations and other basic components (process structuralisation).
3) Each process has a party responsible for the process, its own "owner" (determining process responsibility).
4) In each process one object is transformed / produced (determining a process object).
5) Process components that do not provide a value added are eliminated (focus on creating a value).
6) For each process the best structure (taking time and other resources into consideration) is determined (shaping the course of a process).
7) Each process must be properly protected by the supplier (the input arrangement with the supplier).

While modelling there is a rapid transfer of information about performing a part of a task because it is the start of another part that determines the effectiveness of operations (eliminates unproductive time wasted on waiting for an order and the periods between tasks). It is easy to get statistics concerning how long individual tasks were performed and also a statistical analysis of the length of a work cycle. Process models not only make designing organisation structure easier but also provide a graphical visualization and simulation of the real process [12].

The results of process modelling must be documented. That is why, the name of a process, its starting and final points, aims, criteria, party responsible for a process, object of a process, input with a supplier, output with a receiver and other additional information should be provided on special templates. You cannot include too much information about a process because it may make the description illegible [13]. However, you can always distinguish 10 basic stages of creating a model, using it for simulation and implementing the results (Figure 1).
Many details of the logistics process management require the use of information technologies. In the market there are not fully-integrated tools dedicated to the needs of logistics process management. There are some IT tools facilitating a process analysis of a company and they serve well in improvement processes on a large scale and in the long term [16]. They are a part of the rapidly-developing concept called Business Process Modelling (BPM) and provide a graphical presentation of logistics processes.

Process modelling tools can be divided into three groups [15]:

- programs for creating diagrams are used in visualizations, process mapping by means of diagrams and documentations, e.g. MS Office Visio 2007, iGrafx FlowCharter (Corel), cheap and easily operated,
- CASE tools (Computer Aided Software Engineering) - for process modelling especially when they are to be integrated with IT solutions, e.g. Designer / 2000 (Oracle), Select Enterprise (Select Software),
- advanced tools for designing and improving processes, for advanced analyses and simulations, such as iGrafx Process / iGrafx Process for Six Sigma (Corel), ARIS Toolset (IDS Scheer) [16], Adonis (BOC GmbH), Workflow Analyzer (Meta Software) or process modelling tools in ERP systems (built in these systems), e.g. IFS Business Modeler. They are relatively expensive and difficult to operate.

Although there is a wide range of available IT tools facilitating process mapping and many consulting companies, MS Word and Visi still remain the most commonly used tools.

4. BPMN AS A TOOL FOR MAPPING AND MODELLING LOGISTICS PROCESSES

Transport, forwarding and logistics oriented processes gained popularity and intensified the search for efficient tools for process modelling, analyses, optimization and automatic creating of applications stimulating these processes in IT environments [10].

An example of a tool that got recognition is Business Process Modelling Notation, usually known as BPMN. It is accompanied with a special language BPEL (Business Execution Language for Web Services) based on XML (Extensible Markup Language) which creates a code of a program that stimulates a process described by BPMN.

BPMN became a graphical standard for business process modelling and a standard for service description. It offers semantics and syntax of a language of diagrams that describe processes. BPMN offers a range of advantages in business process modelling in comparison to UML (Unified Modelling Language). First of all, BPMN offers the technique of modelling process flows and workflows. The technique is adjusted better to modelling ways used by business analytics. Secondly, reliable mathematical basis provides direct transformation into the execution languages of business processes while UML does not offer it. BPMN may be transformed to UML and a process model can be a starting point for designing systems via UML tools.

![Figure 1 Stages of creating a model and implementation of its results](image-url)
Generally speaking, BPMN is process mapping and provides a graphical notation of a process or a complex of processes / operations and their interrelations [20,21]. There are some special graphical symbols used to describe elements of a process map. The advantages of BPMN in logistics process mapping are:

- A user-friendly way of describing a logistics process helps experts and other users understand it better,
- Symbols used in process mapping are well-known in many countries which makes it easier to compare standards between companies from many countries,
- Identification of key operations in a given process and specifying necessary inputs and outputs in a given operation,
- Identification of unnecessary operations (that do not provide a value added) such as storing semi-manufactured products between operations, internal transport etc.

BPMN diagrams can be unambiguously translated to other standards - BPEL and XPDL (Process Definition Language). It is helpful in migration between tools of process implementation.

BPMN provides a detailed description of one business process diagram called BPD (Business Process Diagram) which was to serve two purposes. Firstly, it can be easily understood and used. It may be used for quick and easy logistics process modelling since even users without technical abilities will comprehend it. Secondly, with BPMN you can model complicated complex logistics processes and transform it into any execution language of business processes.

In logistics process modelling one has to model only operations starting the process, then operations which carry out the process and finally potential results of the process. Decisions and branched processes are modelled by means of decision nodes regardless of the kind of tool that models the process - the emphasis was put on a comprehensive description for all users irrespective of the used tools. However, to achieve the best possible results an approach should be supplemented by simulation of a process [10].

There are also plenty of limitations and drawbacks of BPMN [19]:

- Can be used only for business process modelling,
- Does not model data flow but only control flow (data can be additionally described),
- Does not inform users about a structure and access to data (especially in a safety section),
- Hardy describes dynamic groups and the hierarchy of users,
- The organisation of a company is poorly presented.

However, in spite of all the mentioned drawbacks BPMN remains the best tool for logistics process mapping, modelling and simulation.

5. CONCLUSION

Logistics process mapping and modelling in BPMN notation is essential to comprehend and connect logistics processes with the business ones in the whole company and provide firm support for other modelling techniques like entity-relationship modelling, designing systems and application by means of UML, designing XML schemes and designing network architecture. All these methods of modelling help a company understand and work out functional architecture in such a way that it accelerates responses to changes in a safer manner. Due to the careful verification of efficiency and effectiveness before logistics process implementation there would not be expensive mistakes any more.

Thanks to using BPMN notation, mapping and modelling let us improve existing processes, implement a process structure in an organisation, understand existing processes better and eliminate or simplify the ones that need to be modified.
REFERENCES

INTELLIGENT SYSTEM FOR RISK MANAGEMENT DEDICATED TO ROAD TRANSPORT COMPANIES

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Abstract

In the presented paper, authors focus on the issues connected with risk management in road transport processes performance. Following this, in the article the main transport risk management definitions are discussed. Later, there is presented the main assumptions and results of project ZEUS - the integrated system of transport safety. This gives the possibility to define the main guidelines for the conception of risk management system dedicated to road transport companies. Article ends with some conclusions and directions for future research.

Keywords: Risk assessment, transport system, support system

1. INTRODUCTION

The road transport system is sensitive to the occurred disruptions of both, external and internal type. Due to the related responsibility both for their own and other people's property, enterprises performing transport services are particularly vulnerable to various types of risks, the occurrence of which leads to the often enormous damages and losses. Therefore, it is crucial to recognize the sources of risk, which will influence both its causes and effects, helping to maintain continuity and timeliness of the transport process performance [1]. Following this, in the article authors focus on the issues connected with risk management in road transport processes performance. The aim of the article is to present the guidelines and main assumptions for risk management system dedicated to road transport companies. As a result, in the next Section, there is provided a brief overview of the literature in the area of transport risk management. Then, authors focus on the presentation of the main assumptions and results of project ZEUS regarding the integrated system of transport safety and being carried out in 2007-2010 time period. This allowed for developing the conception of risk management system dedicated to road transport companies that bases on ISO 31000 standard and Enterprise Risk Management conception implementation. The article concludes with a summary and guidelines, including directions for further research.

2. RISK MANAGEMENT IN TRANSPORT - REVIEW

Risk management for transport system performance has received a growing interest in recent years, see e.g. [3, 4, 5] for comprehensive reviews. In parallel, there is a recent focus on risk assessment and risk management in scientific environment, concerned with risk analysis, risk perspectives, or decision-support issues [6].
There can be found many risk definitions in the recent literature. If we study the research works we find a number of different ways of understanding the risk concept. Some definitions are based on probability, chance or expected values, some on undesirable events or danger, and others on uncertainties [7]. These definitions have been comprehensively overviewed and classified in works e.g. [3, 7, 8, 9]. Taking one step further, the risk management field is investigated in two main pillars: the main risk management strategies available, and the structure of the risk management process. For a review of major strategies commonly used to manage risk we refer to [6]. The risk management process can be broken down into the six main steps (compatible with e.g. ISO 31000 standard): a) establishing a context, b) identifying hazards and threats, c) conducting cause and consequences analysis of these events, d) making judgements of the likelihood of the events and their consequences, e) evaluating risk, f) risk treatment [6]. The transportation risk management issues are investigated in [10]. Following the author, the risk management is focused on two primary causes of concern, natural and man-made disasters. According to Cirjaliu et al. [11] the transport companies should focus on the implementation of occupational risk methods. In this context, there can be defined a lot of organizational and technical factors that can influence on risk in transportation, like: the size of the company, the nature of the business, the safety culture in the company, the presence of safety management systems in the company, or fleet size. The classification of the main transportation system disruptions is given in e.g. [12, 13]. The transportation risk issues are also investigated in e.g. [3, 14], were the maritime transportation issues are overviewed, in [4, 15], where safety management issues are analysed, or in [5, 16] focused on transportation disruptions and decision support systems.

Following a literature review, there can be defined the four main problematic areas (1) hazardous material transport performance, (2) transportation infrastructure issues, (3) accidents in transport, and (4) environmental protection issues. Usually, the proposed scientific research regards to the chosen type of risk issue without taking into account the numerous links with other groups of threats and hazards. Thus, there is still the need for research works in the area of holistic approach for risk management performed in transport companies.

In the '90s a particular importance was gained by a holistic approach to the risk analysis in the form of the concept of Total Risk Management (TRM). Heimes [17] defined TRM as a systemic, statistically based, and holistic process that builds on formal risk assessment and management (answering the previously introduced two sets of triplet questions for risk assessment and risk management) and addresses the set of four sources of failures within a hierarchical-multiobjective framework: (1) hardware failure; (2) software failure; (3) organizational failure; (4) human failure. On this basis, there was developed a conception of Enterprise Risk Management (ERM). The Committee of Sponsoring Organizations of the Treadway Commission (COSO) provides a definition of ERM that has gained considerable acceptance [18]. In comparison to the earlier risk management approaches, ERM is more holistic and stresses all the risks that an organization may be facing. It promotes a ‘portfolio approach’ to risk management. It provides a structure that links various risks together. It promotes risk management that does not merely focus on the sum of various risk elements. It should also consider risk interactions (see e.g. [18, 19, 20, 21]). The possibility of this conception implementation in road transport companies’ performance is analysed based on the investigation of ZEUS project principals and risk management system conception development.

3. AN INTEGRATED SYSTEM OF TRANSPORT SAFETY (ZEUS PROJECT) [22, 23]

In 2007-2010, a scientific consortium led by the Gdansk University of Technology carried out the research project entitled “The integrated system of road safety - ZEUS”. The main objective of the ZEUS project was to develop a model of an integrated transport safety system so that it serves as a tool for policy-makers to make the right decisions concerning the construction and development of infrastructure and transport means, as well as for professionals implementing these decisions. This project concerned the development of a uniform safety
management system in all modes of transport: road, rail, air, and water. However, due to the research area, the authors focus only on the characteristics relating to road transport system performance.

In the performed project work, the risk in road transport was defined as the uncertainties of taken by human activities. The risk was also linked closely to the issue of choice understanding as:

- taking a decision regarding the risk of dangerous behaviour with having a knowledge that there may happen an accident, or
- an attempts to limit, reduce or eliminate the risk of an accident occurrence by driving appropriate to the existing conditions.

The authors of the project also found that the risk in road transport is a combination of the probability of hazard event activation and caused in connection with it the damages or losses. They identified the two types of risk in road transport: the engineering risk and economic risk. Engineering approach applies to the activities carried out by the municipal roads in the course of the life cycle of the road technical objects (planning, design, construction, operation and maintenance), where should be used the full procedure of risk management (analysis, evaluation, elimination, and information). The risk here is the category associated with the choice of action or omission. The approach is similar to the economic but related to individual traffic participants. The driver, in order to achieve the pursued objectives (e.g. travel time), decides to take risky actions, especially in situations of bad traffic conditions or adverse weather conditions. The benefit is then the reduction of travel time by driving at a speed much higher than the permitted, and the loss can be connected with obtaining a mandate for dangerous driving. Simultaneously, the project authors adopted the two groups of measures for analysis and risk assessment for the road network: individual risk and social risk. Individual risk was attributed to the behaviour of a single participant traffic on the road. It is the probability of loss of a specific gravity within a single journey or during the time period in which the traffic participant is exposed to the danger caused by road infrastructure and traffic. The social risk was referred to the behaviour of the entire groups of road users in the selected area. It was defined here as a loss (the number of victims and material losses suffered and occurred in road accidents) in a given time period, in a selected area, which can predictably occur as a result of hazardous events caused by a malfunction of the safety system.

In their research studies, the authors of the project emphasized clearly that in contrast to many fields of engineering, there had not been yet developed a uniform method of risk management for road transport. There are created only the basis for relevant methodology that is established on standard elements: risk analysis, valuation and risk assessment, and the removal of risk and control of remaining risk.

Based on the conducted analyses, it was found that the integration of risk management methods in road transport should aim towards: (a) the implementation of integrated risk management in organizations involved in the management of road transport (ministries, agencies, local authorities); (B) the development and implementation of integrated method for risk management of the road network; (C) the development and implementation of risk management method in road transport companies; (D) harmonization of risk management methods between different modes of transport, through the creation of general management principles.

4. CONCEPTION OF RISK MANAGEMENT SYSTEM DEDICATED FOR ROAD TRANSPORT COMPANIES

The results of published studies conducted in the framework of the ZEUS project were concerned with the narrow view of risk management in road transport. The project authors deliberately confined them mainly to transport security, for which the main measure of risk is the number of recorded accidents. This resulted primarily from the objectives of the project, the effects of which were created to serve departmental transport safety strategy. It would therefore be right to indicate the need to develop and implement of risk management
method in the road transport company. However, making research efforts aimed only at safety issues are currently not sufficient. It is necessary to broaden the look at the risk factors associated with transport activities performance. Risk analysis should therefore apply not only to the issues of transport safety, but also its reliability and efficiency. This requires identifying the various sources of danger associated with road transport operators’ performed processes, and the starting point should be a holistic analysis of the process of freight transport performance (see e.g. [24]). So extensive look at the risk assessment requires the need for collection and processing of numerous data of a quantitative (including statistical data, cost and time) and qualitative nature (such as customer preferences, characteristics of routes). Effective use of these data in the form of risk analysis is only possible thanks to the support of appropriate software to support decision-making processes of managers.

For this reason, the authors of the article began their research on the development of an advisory system (class of decision support system) for managers in road freight transport companies and dedicated to its knowledge base in the field of operational risk management. With the use of the Enterprise Risk Management concept, the decision support system will support decision-making processes in the road freight companies by: (a) improving the planning process of transport in conjunction with the maintenance and operation services, taking into account available resources and the efficiency of performed tasks, and (b) improvements of control system on reliability and effectiveness of the transport services utilizing feedback mechanism and the Deming cycle, which guarantees learning process of the organization. The aim of the implementation of such a tool in a transport company is to assist in a comprehensive planning process and available resources of the transport carrier, increasing performance flexibility, shortening decision-making by managers, and reducing the risk associated with the lack of the required information.

The system will be in accordance with the requirements of ISO 31000 standard. The proposed solution will be characterized by a holistic process approach to the management of risk, and will take into account the complexity of the organization of road freight transport. The risk assessment will therefore be structured as a multi-module one corresponding to the defined groups of risks associated with freight transport services (detailed characteristics of particular groups of risk for this process is presented in [12]). Figure 1:

![Figure 1](image_url)

**Figure 1** The groups of risk in the freight transport performance
Based on: (a) the frequency of occurrence of monitored events (or the likelihood of their occurrence) and (b) the consequences of each event for the business enterprise, which values are defined by the decision-makers on the basis of parameters estimated by the system - the algorithm will evaluate the risk parameters with accompanied costs. On the basis of estimated risk parameters, there will be possible to prepare multi-criteria analyses corresponding to the information needs of decision makers in the company. This will allow for the optimization of processes and taking important steps from the point of view of the rational use of vehicles based on, among others, the type of operating technical objects, type of cargo, route, or logistics and maintenance facilities. For risk identified at medium and high level, there will be prepared suggested performance scenarios, supplemented by the estimated costs of their completion and execution times. It will be also possible to define the best solution for given boundary conditions. In order to ensure the function of organizational learning, the reporting process integrated into the knowledge base will provide the information necessary for continuous improvement of developed scenarios. Algorithms for monitoring the correct implementation of processes will be based on the individualized system of control indicators. They let for keeping responding to changing operating conditions. This enables flexible operations that limit the effects of existing threats, as well as the implementation of preventive actions (based on the results of the implemented Deming cycle). An important innovation of the prepared solution will also be connected with taking into account the specifics of the operation of transport companies and with the inclusion of analyses based on the concept of Risk Based Maintenance (RBM) to the prepared tool.

5. SUMMARY AND CONCLUSIONS

Analysis of the available tools to support risk management in organizations has shown that, at present, there is no available product at the Polish market, which is consistent with the analytical and decision-making needs of managers employed in the road transport enterprises.

REFERENCES


SESSION C:
TRANSPORT
FORECASTING TRAFFIC FLOW AT THE INTERSECTION BASED ON CYCLICAL FLUCTUATIONS

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Abstract

Forecasting future volume of traffic at the intersection may lead to increase the drivers safety on city roads. The possibility of realization forecasting methods for the transportation system is an important element of traffic management in the city. In the article the forecast for future periods on the basis of cyclical fluctuations in the traffic flow using the method of harmonic analysis will be calculated. The forecast data obtained from the intersection of the Słowackiego and Łobzowska street were registered with an interval of time during one week. Cyclical fluctuations are typical for the period exceeding one year. The article aims to prove the application of harmonic analysis for hourly periods in forecasting traffic flow at the intersection. The forecast is confirmed using mean absolute percentage error for long-time periods.

Keywords: Forecasting traffic flow, cyclical fluctuations, spectral analysis

1. INTRODUCTION

When trying to explain changes in the time series, it is necessary to perform its decomposition, i.e. the extraction of the elements through which it is characterized. Splitting the time series into separate components it allows us to understand the fluctuations that occur in the studied phenomenon. The components are as follows:

- secular trend or long term variations,
- seasonal variations,
- cyclical variations,
- irregular variations [1].

To isolate the impact of cyclical fluctuations in the model-building process and its consideration in the forecasting process improves prediction accuracy.

In the analysis of time series, you notice it changes, cyclical, periodic. They occur at the same stage of change for equal intervals of time. The time period for the development of all phases, is called the oscillation period or cycle. Cyclical fluctuations are difficult to simulate because of the length of cycles and amplitude of oscillations which are less regular than seasonal fluctuations. Cyclicity may occur in cycles of different frequencies, for example, it is high when fluctuations occur frequently; low, if fluctuations occur rarely. Cyclicity may also occur in cycles of different length (short, long) and different nature (regular and irregular). Therefore, it is understood as a change that is repeated in a regular, rhythmical, recurring at intervals.

In the transport field methods of spectral analysis that identifies cyclical fluctuations are rarely used. Usually the yearly changes are studied under trend, therefore, the changes that occur for period more than one year come under the category of cyclic changes [2]. Increasingly, scientists use the harmonic analysis method in search of cyclical fluctuations in periods shorter than one year. In work [3], he used it for a prediction in the field of transportation as real-time traffic flow. In turn, Zhang [4] as an element of a hybrid method use spectral analysis in short-term traffic flow forecasting. The efficiency of harmonic analysis for a short period of time based on product demand was demonstrated in work [5].

This work is an attempt to create predictions based on spectral analysis, i.e. one which takes into account the cyclical nature of the time series, as one of the elements of its decomposition. This method does not fully
identify all aspects of cognitive time series and draws attention to the cyclical changes, as an element playing important role in the process of forecasting future values.

2. BACKGROUND SPECTRAL ANALYSIS

Spectral analysis is one of analysis, which is transforming the time series into the frequency domain. This method appeared thanks to J. Fourier, in 1807, proved that the values of the time series exhibit a certain periodicity, can be approximated with any accuracy through the ranks with a correspondingly large number of elements. These series are called harmonic Fourier series.

Spectral analysis is a kind of converting time series into the sum of the sine waves and cosine [6]. Fourier analysis is essentially concerned with approximating a function by a sum of sine and cosine terms, called the Fourier series representation [7]. The model is constructed as a sum so-called harmonics. The quantity of harmonics for \( n \) observations is \( n/2 \). First harmonic has a period equal to \( n \) - number of all observations, the second \( n/2 \), the third \( n/3 \), etc. Cyclicality contained in the time series can only be define by harmonic analysis [8].

An important element why using spectral analysis to construct a predictive model is to test the time series from the point of view of stationarity, i.e., constant in time average, variance and autocorrelation of the studied series [9]. To examine the stationarity of the time series the advanced Dickeya and Fuller test (ADF) developed by Dickeya and Fuller in 1979 will be used [10]. It removes the influence of autocorrelation in the series. In the case of instability, it is necessary to subject the differencing procedure in accordance with the formula

\[
\Delta y_t = y_t - y_{t-1}.
\]

This procedure is used to achieve time series stationarity, however, as a rule, usually no more than three times. The conclusion about the stationarity of time series, most often performed for a significance level equal to \( p = 0.05 \).

3. FORECASTING TRAFFIC FLOW AT THE INTERSECTION USING HARMONIC ANALYSIS

Empirical data, components of time series are the number of cars passing through the intersection of Słowackiego and Łobzowska streets in the period from December 1, 2014 at 1:00 p.m. to 7 December 2014 at 23:00 in hourly periods. Data from each lane at the inlet, they are summed and represent the output of one of the four inlets, which will be considered individually. For prediction at each inlet the data of six days (142 observations), whereas data from the last day to verify forecast (24 observations) will be used.

![Figure 1](image-url)  
**Figure 1** Four-way intersection for studied example (horizontal - Słowackiego street, vertically - Łobzowska street)
The time series graph on each of the four entrances to the intersection in the course of a week is shown in Figure 2.

![Figure 2](image)

**Figure 2** The time series of the number of vehicles at each of the four inlets to the intersection

First, the time series must be checked for the presence of stationarity. Calculated ADF test for all four inlets is sequentially: for inlet 1, $p = 0.0000062$, for inlet 2, $p = 0.0000095$, for inlet 3, $p = 0.0000001$, for inlet 4, $p = 0.0000202$.

The $p$ coefficient of each inlets of intersection is below the level of significance $p = 0.05$, therefore, all time series are stationary and there is no need for their differentiation.

![Figure 3](image)

**Figure 3** Periodograms of the time series for each of the inlets
The basis of spectral analysis is to examine if the time series contains cyclical changes. For this purpose, periodogram, which is designed for detection of periodic oscillations [11]. Periodogram of the number of cars passing through the intersection on any of the inlets is shown in Figure 3.

On the basis of the periodograms, we can conclude that the time series has cyclic fluctuations. In this regard, the harmonics in accordance with the formula (8) and (9) will be assigned. The values of some harmonics that have the largest share in explaining the time series are presented in Table 1. They will be required to build the model and then to determine forecast for future periods.

**Table 1** Harmonics used to build the model

<table>
<thead>
<tr>
<th>Number of harmonic</th>
<th>Designation</th>
<th>Inlet 1</th>
<th>Inlet 2</th>
<th>Inlet 3</th>
<th>Inlet 4</th>
<th>Contribution [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>n/5</td>
<td>-</td>
<td>2.29</td>
<td>-</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>n/6</td>
<td>79.69</td>
<td>81.81</td>
<td>65.87</td>
<td>81.16</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>n/11</td>
<td>-</td>
<td>-</td>
<td>3.47</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>n/12</td>
<td>8.90</td>
<td>4.11</td>
<td>16.39</td>
<td>4.57</td>
<td></td>
</tr>
</tbody>
</table>

Source: own elaboration

The dominance of the harmonic No 6 on each of the inlets is a result of the occurrence of a traffic lights at the intersection. It affects the appearance of cycles in traffic.

Using harmonics from the Table 1 and the model parameters in the process of converting a time series into a frequency domain the models were built. For each inlet models are as follows:

$$y_{R1} = 1684.23 - 1023.68 \cdot \sin \left( \frac{2\pi}{142} t \right) - 629.201 \cdot \cos \left( \frac{2\pi}{142} t \right) - 380.486 \cdot \sin \left( \frac{2\pi}{142} t \right) + 128.495 \cdot \cos \left( \frac{2\pi}{142} t \right)$$

$$y_{R2} = 476.73 + 45.09 \cdot \sin \left( \frac{2\pi}{142} t \right) + 39.3 \cdot \cos \left( \frac{2\pi}{142} t \right) - 299.32 \cdot \sin \left( \frac{2\pi}{142} t \right) - 194.81 \cdot \cos \left( \frac{2\pi}{142} t \right) - 67.47 \cdot \sin \left( \frac{2\pi}{142} t \right) + 43.14 \cdot \cos \left( \frac{2\pi}{142} t \right)$$

$$y_{R3} = 1146.54 - 525.5 \cdot \sin \left( \frac{2\pi}{142} t \right) - 432.68 \cdot \cos \left( \frac{2\pi}{142} t \right) + 148.39 \cdot \sin \left( \frac{2\pi}{142} t \right) - 49.22 \cdot \cos \left( \frac{2\pi}{142} t \right) - 336.11 \cdot \sin \left( \frac{2\pi}{142} t \right) + 48.93 \cdot \cos \left( \frac{2\pi}{142} t \right)$$

$$y_{R4} = 367.71 + 36.03 \cdot \sin \left( \frac{2\pi}{142} t \right) + 38.6 \cdot \cos \left( \frac{2\pi}{142} t \right) - 222.83 \cdot \sin \left( \frac{2\pi}{142} t \right) - 193.53 \cdot \cos \left( \frac{2\pi}{142} t \right) - 66.88 \cdot \sin \left( \frac{2\pi}{142} t \right) + 20.89 \cdot \cos \left( \frac{2\pi}{142} t \right)$$

Based on the constructed models the coefficient of determination $R^2$ was determined. It gives a proportion of the variance in the dependent variable that is predictable from the independent variable. The coefficient of determination is assigned by the formula:

$$R^2 = \frac{\sum_{i=1}^{n}(\hat{y}_t - \bar{y})^2}{\sum_{i=1}^{n}(y_t - \bar{y})^2} \quad (1)$$

where:
- $y_t$ - actual value of the variable in period $t$,
- $\hat{y}_t$ - model value,
- $\bar{y}$ - arithmetic mean of the dependent variable.

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The determined coefficients of determination equal:

- for inlet 1, \( y_{R1} = 0.871 \),
- for inlet 2, \( y_{R2} = 0.947 \),
- for inlet 3, \( y_{R3} = 0.788 \),
- for inlet 4, \( y_{R4} = 0.912 \).

To create predictions for each of the inlets of the intersection constructed model can be used. Substituting the future variable of \( t \) in the formula, it is possible to forecast values for future periods. Of the 166 142 observations were used for making models, while the remaining observations were used to verify the forecast. Forecasts along with the actual data is shown in Figure 4.

![Figure 4 Actual data along with the forecast](image)

**Figure 4** shows, a relatively good coverage predictions with the actual data. It should be noted that the forecast was calculated for 24 periods ahead. In the case of long-horizon forecasting, we can conclude that the farther into the future, the forecast is fraught with even greater error. In the presented example, it is possible to observe that the cyclic factor, acting in the considered time series has consequences even in periods far from the beginning of the forecasting period. It is well illustrated by using mean absolute percentage error (MAPE) in Figure 5.

The largest forecast error for all inlets is from 6th to 14th period. The largest forecast error is 662% for the fourth inlet in the 9th period forecast, and the lowest of 0.31% for the first inlet in 17th of the forecast period. In **Figure 5** you can see that with the 14th period, the average forecast error for the subsequent periods is very small and ranges from 0.31% to almost 20% in long-term period of time.
4. CONCLUSIONS

From the conducted research it follows that the number of vehicles at the traffic light intersection is characterized by cyclic changes. The largest share in explaining the time series have a harmonic no 12, that is, 142 / 12 (n / 12) means that the number of cars varies cyclically every 12 hours. This allowed to build a model for each of the inlets with a high adoption rate of the model on real data.

On the basis of the model the forecast for 24 periods into the future was created. The forecast has been tested on the basis of the mean absolute percentage error. The results are impressive, because the farther into the future, the forecast is more accurate. This is due to the work of the traffic lights at the intersection, which provides the cyclic changes of passing vehicles. Periods in which recorded the highest mean absolute percentage error are periods devoid of cyclical fluctuations and vice versa. The results show that on the basis of cyclic changes, you can achieve a relatively accurate long-term forecast.

Based on these results emphasize the usefulness of harmonic analysis in the long-term forecasting. Further studies to establish the length of time that you can predict the future based on the spectral analysis will be carried out.

REFERENCES

DEPENDABILITY OF THE TIME OF THE DELIVERY PROCESS ON THE LAST 100 METERS IN THE CITY CENTER FROM THE ENERGY EXPENDITURE OF THE SUPPLIER

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Abstract

This article presents a proposition of classification of work of the supplies in the time of the delivery process at the last 100 meters in the city center. Based on fieldwork with 900 points it has been shown how the energy expenditure of supplier depends on the technology used to unload and the movement of goods to the customer. This article presents a proposition for creation of the computer software to calculate the energy expenditure of the supplier.

Keywords: City logistics, delivery process, energy expenditure, ergonomic

1. INTRODUCTION

Energy expenditure of work of the supplier under of the time of delivery is strongly connected with the technology used for unloading and the movement of goods to the customer.

Based on the fieldwork with 900 points it has been shown in the previous research of the change of the actual total time of delivery, depending on the technology used for the unloading and movement of goods to the customer [10].

2. AREA OF INTEREST

The energy expenditure of human labor is very important for the planning of the work of the delivery of goods in the city center. The fatigue of suppliers has influenced the total costs of reliability of the delivery process in the city center. The cost of reliability of delivery is commonly analyzed based on reliability strategies [1], usage of the LCC method (Life Cost Cycle) [2], or analysis of the costs.

The reliability of the delivery in the city center is linked with the reduction of the unloading time by using the technical solution for the handling of the materials. The reliability of the delivery we can describe thus uses the formula 7 R, which is well known in the area the logistics [3]:

a) right product,
b) right quantity,
c) right condition,
d) right place,
e) right customer,
f) right price.
g) right time.

Reliability is the right time when we expect the ordered cargo from the supplier. In area of interest of the city logistics is very often described of the terminology of the delivery. The delivery process is the last phase of the supply chain - from the last warehouse to the recipient. Here due to the difficult conditions for the delivery vehicle, problems with stopping and the obstacles with the accessing time to the city center [10] exist. The urban goods movement (UGM) that is integrated with modeling of the effort needs to address issues
associated with congestion and the air quality with respect to the interaction of the urban structure to land transport [16]. Goods movement is the last phase of the delivery process in the city center (Figure 1).

![Figure 1](Image)

**Figure 1** Place of the movement of goods in the supply chain and delivery process (own work).

3. DEFINITION OF THE PROBLEM

It indicates how technology is used and the method of unloading the goods to the customer movement affects the energy expenditure of supplies in the city center. This limits the reliability of the time of delivery. This model shows the relationship between the proportion of the time for unloading goods to the energy expenditure of the supplier. This has an influence on the condition of the supplier, who may be tired if his energy expenditure during the time of delivery is more than the legal regulations. The tired person may work slower and, as a result, we may obtain a delay of ordered cargo for the customer. The proposed methodology allows for delivery managers in the city center to calculate the profit or loss of money and time, through the introduction of appropriate technology for the delivery of supplies in the city center. It was pointed out that with the appropriate preparation of the ordered consignment, a few minutes at unloading and delivery to the customer can be saved as well as good protection of the health conditions of the supplier.

Additional care must be taken when inserting the formula, figures and tables. The following paragraphs directly quote excerpts from [4].

4. CONDITIONS THAT DETERMINE DELIVERY TIME TO THE CUSTOMER

We take into account the former example of delivery cargo for 8 customers with change of the cases of the delivery process. The main elements that determine the total time of delivery are [11]:

a) Vehicle type Rs:

- Maximum payload / tare weight limit,
Whether it has a floor equal on the entire width and length; this affects whether a EUR pallet without unloading of goods can be used; if you need the goods spread out on the vehicle,

b) Vehicle equipment Ws:
- Is equipped with racks as in the warehouse inside the cargo space; if the racks for the goods before delivery must be extended; if not, the goods can be loaded directly onto pallets as long as the floor is equal on the entire width and length
- Is equipped with a self-unloading device, lift gate or HDS crane,

c) The equipment of the driver for unloading Wkpsr auxiliary equipment, trolley with two or four wheels, etc.

d) The actual conditions of traveling to collect goods Fwrd:
- Whether a dealer has his own place for the supply of goods,
- If access to the site for delivery of goods is always ensured,
- Whether the place of delivery for goods is not occupied by other vehicles,
- Does trading allow the use of the pallets, i.e. whether its door openings are not too narrow for passing pallets 800mm wide.

e) Equipment of the recipient with the auxiliary unloading equipment, trolley with two or four wheels, etc. Wopsr

f) The size of the portion of the delivery Wd.

Therefore, the delivery time to do so can be saved, depending on the aforementioned variables:

\[ T_d \{ R_s, W_s, W_{kpsr}, F_{wrd}, W_{opsr}, W_d \} \]  \hspace{1cm} (1)

Consider a hypothetical delivery of goods with a total mass of 250 kg [13].

Case 1 - We assume that delivery truck gets a load in the form of packaging arranged in packets orders for each recipient. The delivery vehicle does not have a smooth floor of the load box over the entire width and length (Figure 2). The supplier uses only his hands for the entire process.

Figure 2 Delivery truck equipment with a lift gate with packages of cargo on pallets for each recipient (Own work).
Case 2 - Loading is done in the warehouse, and pallets are loads of packages in the form of homogeneous cargo so that the same type of goods are on each pallet (Figure 3); the supplier shall for realization of the complete of the delivery process of consecutively with each pallet individually. The supplier uses only his hands for the entire process.

Case 3 - Loading is done in the warehouse, and pallets are loads of packages in the form of homogeneous cargo that on each pallet there are the same type of goods; the supplier realizing the supply uses a platform hand truck with a capacity of 150kg (Figure 4).

Case 4 - Loading is done in the warehouse, and on pallets - i.e., each pallet is placed in packets for successive orders; the carrier realizing supply uses a mechanical device for self-unloading and a hand fork truck for pallets, self-propelled or not. The carrier does not wait for unloading pallets. The recipient and store owner participate actively in the implementation of delivery (Figure 5).
Case 5 - Loading is done in the warehouse, and pallets are loads of packages in the form of homogeneous cargo that on each pallet there are the same type of goods; the carrier shall for realization of the complete of the delivery process of consecutively with each pallet individually. The supplier is obliged to charge for transfer across the threshold of the store (Figure 6).

We can collect these data to analyze delivery time from the longest to the shortest time (Table 1).

Table 1 Unloading time depending on unloading technology, from longest to shortest time (Own work)

<table>
<thead>
<tr>
<th>Case of delivery</th>
<th>case2</th>
<th>case5</th>
<th>case1</th>
<th>case3</th>
<th>case4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unloading time</td>
<td>51.875</td>
<td>29.725</td>
<td>28.875</td>
<td>24.05</td>
<td>9.1</td>
</tr>
<tr>
<td>for 5 m distance</td>
<td>0.864583333</td>
<td>0.495416667</td>
<td>0.44791</td>
<td>0.400833333</td>
<td>0.151666667</td>
</tr>
</tbody>
</table>

Based on the field research, the conclusion is that the conditions that determine the delivery time to the customer depend on the technology used for unloading and the movement of goods.

5. ANALYSIS OF ENERGY EXPENDITURE OF THE SUPPLIER

Without auxiliary transport equipment, the person who works as a driver and supplier at the same time is exposed to being very tired. For analysis of the workload, we can use ergonomic tools.

In Poland, the regulation for handling work is described as the maximal energy expenditure for man per one workday is for light-medium-hard work 6300 [kJ] ([kcal]). The maximal distance of handling the cargo is 25 m, with 25kg. This regulation suggests that the maximal mass of handling less than 1 m will be less than 120kg per 1 minute, 7000kg per 1 hour and 12000kg per one workday. Maximal energy expenditure per man should be no more than 8400 kJ [8].

On the basis of the ergonomic calculation, we assume to analyze the parameters of energy expenditure in the time of the delivery in the city center (Table 2).

Table 2 Parameters of energy expenditure under delivery in city center. Own work

<table>
<thead>
<tr>
<th>Operation</th>
<th>Energy expenditure [kJ/min]</th>
<th>Index</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving delivery vehicle in city center</td>
<td>10.0</td>
<td>Esdvc</td>
<td>[4]</td>
</tr>
<tr>
<td>Loader</td>
<td>23.8</td>
<td>Eload</td>
<td>[7]</td>
</tr>
<tr>
<td>Warehouse man</td>
<td>26.2</td>
<td>Ewrhs</td>
<td>[7]</td>
</tr>
<tr>
<td>Preparatory activities</td>
<td>10.47</td>
<td>Eprac</td>
<td>[7]</td>
</tr>
<tr>
<td>Going without weight</td>
<td>12.9</td>
<td>Egm c</td>
<td>[9]</td>
</tr>
<tr>
<td>Pulling 150kg trolley</td>
<td>35.6</td>
<td>Ep150kg</td>
<td>[9]</td>
</tr>
<tr>
<td>Pulling 250kg pallet truck</td>
<td>45.6</td>
<td>Ep250kg</td>
<td>[9]</td>
</tr>
<tr>
<td>Pulling empty trolley</td>
<td>20</td>
<td>Emp150kg</td>
<td>Own work</td>
</tr>
<tr>
<td>Pulling empty pallet truck</td>
<td>25</td>
<td>Emp250kg</td>
<td>Own work</td>
</tr>
</tbody>
</table>

The maximal of the energy expenditure in the time of the delivery in the city center is strongly connected with the case of delivery. We can calculate this based on the use formulas.
Case 1 and Case 2

\[ E_{ed} = t_{o1} \cdot E_{prac} + n \cdot v_{pzl10kg} \cdot l \cdot E_{wrhs} + n \cdot v_{p} \cdot l \cdot E_{gmc} + n \cdot t_{o2} \cdot E_{load} + t_{zd} \cdot E_{prac} \]  
(2)

Case 3

\[ E_{ed} = t_{o1} \cdot E_{prac} + n \cdot v_{jzl150kg} \cdot l \cdot E_{p150kg} + n \cdot v_{jp} \cdot l \cdot E_{mp150kg} + 2 \cdot n \cdot t_{o2} \cdot E_{load} + t_{zd} \cdot E_{prac} \]  
(3)

Case 4

\[ E_{ed} = t_{o1} \cdot E_{prac} + n \cdot v_{jzl250kg} \cdot l \cdot E_{p250kg} + n \cdot v_{jp} \cdot l \cdot E_{mp250kg} + n \cdot t_{o2} \cdot E_{load} + t_{zd} \cdot E_{prac} \]  
(4)

Case 5

\[ E_{ed} = t_{o1} \cdot E_{prac} + n \cdot v_{jzl250kg} \cdot l \cdot E_{p250kg} + n \cdot v_{jp} \cdot l \cdot E_{mp250kg} + n \cdot t_{o2} \cdot E_{load} + t_{zd} + t_{roz} \cdot palez \]  
(5)

Where

Td - delivery time

t_{o1} - the time of the carrier to the customer, checking invoices, an indication of the view loads in the store or in front of him,

n - number of complete cycles of cargo transfer from the vehicle to the store,

v_{pzl10kg} - the speed of the human walking distance with a 10kg load

v_{p} - a speed of the man walking on this distance without load

l - distance between the place of delivery to the point of receiving

t_{o2} - time of opening of the doors of load box on the car, retrieve the cargo, and the closure of the cargo box from 2 = 0.5 min

t_{zd} - time to close the load door of the box truck after delivery of the last batch, checking documentation, the passage of the carrier to the cab driver, taking a seat behind the steering wheel to check the next trip, setting driving directions, starting the engine.

t_{o2} - opening time of load box

v_{jzl150kg} - the speed of the man pushing a the truck with a 150kg load

v_{jp} - the speed of the man pulling of the empty the truck

v_{jzl250kg} - the speed of the man pushing the truck with a 250kg load

v_{jp} - the speed of the man pulling of the empty the truck

t_{roz} - pallet unloading time at the threshold of the store.

Other parameters are given from the former example (Figure 8). Energy expenditure of delivery 250kg with a change in the distance between the box of the delivery vehicle and the doors of the trade point is in Figure 9.

Now, we do the calculation of the total energy of the expenditure of delivery for eight trade points with a change in the distance between the box of the delivery vehicle and the doors of the trade point from 5 to 30 meters. For each trade point, carrying one pallet with a total mass of 250kg is placed on the typical delivery vehicle with 8 EUR pallets (Figure 10).

The results shows for us (Figure 11) that if the supplier did a delivery using case 2, the total energy expenditure is obtained at the 6th pallet for a distance 5 meters between box of the delivery vehicle and the doors of the
trade point. If between the box of the delivery vehicle and the doors of trade point is about 30 meters, the total energy expenditure is obtained at the 4th pallet. In this moment, the supplier must have rest time and a meal so he can physically refuel.

**Figure 8** Energy expenditure of delivery up to 250kg to one trade point at a 5m distance

**Figure 9** Energy expenditure of delivery 250kg with a change in the distance between the box of the delivery vehicle and the doors of the trade point
Figure 10 Location of pallets inside the delivery vehicle unless than 3.5 tons of the total mass [5]

Figure 11 The energy expenditure of delivery for eight trade points with changes in the distance between the box of the delivery vehicle and the doors of the trade point from 5 to 30 meters

6. DISCUSSION

Simulation of the total energy expenditure of delivery to eight trade points suggest classification of the work of suppliers as the light-medium-hard work with 6300 [kJ]. Tired individuals have weak concentration [12][15]. In the time conditions of the traffic in the city center, the delivery vehicle very often stops at random places [10][12], which could change safety conditions for the supplier. There is higher possibility of accidents happening.
This changes the dependability of this process. It is shown how technology used for the moving of goods influences the total time of the delivery process and the health conditions of the supplier. It suggests the creation of a mandatory law that in all delivery vehicles without any technical equipment, there must be a second person - the loader.

7. SUMMARY

Through analysis of the work of the suppliers in the delivery process on the last 100 meters in the city center, there is a suggestion to create a software program to calculate for analysis of the risk of the dependability of the time of this process from the energy expenditure of the supplier (Figure 12).

![Figure 12: Proposition of the functional structure of software to calculate the energy expenditure of the supplier](image)

The time of unloading of the goods depends on the technology used for unloading and the movement of goods to customers and the energy expenditure of the supplier. It may explain why the ordered cargo is delivered with the delay. Ergonomic studies have shown proposition of the classification of work of the supplier in the time of the delivery in the city center [7]. It is indicated in the associations between inputs and economic effects of the delivery in the city center from the dependability of this process from the ergonomic effort of the supplier.

A similar situation occurs in the time of collecting municipal waste [6]. This model may be used to improve of work of personnel.

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EVALUATION OF A COURIER COMPANY’S OPERATIONS
BY DECISION ANALYSIS METHODS

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Abstract
The main objective of this paper is to point out all deficiencies within the consignment sorting process. The article suggests an appropriate alternative for unloading, reloading, sorting, and loading of consignments, using the multiple-criteria decision making. Within the decision-making process, the emphasis is put on energy consumption and investment costs in the case of using new handling equipment. The proposed solution will reduce the sorting time, decrease the risk of consignment damage, and increase safety and smoothness of work in the depot.

Keywords: Sorting process, multiple-criteria decision making

1. INTRODUCTION
The solution proposed by the article is focused on identification of deficiencies related to the use of a roller conveyor in a depot during the morning and the evening consignments sorting in the depot no. 652. The depot ensures transportation of consignments to 13 smaller areas (Figure 1), referred to as routes. Each route in the depot is assigned a separate sector (site), designated with a number. Individual routes in the depot are separated from other routes by fictive lines on the ground. Sector size depends on the quantity of parcels falling to a particular route. Figure 1 shows the depot layout and consignment sectors.

The evening sorting (Figure 2) and loading is carried out by employees who load consignments according to a designated number of an acceptance depot. Cages are lined in two rows, from the lowest to the highest depot numbers, with the exception of first two cages designated as 660, heading to Bratislava, and without cage 652, as the parcels designated with this number do not have to be sent anywhere - they stay on the pallet overnight at the end of a roller conveyor. In the morning, these parcels are scanned only as items accepted to a depot. At the end of a row, there are Export, HUB, and Export-DE cages. The Export cage is intended for parcels to be sent out of the Slovak Republic, but only within the EU. Parcels heading out of the EU are placed into the HUB cage. This cage also contains guaranteed parcels for which a cage must be also designated with the “Express” label, a box with replaceable envelopes, cash on delivery and acceptance protocols, accounting
documents of cash on delivery payments and cash, and it may also contain parcels incorrectly sorted. The Export-DE cage is intended exclusively for parcels heading to Germany.

![Depot layout for the evening sorting](image)

**Figure 2** Depot layout for the evening sorting

2. IDENTIFICATION OF DEFICIENCIES OF THE CURRENT SORTING METHOD

Pictures, Equations, Tables

At present, sorting is carried out using a roller conveyor. It enables handling piece consignments, transportation of material inside manufacture halls or warehouses. Conveyor’s structure is adjusted for easy manipulation [1]. Disadvantages of a roller conveyor used in the depot are as follows:

- **Constant speed.** A roller conveyor track is set to a constant speed which is not suitable for the morning and evening consignments sorting. When a larger amount of consignments is to be transported, couriers need more time to take over the consignments. If a roller track movement is set to a constant speed, couriers are not able to watch moving consignments on the belt, place them in determined sectors, and scan them at the same time. Parcels not caught and placed to a correct site move forward and accumulate at the end of the belt, where they obstruct the work of other couriers. They often fall off the belt and get damaged.

- **Missing guide rails.** There is only one small guide rail on the roller track. Parcels unusually get stuck there, often causing accumulation and twisting of parcels. In such case, an employee must approach this site and release the stuck parcels. Twisted parcels move from the track centre to the roller track side, fall on the ground and get damaged. The proposed solution - installing higher, funnel-shaped guide rails would prevent from several mishaps and time loss during the parcel directing process.

- **Inappropriate spacing between rollers.** In some cases, rather small parcels, light parcels, envelopes, oval parcels, and similar items are transported in a depot. If the spacing between the rollers is too long, parcels stuck between the rollers and an employee’s intervention is required; sometimes parcels even fall between the rollers down on the ground. In such cases, parcel content or cardboard packaging is damaged. Proposed solution - use of a conveyor with a rubber belt.

- **Dead end of a roller track.** A roller track in a depot is driven by electric motors, with 5m spacing. The last 5 meters of the track is free of any electric drive and rollers are freely placed in a housing. When accumulation of parcels occurs and couriers are busy, parcels fall off. The track is equipped with a manual brake to stop the track instantly, if necessary. Proposed solution - to install a parcel quantity sensor for the purpose of automatic stop of a roller track movement and replacement of a finite roller track with an infinite roller track.

- **Loading and unloading of parcels in the exterior.** During the morning and evening reloading, parcels are unloaded in the exterior. They are relocated by employees from the exterior to a conveyor. Proposed solution - the use of a telescopic conveyor with a rubber conveyor belt or an expendable roller track that may be
positioned to reach even inside a vehicle. In both cases it is necessary to reconstruct the entrance to the depot, extending the door width and building a ramp suitable for the placement of conveyors.

3. PROPOSED ALTERNATIVE SOLUTIONS OF CONSIGNMENT SORTING

An optimal solution was chosen while considering the conveyor location and type and the consignments transport direction. The selection will be carried out while assessing 3 options. Calculation of a conveyor’s output is carried out according to Martinek [2]. The first alternative presents consignment sorting with concurrent placement of a roller conveyor (Figure 2). The second alternative - a circulating roller conveyor (Figure 3), and the third alternative - a combined conveyor (Figure 4).

Conveyors are arranged so that a telescopic conveyor or an expandable roller track may be attached to them. In the case of a combined conveyor, straight sections are formed by a rubber conveyor belt and arch sections of a conveyor track are formed by rollers (Figure 4).

Table 1 shows the strengths and weaknesses of three assessed alternative solutions of consignment sorting. In the proposed alternative 3 of the sorting solution, a consignment handling procedure was characterized. Table 1 shows the strengths and weaknesses of the assessed sorting alternatives and Table 2 shows the basic evaluation criteria and input data for the selection of the most appropriate alternative. The basic evaluation criteria included:
Investment costs. They were determined, in the case of a roller conveyor, on the basis of the quantity and price of electric motors. In the case of a combined conveyor, they were determined on the basis of the price of electric motors and of a conveyor belt, as well as support rollers. A roller conveyor operation requires:

- to buy twelve 1.1 kW motors, and in arch section two 1.1 kW electric motors,
- the price of 1 Siemens electric motor is EUR 178 and the price of 14 electric motors is EUR 2,498.

### Table 1 Analysis of strengths and weaknesses of the assessed alternatives

<table>
<thead>
<tr>
<th>ALTERNATIVES</th>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 Currently used roller conveyor</td>
<td>Simple structure</td>
<td>Parcels accumulation at the end of a track</td>
</tr>
<tr>
<td></td>
<td>Low spatial requirements</td>
<td>Damage to parcels when they fall off a track</td>
</tr>
<tr>
<td></td>
<td>Flexibility for roller track adjustment</td>
<td>Long spacing between rollers</td>
</tr>
<tr>
<td>V2 Circulating roller conveyor</td>
<td>Modular structure made of segments</td>
<td>Higher noise level</td>
</tr>
<tr>
<td></td>
<td>Shorter spacing between rollers</td>
<td>Low friction between parcels and rollers</td>
</tr>
<tr>
<td></td>
<td>Flexibility for roller track adjustment</td>
<td>Reduced space for couriers</td>
</tr>
<tr>
<td>V3 Combined conveyor</td>
<td>Lower noise level</td>
<td>Higher maintenance requirements</td>
</tr>
<tr>
<td></td>
<td>Higher safety</td>
<td>Reduced space for couriers</td>
</tr>
<tr>
<td></td>
<td>Parcels do not slip on a belt</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Elimination of consignments falling off the conveyor</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Telescopic extension of a conveyor</td>
<td>-</td>
</tr>
</tbody>
</table>

A belt conveyor consists of three main parts:

- the first part is 4 metres long and the operation thereof requires a 1.1 kW Siemens motor.
- the second part is 24 metres long and the third part is 20 metres long. A conveyor belt driving requires a 4kW MEZ motor for the price of EUR 249.
- a combined conveyor has two arch roller parts driven by a 1.1 kW motor. The total cost of all electric motors is EUR 1,032.

Power consumption is determined according to the calculation from the output of electric motors according to [2] and the power consumption:

- when a roller conveyor is used, the power consumption per hour at the full capacity will be 15.4 kW,
- when a combined conveyor is used, the power consumption will be 11.3 kW.

**Flexibility.** All assessed conveyor structures are stabile. In the case of a roller conveyor, a conveyor may be extended using an expendable roller track (Figure 5) with the structure formed by joint-connected sections with adjustable track length [3]. In the case of a combined conveyor, a telescopic conveyor may be used, with adjustable height and length, and with the maximum carrying capacity of up to 100 kg. A telescopic conveyor may be extended in length to a triple size (Figure 6), facilitating thus loading and unloading of consignments directly from or to a vehicle [4].
Noise level during the operation. In the case of roller conveyors, the noise is produced by rotation of rollers and chain gears. When combined conveyors are used, the noise level is lower due to reduced number of rollers.

Safety - for conveyors, safety assessment is focused on occupational safety of operators and the risk of injury. In the case of roller conveyors, a person’s arm may be caught between the rollers. In the case of a combined conveyor, the risk of injury is lower, as majority of the track is formed by a conveyor belt.

Table 2 Table of input data for the multiple-criteria decision making

<table>
<thead>
<tr>
<th>Evaluation criterion</th>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V1</td>
</tr>
<tr>
<td></td>
<td>Finite conveyor</td>
</tr>
<tr>
<td>K1 - investments</td>
<td>EUR 0</td>
</tr>
<tr>
<td>K2 - power consumption</td>
<td>4.4 kW</td>
</tr>
<tr>
<td>K3 - flexibility</td>
<td>40%</td>
</tr>
<tr>
<td>K4 - noise level</td>
<td>60%</td>
</tr>
<tr>
<td>K5 - safety</td>
<td>60%</td>
</tr>
</tbody>
</table>

4. IMPLEMENTATION OF DECISION ANALYSIS METHODS WITHIN THE SELECTION OF OPTIMAL CONSIGNMENT HANDLING EQUIPMENT

At present, multiple-criteria decision-making methods play more and more important role in the selection of optimal handling equipment [6,7,8]. Almost none of our decisions are affected solely by a single criterion. An important step within the decision-making is the determination of criteria and subsequent determination of criteria preferences, or weights. Therefore, within the selection of an optimal conveyor structure, 5 basic criteria were determined. In the decision-making process, 2 decision-making methods were used to determine the most optimal solution for consignment handling. The first method is the Decision Matrix Method (DMM), in which the weight αi was specified on the basis of the importance (priority) and a numerical value of the point scale ranges from 1 to 10 for each evaluation criterion. A similar method is used to assign a weight (usefulness) \( u_i \) - to meet the criteria for individual evaluated alternatives, while using the point scale ranging from 1 to 10. This method was designed as the maximisation method [9]. Assigning numerical values to weights and rates of meeting the criteria for individual alternatives was carried out by a group of 3 experts. The resulting order of alternatives was determined on the basis of the largest weighted sum. The results of the decision-making process, while using the DMM method, are shown in Table 3.
### Table 3 Decision-making table DMM

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weights (a_i)</th>
<th>Finite roller conveyor</th>
<th>Circulating roller conveyor</th>
<th>Combined conveyor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\omega_i)</td>
<td>(\omega_i \cdot a_i)</td>
<td>(\omega_i)</td>
<td>(\omega_i \cdot a_i)</td>
</tr>
<tr>
<td>K1 - Investments</td>
<td>5</td>
<td>9</td>
<td>45</td>
<td>5</td>
</tr>
<tr>
<td>K2 - Power Consumption</td>
<td>9</td>
<td>9</td>
<td>81</td>
<td>6</td>
</tr>
<tr>
<td>K3 - Flexibility</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>K4 - Noise Level</td>
<td>7</td>
<td>3</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>K5 - Safety</td>
<td>6</td>
<td>3</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Weighted sum</td>
<td>(\Sigma 173)</td>
<td>(\Sigma 214)</td>
<td>(\Sigma 268)</td>
<td></td>
</tr>
<tr>
<td>Order</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

The second decision-making method was the Forced Decision Matrix Method (FDMM). The principle of FDMM application is analogous to the DMM. The difference consists solely in assigning individual weights to evaluation criteria by the so-called pairwise comparison. When comparing individual criteria, a more important criterion (more important for a decision) is ranked as “1” and a less important as “0”. A similar procedure applies to the pairwise comparison of alternatives. The resulting evaluation of criteria weights and methods is carried out by applying the evaluation “standardisation”, i.e. by requesting that the sum of all evaluations, or weights, equals 1. Results of the decision-making process, while applying the FDMM, are shown in Table 4.

### Table 4 Decision-making table FDMM

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weights (a_i)</th>
<th>Finite roller conveyor</th>
<th>Circulating roller conveyor</th>
<th>Combined conveyor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\omega_i)</td>
<td>(\omega_i \cdot a_i)</td>
<td>(\omega_i)</td>
<td>(\omega_i \cdot a_i)</td>
</tr>
<tr>
<td>K1 - Investments</td>
<td>0</td>
<td>0.666</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>K2 - Power Consumption</td>
<td>0.4</td>
<td>0.666</td>
<td>0.2664</td>
<td>0</td>
</tr>
<tr>
<td>K3 - Flexibility</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>K4 - Noise Level</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0.333</td>
</tr>
<tr>
<td>K5 - Safety</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0.333</td>
</tr>
<tr>
<td>Weighted sum</td>
<td>(\Sigma 0.2664)</td>
<td>(\Sigma 0.2499)</td>
<td>(\Sigma 0.483)</td>
<td></td>
</tr>
<tr>
<td>Order</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

5. **CONCLUSION**

The article was dealing with the process of proposing alternative solutions for consignment sorting, while using various handling equipments (conveyors). A decision-making process is based on relevant technical and economic parameters of conveyors. Evaluation criteria were determined for the adjustment of conveyor technical parameters and applicable priorities were specified for conveyor innovation. At the same time, a financial comparison was carried out for the currently applied and the proposed method of consignment handling and an optimal adjustment option was chosen. The results of the application of both multiple-criteria decision-making methods (DMM a FDMM) were identical. Evaluation criteria were best met by a combined conveyor.
ACKNOWLEDGEMENTS

This work is a part of these project kega 009tuke - 4/2016 - design of the specialized training concept oriented to the development of experimental skills within the frame of education in the study branch logistics.

REFERENCES

TRANSPORT MANAGEMENT TOOLS - THE CASE OF POLISH CHEMICAL SECTOR

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Abstracts
Constant global economic growth and deepening differentiation in customer demand resulting in expectation of supplies customization are stimulating increasing in international trade. In effect transport activates are becoming more intensive on the global scale. At the same time transport management process is supported by different types of tools helping managers to achieve strategic supply chain goals. However, transport operations are rarely indicated as those that add value in the area of its sustainable development. Therefore it is worth to promote such a solutions as multimodal transport that adds value not only in terms of door-to-door model but as a sustainable mode. Project ChemMultimodal, as a reply to those challenges, aims to promote multimodal transport by designing special tool for those kind of operations. The part of the first phase of the Project was to diagnose current tools used by companies engaged in the supply chain in chemical sector in Poland. The results show that the most common IS solution are the systems integrated within one company. Respondents evaluated them on quite high level in terms of time savings and data security. However they also underlined limited access to information as one of the main IS disadvantage. Those results confirm the need for in-depth analysis of the possibility of increased use of multimodal transport by supporting firms with the tool that helps planning and decisions making. In effect they can increase competitive advantages and meet environmental requirements by rise of multimodal transport solutions usage.

Keywords: Transport management tools, sustainable transport, multimodal

1. INTRODUCTION

Transport management process is supported by different types of tools helping managers to achieve strategic supply chain goals. As the logistics and supply chain goals are supposed to be in line with company’s strategy, the choice of the tool should also be made based on its ability to help company’s development and creation of competitive advantages. Increasingly, the search for competitive advantages takes place in areas of sustainable development. However, transport operations are rarely indicated as those that add value to the company in the area of its sustainable development. That is why it is important to study and develop transport management tools that will be able to support the increase use of transport modes that are environmentally friendly. This is also the main objective of ChemMultimodal Project - promotion of multimodal transport of chemical logistics. The project aims to achieve that by coordinating and facilitating cooperation between chemical companies, specialized logistics service providers (LSP), terminal operators and public authorities in chemical regions in Central Europe. The Project is carried out under the Interreg Central Europe Programme between June 2016 and May 2019. The scientific goal of the article is to present part of the effects of the first phase of the Project - the results of research on transport management tools used in supply chain in Polish Chemical Sector. Study was conducted between August and September 2016 by Warsaw School of Economics and Polish Chamber of Chemical Industry.

2. TRANSPORT-INTENSITY AND ITS IMPACT ON FOOTPRINT

2.1. Transport-intensity as part of supply chain performance
Constant global economic growth and deepening differentiation in customer demand resulting in expectation of supplies customization are stimulating increasing in international trade. In effect transport activates are
becoming more intensive on the global scale. Additionally, possibilities of global sourcing have led to products travelling greater distances. Therefore the increase in transport-intensity in supply chain can be noticed [1]. That could be measured in number of kilometers and trips that different SKUs are overcoming on daily basis. Transport-intensity may be a barometer of economic growth, but at the same time it has direct influence on environment and should not be neglected when considering supply chain management activities. Especially if the sustainability and corporate social responsibility concepts are becoming more important in practice than ever before they had been. Therefore improving quality of transport-intensity activities resulting in eco-efficiency is becoming a special issue of global commerce. To improve transport-intensity within supply chain the following steps can be taken [1]: review product design and bill of materials (materials characteristics, possibility to recycling or reuse); review sourcing strategy (especially low-cost country due to the distance); review transport options (choosing eco-friendly transport modes, design vehicles and vessels, etc.); improve transport utilization (empty loading spaces limitation); use postponement strategies (product customization can be finalized near point of use).

Based the listed possible activities that can be done by supply chain managers, one can assume that direct or indirect influence on carbon footprint exists within supply chain decisions. They can be divided by particular phases of supply chain process as it is described on the Figure 1. [1].

![Figure 1](image.png)

**Figure 1** Supply chain decisions impact the resource footprint

The direct impact of transport activities is located in “Deliver” phase of the presented supply chain process. It should be underlined that only part of the possible actions are mentioned and transport management skills have direct and crucial impact on transport-intensity performance. One of them is ability to configure different modes of transport between partners and so increase multimodal solution exploitation.

### 2.2. Multimodal as a solution helping in improving transport sustainability and supply chain performance

When analyzing transport decision an approach of *door-to-door* is worth to consider. It is the easiest way to have a broad view on distance and its conditions due to the possibility of a diverse selection of transport modes. The availability mode of transport is limited not only by the characteristics of the product, but also the distance and availability of reloading space and capacity. However multimodal solution that is “carriage of goods by two or more modes of transport” is the wider approach to configuration of different modes of transport and transported units described in the literature. Other terminology used to explain combined transport types lists also intermodal transport (“the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes”) or combined transport (“intermodal transport where the major part of the European journey is by rail, inland waterways or sea and any initial and / or final legs carried out by road are as short as possible”) [2]. However intermodal and combined transport have some limitations that could exclude their usage by particular supply
chain. Therefore multimodal is revised as the most flexible solution that could be used to improve transport sustainability and influence on supply chain eco-friendly performance. It is due to the possibility to wider include railway or inland modes. At the same time it should be underline that proper management and so the tools used for the transport management are critical for its successful development and multimodal exploitation.

3. TRANSPORT MANAGEMENT AND ITS ICT TOOLS

According to Griffin “management is a set of activites including planning and decision making, organizing, leading and controlling directed at an organization’s resources with the aim to achieving organizational goals in an effective and efficient manner” [3]. Whether managers are trying to boost revenues, innovate, improve quality, increase efficiencies or plan for the future they have searched for tools to help them. However not every tool is a cure-all and there has to be some decision made on what suits best current environmental conditions. The same situation can be observed when considering transport management tools. The most important part of management process in this case is planning and decision making, especially if it comes to the management of multimodal transport. There are some specific circumstances that should be consider when evaluating transport mode. First it is the product characteristics and its cargo transport vulnerability. Than the distance between each party and the nature of primary need for transport should be revised.

When considering global supply chain one can easily observe the complexity in the number of parties, the distance diversity and differentiated goals of particular supply chain members. Therefore, for smooth flows’ of goods, money and information, some conditions should be taken into consideration. These are the following: leader who is able to set the priorities in the net of companies engaged in the supply chain system; strategy that links and combines the activates of individuals and makes them compatible and able to achieve competitive advantages; integration and partnership between companies leading to value chain creation that is “a set of activities that are performed to design, produce, market, deliver and support its product” [4]; tool that provides information on flows and its current capacity in the supply chain.

The above conditions are required to achieve expected level of value and market advantages. Therefore one of the most important aspect - being a base for planning and decision making - is ability to interorganizational coordination of the flows and dependencies. Thus companies are using different tools allowing them for synchronization through shared information rather than series of separate acts realized by each stage of the conventional supply chain model. The most frequently used tools for transport planning within supply chain are based on information and telecommunication technology (ICT). Information systems (IS) can help companies on the different level of their integrality and technology level of advancement. There are several possible ISs’ solutions used by companies for transport planning and coordination, like: separate applications serving to particular tasks within a single company; systems that are integrated within one company; systems that are integrated between company and suppliers and / or customers; systems integrated inside the company with different logistics service providers (LSP) or forwarders; systems served by LSPs, advanced platforms that serve simultaneously many parties.

The last ones can be supported by cloud computing model and rise whole supply chain on a higher level of competitiveness [5]. Transport management tools, especially when considering multimodal solutions, are supposed to find a transport solution that matches a transport requirements. The more criteria evaluating transport possibilities is taken into account the better result of comparison is achieved. There are criteria that are transport-related, e.g. costs, time, environmental effect, physical complexity, administrative complexity, extra service and other criteria that are participant-related: quality, reliability, personal relationship and after-sales service. Thus IS should cover several requirements. They are - multiply transport modes; multiple time aspect and multiply criteria [6]. The proper IS should cover requirements and be able to meet interoperable conditions for its development. Only in this way supply chain can reach sustainability in managing transport.
4. MULTIMODAL TRANSPORT MANAGEMENT TOOLS IN POLISH CHEMICAL SECTOR

4.1. Project ChemMultimodal concept

The main objective of ChemMultimodal Project is the promotion of multimodal transport of chemical goods. The Project aims to achieve this by coordinating and facilitating cooperation between chemical companies, specialized LSP, terminal operators and public authorities in chemical regions in Central Europe. The Project is carried out under the Interreg Central Europe Programme between June 2016 and May 2019.

The first phase of the Project concentrated on diagnose on how physical flows of chemical goods are managed and what kind of tools are used in supply chain to support smooth and continues flows. This information will be a base for a tool development that aims to promote increasing in multimodal transport usage. The first phase of the Project was the research conducted within 49 main market players by Warsaw School of Economics and Polish Chamber of Chemical Industry between August and September 2016. There were two groups of respondents invited to the study - chemical producers and LSPs that cooperate with producers or within chemical supply chain in Poland. Finally, 22 questionnaires were filled in - 13 by chemical producers and 9 by LSPs. In the next section, the main results from the part concerning current tools for transport management usage are presented.

4.2. Transport management tools used in chemical supply chains in Poland

During the first phase of the Project respondents were asked about the type and the capabilities of the IS used as a tool for transport management in the chemical supply chain in Poland. The most popular solution among both groups of respondents was the system integrated within one company - 26% of chemical producers and 19% of LSPs are using this solution. The second most common IS, rated at the same level (16%) by both groups, was system integrated between company and suppliers and / or customers. Detailed results are shown on Figure 2. It is worth to mention, that companies still use spreadsheets for transport activates planning and management. Using a platform as a base for information flow is a rarity and cloud computing model is used only occasionally.

![Figure 2](Image)

**Figure 2** Information systems used for transport management in Polish Chemical Sector

Respondents were also asked for their IS evaluation. The highest ratings for IS advantages were assigned to time savings (Chemical producers - 4.4 point and LSPs - 4 points in the scale were 5 was the highest advantage), and data security (Chemical producers - 4.2 point and LSPs - 4.5 point). Figure 3, presents results of IS advantages evaluation.
At the same time both groups of companies were asked to identify the main disadvantages of the IS they are currently using as a tool for transport management. On average, evaluated factors were rated at the similar levels. Chemical producers and LSPs indicated limited access to information and long time access to information as the main disadvantages of the system they are using. Also lack of communication between partners and high costs were mentioned as negative sides of IS. Detail results are shown on Figure 4.

In general companies are satisfied by the IS they are currently using for transport management and they are not particularly interested in their improvements. However it should underline, that whenever companies recognize the need for increased use of multimodal transport in their supply chains than this will require increasing the interoperability of the system used as a tool for transport management and therefore need to be developed.

5. CONCLUSION

The current environment of globalization, rapid technological advances and economic turbulence has increased the challenges for supply chain management. The problem arises when sustainability in transport management is taken into account. At the same time the availability mode of transport is limited not only by the characteristics of the product, but also the distance and availability of reloading space and capacity. When analyzing reconciliation between ability to supply commodity in the door-to-door model and sustainable modes
of the transport, the multimodal transport (that includes railway and/or inland modes) can be a good solution. However it is a complex and multi-dimension problem that should be supported by specific management tool. The most common practice is the usage of IS as a transport management tool. However not every IS is suitable for planning, coordination and synchronization many parties and their goals in the supply chain. Thus the concept of ChemMultimodal Project arisen. The main objective of the Project is a promotion of multimodal transport of chemical goods. To fulfill the objective, first there was a need to diagnose what kind of tools are used currently among companies engaged in Polish Chemical Sector supply chain. The part of the first phase of the Project resulted in the information that the most common IS are the systems that are integrated within one company. Respondents evaluated that on quite high level in terms of time savings and data security. However they also underlined limited access to information as one of the main disadvantages of the transport management tool. Those results confirm the need for in-depth analysis of the possibility of increased use of multimodal transport in terms of supporting firms in the specific tool that helps planning and decisions making. Currently available ICT capabilities are able to add value to supply chains due to their interoperability. Those can help companies to increase their competitive advantages and meet environmental requirements by rise of multimodal transport usage.

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CLOUD-BASED MACHINE LEARNING FOR BUS ARRIVAL TIME PREDICTION

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Abstract

The bus arrival time is one of the key elements in public transport information systems. The amount of Automated Vehicle Location (AVL) systems is growing, therefore in this paper we aim to provide a cloud-based machine learning solution of this problem. Using bus location data, we created models in Microsoft Azure Machine Learning Studio using different machine learning methods: Artificial Neural Network (ANN), Support Vector Machine (SVM) and Linear Regression (LR). We validated the methods using historical data and compared the results to naïve predictions that use either historical data with a delay or a vehicle speed.

Keywords: Public transport network, bus arrival time prediction, machine learning, artificial neural network, support vector machine, linear regression

1. INTRODUCTION

The bus arrival time is one of the key elements in public transport information systems. In this paper we aim to create a cloud-based machine learning solution for bus arrival time prediction problem. We will test the solution for an increasing distance between last known bus location and prediction location. Also we’ll compare the models to naïve solution, where we’ll get the delay information from the last known bus location and use it as a prediction on a subsequent location.

2. BACKGROUND

It the past years a number of methods have been developed for bus arrival time prediction. The basic, naïve approach uses involve bus delay measurement on preceding stop and transferring this value to the stop on which the prediction is being made. Fortunately, over the years more sophisticated methods have been introduced.

The bus arrival time prediction research begun by the end of 1900s with Lin and Zeng [1] work. They extracted bus operation information from vehicle monitoring systems and developed an algorithm that was based on historical data. They used bus location data and schedule data to calculate bus delay. Then they compared the difference between scheduled and actual arrival times and on this based they predicted the delay.

Chien et al. [2] proposed two models based on Artificial Neural Network (ANN). First was Stop Based Model, in which whey measured vehicle delay only on the stops. The difference between scheduled and actual arrival time was used to predict arrival time on succeeding stop. The second model (Link Based Model) were based on route division between stops (intersection were used as a point of reference). The results showed that although Link Based Model required more preparation (intermediate expected times had to be calculated upfront) it outperformed Stop Based Model even if the number of intersections was relatively small.

In recent years more machine learning methods have been developed, tested and compared [3,4]. It includes methods such as support vector machine (SVM), artificial neural network (ANN) [5], k-nearest neighbours algorithm (k-NN) and linear regression (LR). Depending on the study, quality of the data and implementation every method is able to outperform other ones given the right context [6].

Additionally, some research proposes some heuristic methods that contain two steps. First, a historical data trained SVM, and second, a real-time data Kalman Filter.
Most of the systems rely on the Global Positioning System (GPS) or some other vehicle location solution with some notable exceptions. For example, system could be developed to rely completely on collaborative passenger information. This approach is completely independent from bus operation companies and could be applied to almost every public transport system with enough passengers willing to participate. The prediction algorithm used are not different to other systems, only the vehicle location comes from other source.

3. THE MODEL

Bus arrival time prediction at bus stop can be described in the following way: given the bus route location, the goal is to predict arrival time at the bus stop at the desired bus stop. The Figure 1 illustrates the prediction framework for this study.

When a bus of given bus route arrives at Location A the bus arrival time \( T_A \) is recorded. Then, given the scheduled arrival time \( T_s \) and actual arrival time \( T_a \) the delay \( d \) is calculated (Equation 1).

\[
d = T_s - T_a
\]

The predicted vehicle arrival delay \( d_B \) on Location B can be calculated using Equation 2.

\[
d_B = T_s - \hat{T}_a
\]

3.1. Support vector machine

SVM is a type of machine learning algorithms based on statistical learning. It can be used to map the input-output relationship for the non-linear system. The solution is always unique and globally optimal since training SVM is equivalent to solving a linearly constrainer quadratic programming problem.

3.2. Artificial neural network

ANN is a mathematical model that has been inspired by the human’s brain neural structure. ANN processes processes information by interaction between neurons with differently weighted weights. ANN has the ability to model complex input-output relationships.

3.3. Linear regression

Linear regression is a mathematical approach for modelling the scalar relationship between variables. It’s the first type of regression analysis. For vehicle arrival time prediction linear regression model is one of the simplest methods and is used extensively.
4. CASE STUDY

We collected data for bus and rail services in the Portland, Oregon. The acquired data spans over one month, starting on June 1st 2016. General network information and schedules were obtained in GTFS format, and real-time data with vehicle location were recorded and stored in the separate database.

For the analysis we selected a bus route 38, which includes 59 stops. The route is visualised on Figure 2.

Figure 1 System design on Microsoft Azure Machine Studio
For data analysis and bus arrival time prediction we’ve used Microsoft Azure Machine Learning Studio. The software allowed computations in the cloud and convenient machine learning model switching.

As an input data we used a bus delay on a four preceding locations (Equation 1). The system was designed as on Figure 3. We divided data into equal training and validation sets. After a training we validated the model using the validation set and prediction a bus delay on the one of subsequent stops (Figure 4).

We used three machine learning models: Artificial Neural Network (ANN), Linear Regression (LR) and Support Vector Machine (SVM) and compared them to naïve delay transfer (COPY) from the last known bus location. The models were validated for a different number of stops between last known bus location and a bus stop on which we were making a prediction.

![Figure 4](image)

The results show that with an increase of a number of stops between last known bus location and the prediction location the mean average error (MAE) also increases. We noticed that as overall MAE value doesn’t exceed 2 minutes the error for large number of subsequent stops is not growing. The reason for this might be that a average delay for a location is not exceeding certain value, thus prediction should trend to the same value.

From thee machine learning models the SVM outperformed other methods, although ANN also yielded similar results. Naïve method of transferring delay from the last known bus location to the predicted location resulted in a worst prediction, but not completely useless.

5. CONCLUSION

In this paper we case study where we collected a real-time bus location data in Portland, Oregon. Using stored historical values, we created three machine learning models in Microsoft Azure Machine Learning Studio. We used created models for bus arrival time prediction. Results showed that SVM model outperformed ANN, LR and naïve methods.

REFERENCES


SELECTION OF TECHNOLOGICAL VEHICLES TO THE GEOLOGICAL AND MINING CONDITIONS WITH AN APPLICATION OF STOCHASTIC GROUP DECISION AIDING METHOD

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Abstract

This paper deals with the selection of technological vehicles to the specific mining and geological conditions in open cast surface mining. The problem is formulated as a multiple criteria ranking of variants, which are different types of technological vehicles. They are evaluated by the family of ten criteria according to several aspects, including: economy, technology and construction, exploitation and reliability. Vehicle selection is carried out by the group of decision makers involved in the decision process. They are professionals with different expertise profiles. The solution of the problem is performed with an application of stochastic group decision aiding method proposed by the authors. This approach is composed of five phases, i.e.: 1) analysis of the decision situation, 2) construction of variants, and definition of the set of criteria, 3) evaluation of variants, 4) preference modeling and computations, 5) construction of the stochastic ranking. The obtained results are compared with the previous research on selection of technological vehicles based on separate individual preferences of each expert.

Keywords: Vehicle selection, surface mining, haul trucks, multiple criteria decision aiding, group of experts

1. INTRODUCTION

Road transport carried out by haul and articulated trucks is a dominant one, and sometimes it is the only possible mode of transportation in surface mining. The share of transport expenditures in the surface mining indicates the importance of the role the transport plays in the overall mining process. High costs generated by the output transport, in terms of investments and further exploitation, are estimated by around 60% of total operational costs [1]. The basic condition of transport efficiency is the selection of appropriate means of transport. All the methods typically applied into a transport means selection process can be divided into two key groups. In the first one an optimal vehicle’s operating lifetime is based on analysis of operating expenditures with respect to the useful life (e.g. [2, 3]). The second group of the methods is concentrated on the optimisation of economic viability of all repairs activities with respect to the effectiveness of mining output transport (e.g. [4, 5]). In most of the papers an interaction between transport means and mining operating conditions is omitted and the multiple criteria character of the problem, as well.

One of the universal approaches applied to solve many decision problems is a multiple criteria decision aiding (MCDA) methodology [6, 7, 8]. It aims at giving the decision maker the tool, which enables his / her to solve complex decision problems, where different points of view are taken into consideration. Many real-world problems are solved using group support systems. In the literature are presented two main streams in solving multiple criteria decision making problems, which have at least two decision makers [9]. The first one are specialized group decision making tools e.g. Co-oP [10], SCDAS - Selection Committee Decision Analysis and Support [11], MEDIATOR [12], while the second one are group decision making tools designed to solve analysed decision problem, e.g. for classification of companies using experts’ knowledge [13, 14]. An overview of the models of group decisions and negotiations is presented by Jelassi et al., [15]. The authors discuss
similarities and differences between the group decision making and negotiations with examples of the use of group decision support systems and negotiations support systems.

The use of group decision making, as one of the trends of multicriteria decision aiding methodology allows to reflect the multiplicity of points of view on the same problem expressed by several evaluation criteria, aggregation of preferences of many decision makers and the organization of the whole decision making process [10]. However, the most common problem is a method of aggregation of preferences expressed by different decision makers and simplification of these preferences into the deterministic information, while in many cases their character is stochastic.

In this paper a novel method solving a stochastic group decision aiding problem is proposed. This method is applied to solve a real-world ranking problem, where each variant is a specific haul truck evaluated by the set of criteria. Decision makers (DMs) are experts with specific professional mining perspective, including mining operations and machine design and its utilisation. The results of decision process are compared with the outcome of author’s previous work presented in paper of Bodziony et al., [16], where preferences of experts are considered separately. The approach applied in this paper is also a continuation of the authors’ previous works on stochastic values of criteria in multiple criteria decision aiding problems presented in e.g. Sawicka [17], Sawicki and Sawicka [18].

2. PROPOSED METHODOLOGY

The proposed approach is composed of five iterative phases presented in Figure 1. Phase 1 is dedicated to an analysis of the decision situation. Context of a decision problem is considered in details and reflected in the next phases of the procedure. During phase 2, set of variants (phase 2.1) and set of criteria (phase 2.2.) are constructed. While creating variants a specific character of a single solution is articulated and modelled. By defining the set of criteria a comprehensive evaluation of each variant is performed and presented in the next phase. Phase 3 is devoted to the complex evaluation of variants with respect to the previously defined set of criteria. Finally, a vector of the values of criteria describes each variant, and the output of the phase 3 is a matrix of performances.

![Figure 1 Key phases of the proposed procedure. Own work](image)

Phase 4 is concentrated on advanced preferences’ modelling, their application in multiple criteria decision aiding method and computations. These preferences are expressed by the group of experts (several decision makers) involved in the problem solution. The individual DMs’ preferences refer to criteria, i.e. their relative importance, as well as to performances of variants, i.e. the tolerance of performance differences. They are presented as models and then they are integrated (see phase 4.2) into the single stochastic model. During phase 4.3 a random sampling of preference stochastic values is repeatedly performed, and each sample is an
input data for computation of deterministic ranking (see phase 4.4). In the last phase of the procedure (see phase 5) the set of all previously generated rankings is transformed into the single stochastic ranking.

3. APPLICATION OF THE METHODOLOGY

3.1. Analysis of the decision situation

The decision situation presented in this paper comes from a real-world problem analysed in the surface mining. Vehicle transport is one of the most important technological processes in this area and its selection is a difficult and complex task. The mining process profitability is strictly dependent on overall cost of fleet’s exploitation. Strong impacts on its selection have exploitation conditions and the user’s preferences and experience. Thus, a rational design of transportation system based on haul trucks should result from thorough analysis of several aspects, including technology, exploitation, machine design and economy.

The decision problem (phase 1 in Figure 1) considered in this paper is defined as the haul truck selection for a specific exploitation conditions in surface mining. In the analysis carried out, a group of decision makers i.e. team of experts, is examined. They are represented by 3 academic experts and 2 mining managers (including one who is also an academic expert in the field of surface mining technology). Their priorities and preferences differ and they are strongly depended on professional experience and background.

3.2. Construction of variants and definition of the set of criteria

The decision problem is composed of 7 variants of haul trucks and 10 evaluation criteria (phase 2 in Figure 1). The set of variants consists of 21 vehicles accepted for analysis. It is defined a priori - it is inalterable during the decision procedure. It includes the existing fleet of haul trucks with different types and new vehicles, as well. They are utilised in two selected reference opencast mines. When defining the variants, the mines’ similar exploitation conditions have been taken into account, as well as the specificity of the transport environment, i.e.: a) mining-geological conditions, b) mineral deposits operating system, c) transport distance, d) type of road surface (bituminous surface, hard-macadam surface, mixed road surface), e) differences in the levels of transport road, f) the amount of output transported during single transport cycle, g) the nature and quality of sourced minerals, h) weather and road changing conditions in the seasons.

The vehicles have been evaluated by the set of criteria, representing different aspects such as: economic ($C_1$ - total investment costs [PLN], minimized criterion; $C_2$ - total operating costs [PLN / 5,000 engine hours], minimized criterion), technical-construction ($C_3$ - maximum power [kW], maximized criterion; $C_4$ - maximum torque [Nm] maximized criterion; $C_5$ - minimum turning radius [m], minimized criterion; $C_6$ - payload capacity [Mg], maximized criterion), exploitation and reliability ($C_7$ - unit energy consumption [\text{L}], minimized criterion; $C_8$ - reliability index [%], maximized criterion; $C_9$ - stream damage parameter [damages / engine hours], minimized criterion; $C_{10}$ - ergonomics and driver comfort [points], maximized criterion). More information about the family of criteria is presented in paper Bodziony et al., [16].

3.3. Evaluation of variants

The set of 7 variants, denoted from $A_1$ to $A_7$ has been evaluated by the family of 10 criteria (phase 3 in Figure 1). The resulted matrix of performances is presented in Table 1. Based on that it is hard to select the best variant. Some of the vehicles have the most desirable characteristic on one criterion, such as e.g. $A_2$ on criterion $C_2$, $A_5$ on criterion $C_5$ while on the other criteria these variants are evaluated as the worst, e.g. $A_2$ on criterion $C_6$, $A_5$ on criterion $C_2$. Thus, the application of the one of MCDM methodology becomes crucial to solve this problem.
### Table 1: Matrix of performances. Own work

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Variants</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>thous. PLN</td>
<td>min</td>
<td>740</td>
<td>815</td>
<td>1.018</td>
<td>1.959</td>
<td>1.262</td>
<td>1.844</td>
</tr>
<tr>
<td>C2</td>
<td>thous. PLN / 5000 eng.h</td>
<td>min</td>
<td>2.509</td>
<td>1.982</td>
<td>2.326</td>
<td>2.381</td>
<td>2.576</td>
<td>2.456</td>
</tr>
<tr>
<td>C3</td>
<td>kW</td>
<td>max</td>
<td>448</td>
<td>440</td>
<td>522</td>
<td>533</td>
<td>371</td>
<td>522</td>
</tr>
<tr>
<td>C4</td>
<td>Nm</td>
<td>max</td>
<td>2.237</td>
<td>2.350</td>
<td>2.731</td>
<td>3.326</td>
<td>2.167</td>
<td>2.739</td>
</tr>
<tr>
<td>C5</td>
<td>m</td>
<td>min</td>
<td>10.2</td>
<td>10.0</td>
<td>9.0</td>
<td>8.5</td>
<td>7.2</td>
<td>9.6</td>
</tr>
<tr>
<td>C6</td>
<td>Mg</td>
<td>max</td>
<td>45.0</td>
<td>42.0</td>
<td>55.0</td>
<td>64.0</td>
<td>45.0</td>
<td>63.1</td>
</tr>
<tr>
<td>C7</td>
<td></td>
<td>min</td>
<td>0.831</td>
<td>0.797</td>
<td>0.827</td>
<td>0.790</td>
<td>0.540</td>
<td>0.877</td>
</tr>
<tr>
<td>C8</td>
<td>%</td>
<td>max</td>
<td>66</td>
<td>61</td>
<td>61</td>
<td>92</td>
<td>92</td>
<td>57</td>
</tr>
<tr>
<td>C9</td>
<td>damages / 1000 eng.h</td>
<td>min</td>
<td>7.18</td>
<td>9.36</td>
<td>15.0</td>
<td>6.46</td>
<td>6.15</td>
<td>9.10</td>
</tr>
<tr>
<td>C10</td>
<td>points</td>
<td>max</td>
<td>43.7</td>
<td>38.2</td>
<td>82.8</td>
<td>116.1</td>
<td>96.0</td>
<td>72.7</td>
</tr>
</tbody>
</table>

### 3.4. Modelling of preferences and computations

The decision makers have been asked about their attitude to the way of expressing the preferences. All of them agree that the weights of criteria should be given on a scale, such as the best criterion has the highest weight and the worst - the lowest one. In decision makers opinions some of the criteria are indifferent, thus their weights have the same values. Moreover, the decision makers perceive some of the variants as indifferent on one criterion, while on the other they are weekly or strongly preferred. It is hard to compare some of the considered vehicles. One of the MCDM methods, which can reflect such a way of modeling the preferences and decision makers hesitation is ELECTRE III [6, 8]. This method is based on the outranking relation. The definition of the model of the DM’s preferences is determined by the indifference $q_j$, preference $p_j$, and veto $v_j$ thresholds and weights $w_j$ for each criterion $j$. Then the outranking relation is constructed. Finally, the ranking of alternatives is generated. At this point the outranking relation is exploited.

Based on the opinions collected from the decision makers (phase 4.1 in Figure 1), the matrix of preferences including the above mentioned thresholds and weights, has been constructed (phase 4.2 in Figure 1). Its values are presented in Table 2 as the ranges of variations of individual preferences [16].

### Table 2: Stochastic model of DMs' preferences. Own work

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ranges of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weights $w_j$</td>
</tr>
<tr>
<td></td>
<td>Indifference $q_j$</td>
</tr>
<tr>
<td>C1</td>
<td>(5, 30)</td>
</tr>
<tr>
<td>C2</td>
<td>(10, 30)</td>
</tr>
<tr>
<td>C3</td>
<td>(2, 9)</td>
</tr>
<tr>
<td>C4</td>
<td>(2, 9)</td>
</tr>
<tr>
<td>C5</td>
<td>(1, 10)</td>
</tr>
<tr>
<td>C6</td>
<td>(10, 15)</td>
</tr>
<tr>
<td>C7</td>
<td>(7, 10)</td>
</tr>
<tr>
<td>C8</td>
<td>(10, 20)</td>
</tr>
<tr>
<td>C9</td>
<td>(5, 10)</td>
</tr>
<tr>
<td>C10</td>
<td>(5, 20)</td>
</tr>
</tbody>
</table>
Next, the random sampling has been carried out (phase 4.3 in Figure 1). The algorithm AS 183 of Wichman & Hill [19] has been applied. Based on this phase, 100 computational experiments with an application of the deterministic multiple criteria ranking method ELECTRE III has been carried out (phase 4.4). Their results are presented as 100 ranking matrices including relations between variants, such as indifference (I), preference (P), inverse preference (P') and incomparability (R).

3.5. Construction of the final stochastic ranking

The construction of the final stochastic ranking is based on the computation of the probability of a particular relation between variants (phase 5 in Figure 1). The ranking matrix and final stochastic ranking are presented in Figures 2a and 2b.

![Figure 2](image_url)

**Figure 2** The final ranking matrix (a), final stochastic ranking (b), expert no. 2 ranking (c). Own work

The ranking matrix shows the relation between pairs of variants - an intersection of a row and a column, i.e. variant A_i is preferred to variant A_j with the probability of preference relation P, which equals 0.600. The probability of indifference relation between this pair of variants is 0.400. Based on the information presented in the ranking matrix, the final ranking has been constructed. Variant A_4 located at the top of it is a compromise solution. Next position in a ranking holds variant A_7 and the preference relation between A_4 and A_7 is 0.467. These variants are very close in the ranking, because the probability (P) of the indifference relation P(A_4 I A_7) between them equals 0.433. Third, fourth and fifth position in the ranking have variants A_5, A_3 and A_6, respectively. Variant A_1, which is one before last, is preferred to the last variant in the ranking, i.e. A_2. The preference relation P between them equals 0.600. This ranking, especially the top of it, is compared to the final order of variants obtained for preferences expressed by expert no. 2 (Figure 2c). In the first case the compromise solution is A_4, while in the second one - variant A_4 which is indifferent to variant A_7. There are at least two reasons of the differences between results. The deterministic ELECTRE III method doesn't present the distance between variants in the final ranking and three types of relations between them can be exploited, i.e. indifference I, preference P and incomparability R. The probability of relations between variants in the proposed methodology...
can be interpreted as the distance between them. If the values between indifference and preference relations are similar, then there is a weak preference of variant $A_4$ over $A_7$. Moreover, the result presented in Figure 2b is computed on the wide spectrum of preferences defined by different experts, while the ranking showed in Figure 2c reflects only one point of view.

4. CONCLUSIONS

In this paper a classical multiple criteria ranking method ELECTRE III has been presented. Based on that, it is possible to solve decision problem with deterministic values of criteria evaluating the set of alternatives, decision maker’s preferences with his / her hesitations. However, some decision situations are complex, there are more than one decision maker and the application of existing methods would not be applicable or would not result in a desirable solution. Thus, the concept of stochastic multiple criteria decision aiding method to solve group decision problems aiming at ranking of variants has been presented. It is based on a composition of classical methodologies, i.e. multiple criteria decision aiding and probability theory.

The proposed method has been successfully implemented in the real-world surface mining company, where seven variants, representing different haul trucks, has been considered. The final ranking obtained shows that the compromise solution is variant $A_4$. This result has been compared to the ranking calculated according to preferences of expert no. 2, selected arbitrary as the representative of the group of experts. In this case, variants $A_4$ and $A_7$ are indifferent. Thus, it is hard to decide which of them should be selected. Thanks to the proposed stochastic methodology, the weak preference of variant $A_4$ to variant $A_7$ has been specified, which helps to select the final result.

The future direction of the proposed methodology are as follows: 1) verification of the methodology on a wide range of problems, i.e. correct matching of wheel loaders or excavators and haul trucks, 2) representation of stochastic preferences by different types of probability distributions, 3) application of the other multiple criteria decision aiding methods, such as Promethee, AHP.

REFERENCES


DETECTING THE TRANSPORT HUBS PROBLEM: AN EVOLUTIONARY APPROACH

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Abstract

In this paper we consider the well known Hub and Spoke problem according to the Warsaw Public Transport System. Our approach is based on data available on the website of the ZTM (Zakłady Transportu Miejskiego - Urban Transport Company) and an evolutionary algorithm method that detects logistic hubs well connected (with the high capacity of available transport means) with the center of the city and other detected hubs. These hubs can become the skeleton of the public transport system and for instance can be good points for localization of the Park and Ride car parks.

Keywords: Hub and spoke, evolutionary algorithm

1. INTRODUCTION

The dynamic development of the agglomerations causes several new challenges. The continuous increasing of pollutions and expanding the traffic as a reason of growing traffic jams make the popularization of the public transport one of the most urgent task. One of the essential problems for this task is the improvement of the travel time. Generally, the concept behind such a system is simple: let the public transport be effective as possible, making using public transport cheaper than the others. The widely used in transportation systems idea of hub and spoke (H&S) structure can be helpful also in the case of the urban transport system, where fast transport means like metro or urban trains can create a skeleton of fast and high capacity connections and slower transport means like trams or buses can support local connections. In the second part of the XX century the H&S structure began to gain in popularity especially after the deregulation in 1978 in the US airline [1]. Since 1986 the hub and spoke problem has become a distinct research area [2].

To reorganize the transportation system into the instance of H&S structure it is necessary to detect potential hubs in the graph of the city logistic system. This quite a big computational task is a job for evolutionary method often used for solving of this type problems. In this paper we present our method useful for obtaining H&S structure in the logistic system.

2. GRAPHS AND THEIR RELEVANT STRUCTURES

Since we shall be modeling the entirety of the hub and spoke problem through the graph representation and then solving it as a problem defined on graphs, we start with the basic notions from graph theory, here given following [16].

A graph is a pair $G = (V, E)$, where $V$ is a non-empty set of vertices and $E$ is a set of edges. Each edge is a pair of vertices $\{v_1, v_2\}$ with $v_1 \neq v_2$. A degree of a vertex is the number of edges to which this vertex belongs. A clique (a complete subgraph) $Q = (V_q, E_q)$ in a graph $G = (V, E)$ is a graph such that $V_q \subseteq V$ and $E_q \subseteq E$ and $\text{Card}(V_q) = 1$ or each pair of vertices $v_1, v_2 \in V_q$ fulfills the condition $\{v_1, v_2\} \in E_q$ [4]. Each subgraph of a clique is a clique. An $\alpha$-clique [6], [11], [12], [14] can be defined as follows: let $A=(V', E')$ be a subgraph of graph $G = (V, E)$, $V' \subseteq V$, $E' \subseteq E$, $k = \text{Card}(V')$ and let $k$ be a number of vertices $v_j \in V'$ that $\{v_i, v_j\} \in E'$.
1. For \( k = 1 \) the subgraph \( A \) of graph \( G \) is an \( \alpha \)-clique(\( \alpha \)).

2. For \( k > 1 \) the subgraph \( A \) of graph \( G \) is an \( \alpha \)-clique(\( \alpha \)) if for all vertices \( v_i \in V' \) fulfill the condition \( \alpha = (k_i + 1) / k \), where \( \alpha \in (0, 1] \).

Further on we will use the notion of \( \alpha \)-clique in the sense of \( \alpha \)-clique(\( \alpha \)) for an earlier established \( \alpha \). A subgraph of an \( \alpha \)-clique may not be an \( \alpha \)-clique for the established \( \alpha \).

A hub and spoke structure (Figure 1b) is a graph \( H = (G_h \cup G_s, E) \) where the subset \( G_h \) corresponds to at least a connected graph (of hubs) with the relevant subset of set \( E \), each vertex of subset \( G_s \) (of spokes) has degree 1 and is connected exactly with one vertex from subset \( G_h \) [6], [7].

The proposed method uses a predetermined by some expert number of communication hubs, with the possibility of directly determining which nodes should become hubs or selecting them by the solving method.

3. THE PROBLEM REPRESENTATION

The structures we introduced in the previous section are helpful in solving the hub and spoke problem, or they can even directly represent such solutions, since edges correspond to transport-wise connections, and nodes represent transport nodes. Thus, by finding these structures, we obtain the solution or the basis for determining the solution.

We assume there is a direct connection between two communication graph nodes if there is a public transport line they are belonging to. Thus, the graph describing the transportation network, used in our approach, is not a simple graph representation of city transportation routes, but a denser structure with interconnections among stops belonging to one transport line. Different lines may have common stops, so the transportation graph consists of overlapping “blocks” of lines. In our approach the graph of connections is a weighted graph, where all edges may have different values assigned. These values may represent not only the fact of connection existence but also some parameters of it: the number of scheduled courses over the connection (frequency), the travel time, potential capacity of the given means of transport (within a given period of time), actual/estimated number of passengers (in the vehicle: descending / boarding).

In this paper we use values (weights) assigned to edges proportional to the connection capacity. For stops, common for a few or more transport lines, these values are properly modified, for instance the capacity and frequency can be added, the travel time averaged, as so to consider more transport means available. The hub and spoke method in the big city case can assure fast and high capacity connections (in real cases the fastest
means of transport are: metro, urban trains and fast trams) among hubs and to the center of the city, and slower or smaller capacity ones to less important stops - spokes (in this case buses and ordinary trams). Such transport organization in the city can significantly improve the transport system efficiency [9], [10].

4. THE EVOLUTIONARY METHOD TO OBTAIN THE HUB AND SPOKE STRUCTURE

Evolutionary algorithms (EAs) are often used to solve hard graph problems such as graph coloring, TSP, graph partitioning, maximum clique problem, etc. [3], [5], [15], [17], thus, it is justified to use the evolutionary algorithm in the presented graph transformation problem. Basic EA method is a well-known technique, but this scheme requires problem specific improvements to work efficiently [8]. The adjustment of the evolutionary algorithm to solve a problem requires proper encoding of solutions, development of specialized genetic operators proper for the analyzed data structure and the solved problem and, finally, the fitness function (or another manner of evaluating solutions) to be optimized by the algorithm.

The selected hubs should constitute a complete graph, but when the connections between nodes are very sparse or are determined as existing junction nodes (for instance: railway stations), it is admitted that the subgraph of hubs constitute an $\alpha$-clique with $\alpha$ as high as possible or a connected graph (when the whole graph of connections is very sparse). Considering a weighted graph, weights of edges connecting hubs should have values as big as possible.

A member of the population contains several data items, including: vectors of detected hubs and their spokes, a vector of real numbers, describing its knowledge of genetic operators and the index of the operator chosen to modify the solution in the current iteration (for details see [13]).

The quality function to obtain the desired hub and spoke structure with the predetermined number of kernel nodes is presented in formula (1):

$$\max Q = \sum_{i=1}^{n} \left( \sum_{j=1}^{m} w_{ij}^{C} + \sum_{l=i+1}^{n} w_{ij} + \sum_{p=1}^{k} w_{ip} \right)$$

(1)

$n$ - imposed number of hubs, $k$ - number of nodes (stops) in the considered graph, $w_{ij}^{C}$ - weight of the connection between $i^{th}$ hub and $j^{th}$ stop of the set of $m$ important stops (we decided to emphasize several important communication stops in the city as a virtual aim of the majority of commuters) in the center of the city, $w_{ij}$ - weight of the connection between $i^{th}$ hub and hub $j^{th}$, $w_{ip}$ - weight of the connection between $i^{th}$ hub and $p^{th}$ node of the graph.

The quality function (1) maximizes connections among: selected hubs ($\sum_{l=i+1}^{n} w_{il}$), hubs and the set of the most important virtual aims of the commuters’ travels ($\sum_{j=1}^{m} w_{ij}^{C}$) and each hub and remaining stops ($\sum_{p=1}^{k} w_{ip}$). The connection weights in the graph represent a connection capacity, means as a number of average transportation vehicles in one hour.

This problem can be solved using a set of the specialized genetic operators, modifying the structure of the population member. When the executed operator tries to move one node (spoke) to the shell associated with another hub, must the first to be checked for the connection with this new hub. If there is not, the operation is canceled and no modifications are performed, so as to preserve the feasibility of the solution. The set of genetic operators consists of: mutation - exchange of randomly chosen nodes in different sets of spokes, relocation of a randomly chosen node to a different set of spokes, exchange of a randomly selected hub for randomly selected spoke, this operator is inactive when kernel nodes are explicitly assigned.
5. RESULTS OF THE COMPUTER SIMULATIONS

5.1. The real data of the Warsaw transport system

The real data describing the Warsaw transportation network were obtained from the ZTM website [18]. As it can be seen in subsequent figures, the network is well developed, and composed of: subway - 2 lines, fast city trains (SKM) / suburban trains (WKD) / trains (KM) - 13 lines, trams - 25 lines, buses urban / suburban / night - 199 lines.

We take into account almost all means of public transport, only some private bus lines, taxis, long distance buses and trains are not considered. Generally it is very difficult to deal with the real data describing the city transport system, because they change almost every day, there are often flaws in the data and unexpected variants of some communication lines circulation (one-direction lines, different routes in different hours, loops, etc.). The whole transport network has about 10 000 (physical) stops but for computational purposes this value can be reduced to about 2 500 integrated nodes. An integrated node consists of corresponding stops in both directions and often also several sub-stops in both directions in places with very intensive commuter traffic.

5.2. Obtained results

The figures in this section presents candidates for hubs detected by evolutionary method on the basis of the capacity of their connections with the virtual center of the city and with other detected hubs. The simulations were performed for 20, 50 and 100 imposed hub numbers.

As we can see the method proposes several candidates located along the most important communication arteries in the city. It is obvious that only several of them can be turned into communication hubs, but this could definitely improve the transport system in Warsaw, improving the life level of residents of the capital of Poland. It should be noticed that detected hub candidates are mainly connected with rail transport means.
Figure 3 The scheme of Warsaw, small dots - ordinary stops, 50 big dots - candidates for hubs

Figure 4 The scheme of Warsaw, small dots - ordinary stops, 100 big dots - candidates for hubs
6. CONCLUSION

The approach presented appears as a promising methodology for supporting the planning and improving the public transport model and also other logistic branches, where the hub and spoke methodology can be applied without big costs connected to the construction of new communication lines.

REFERENCES


SESSION D:
SERVICE LOGISTICS AND SMART LOGISTICS
AUTONOMOUS ELECTRONIC TOLL COLLECTION SYSTEM AS A PART OF LOGISTIC INFORMATION SYSTEM

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Abstract

The paper deals with the design of a possible technical solution of utilisation of an autonomous (satellite) system of electronic toll collection in the framework of a logistics information system. The introduction is dedicated to general characteristics of autonomous electronic toll collection system and the state in the Slovak Republic. The principles that were respected during the design are defined. Further the On-Board Unit (OBU) is analysed and then its specifications and restrictions, the communication OBU with the sensors (e.g. RFID) and OBU with tracking system is solved. Finally the overall description of the designed solution and possible multiple utilisation in practise is presented.

Keywords: Toll, logistics, T&T, on-board unit, RFID

1. INTRODUCTION

Charging of road infrastructure is used as a financial instrument or measure for traffic regulation [1]. The framework for technological solution of electronic toll collection defines Directive on the interoperability of electronic road toll systems [2]. The Directive determines that toll systems based on On-Board Unit (OBU) should use at least one of mentioned technologies (satellite positioning, mobile communications using the GSM / GPRS - Global System for Mobile Communications / General Packet Radio Service, 5.8 GHz microwave technology). Generally deployed systems so can be microwave or satellite also referred to as autonomous (based on satellite positioning and mobile communications) [3].

Despite of incontestable advantages of satellite technology (flexibility, potential to offer value added services, technological readiness for European Electronic Toll Service, ...), the technology has been enforced relatively moderately (Germany, Slovakia, Hungary). The modern satellite toll system in Slovakia was deployed in 2010 [1]. Meanwhile the system has proved its effectiveness, reliability and flexibility. Taking into account modern technological solution, the question of possible multiplicative utilisation of available resources has raised [4]. On the other hand there are many areas where the telematics resources can solve specific technical requirements, e.g. in asset management [5], logistics [6, 7, 8], Smart City [9] and so on.

In generally the toll system can be divided into a number subsystems: central equipment (CE), On-Board Unit (OBU) and enforcement (can be realised as fixed, portable and mobile one). The principle (Figure 1) of the autonomous (satellite) toll system is that OBU receives signals from GNSS (Global Navigation Satellite System) satellites (currently specifically GPS - Global Positioning System) on base which the location of the vehicle is determined and thereby the use of particular charged road segment [10]. The decision of using particular charged segment can be realised in OBU (so called thick client) or in CE (so called thin client), Slovak solution is somewhere between this approaches - a part of this process is realised in OBU, the rest in CE. The information from OBU is necessary to transmit to CE so what a mobile communication network serves on (it ensures so called wide area communication). On the purposes of enforcement (and in microwave systems also for tolling) a microwave technology dedicated short range communication (DSRC) is used (it ensures so called spot communication with enforcement gates, enforcement portable devices and enforcement vehicles).
2. ELECTRONIC TOLL COLLECTION IN SLOVAKIA

Since the beginning of operation of the system in Slovakia, electronic toll collection has been applied on vehicles and vehicle combination over 3.5 tones (excluding vehicles exempted from tolling duty according to toll) which are obligatory equipped OBUs, while the other vehicles (up to 3.5 t) are charged in time (via vignettes, since 2016 via e-vignettes). Till the end of 2013 charging was applied on motorways, highways and selected 1st class roads and legislative changes were related to issues which had been brought by practice application of the law. Since beginning of 2014 essential changes has been introduced namely in that the selected road network has been significantly extended on all 1st, 2nd and 3rd class roads (even though some 1st class road sections and all roads of 2nd and 3rd class roads with null rates, whereby nonzero rates were applied on tolling of town and village passing roads at the beginning of 2014), system of discounts from toll rates has been introduced (up to 9% according distance travelled), strict liability has been introduced and European electronic toll service has been legislatively adopted [11].

After the changes, the coverage of toll scheme is almost all roads in Slovakia (just local, commercial and specific roads are not covered). Particularly, as of October 2016, total length of the motorways, expressways, 1st, 2nd and 3rd class roads in Slovakia is 18019 km of which 17559 km are selected in the framework of toll scheme (Figure 2). The selected road network is covered by 4134 toll sections and the scheme registers more than 255 thousands OBUs.
Since first statutory the text of Act on electronic toll collection, the Directive [2] has been took over into Slovak legislation. Followed description shows that the Slovak OBU disposers all of the required technologies what means that from technical point of view it fulfil the requirements on interoperability.

3. PRINCIPLES AND OBJECTIVES OF DESIGN

The basic idea, according to the above mentioned, is to utilise available resources disposable in the framework of electronic toll collection system, i.e. mainly OBU and communication infrastructure. It is evident that it is necessary to consider all aspects of applicability of available OBU for supposed purposes so that the designed solution will not require essential modification of OBU or even development of new OBU type.

From point of view of functionality of the system, there are defined fundamental borders that have to be kept. Primarily it should not affect functionality, reliability and security of toll collection procedures what secondarily means that the toll system disposers sufficiency of computational, communication and energy resources in the all affected subsystems and levels.

In term of operation of toll system - of the relationship charger-operator of the toll system (i.e. considering the relationship of toll collection for a road use of charged road segments vs. alone operation of toll system - what compensation for system operation service to operator from charger is related with) - it is necessary to monitor costs initiated by a new service, i.e. investment and operation costs associated with a new commercial service in regard to using of resources procured as toll collection service.

The investment and operation costs have to be adequate to benefits of the T&T (Track & Trace) service, i.e. in order to be such service a commercially interesting. This should be also supported by that the service should be public available through various communication means and be sufficiently flexible and scalable. It also means the flexibility in defining of the range of monitored data (mainly related to load) including the trigger of the data transmitting (e.g. periodically or after the change of state or data), flexibility in the placement and RF (Radio Frequency) parameters of a RFID (Radio Frequency Identification) reader and flexibility in the defining of user interface (e.g. dispatcher workplace) to communicate with the server (T&T centre).

4. USE OF TOLL OBU

According to the above mentioned analyse it follows that OBU is an effective navigation (it includes GPS module) and communication means (it includes DSRC and GSM / GPRS module). That means it can be utilised in a number manners, one of the way of using are applications safety, in logistics - mainly for T&T purposes and many others [4].

Three versions (generations) of on-board units have been used for electronic toll collection (Figure 3) so far, mainly different in human - machine interface - Continental VDO 1374 [13], Sitraffic Sensus Unit [14] and Billien OBU 5010 [15], while all of them dispose basic required means for localization (GPS module) and mobile communication (GSM module). According to available information all types are equipped with service interface which detailed specifications are not known but it can be assumed that this service interface is USB type. Other interface for contact with the surroundings usable for communication with RFID reader or sensor network is not currently available [4]. It can be also assumed that more modern OBUs would be possible to equip with other types of interfaces either wired (e.g. serial interface, CAN - Controller Area Network) or wireless (Bluetooth, ZigBee) because the new generation OBUs are considered also for other telematics applications. In all variants of OBU the coordinates of the vehicle obtained from embedded GPS receiver are acceptable in respect of accuracy and periodicity.

From point of view of communication facility, OBU dispose of two communication modules: DSRC and GSM / GPRS. In term of communication with CE (and by that also for communication with considered T&T system) DSRC is nonutilisable in regard to spot type of communication. Moreover, with respect to typical characteristics
of DSRC (communication range in order of meters, installation of OBU behind the front screen, communication zone of OBU directed at front of vehicle), DSRC communication is not usable either for communication with RFID reader located at cargo space (additionally it would be uneconomical because RFID reader should be equipped by DSRC interface).

![Figure 3 OBU used in the Slovak electronic toll collect system](image)

A possible solution of this problem is presented on the Figure 4. The principle of this solution consists in using of matching node that shall convert the data from RFID reader placed on the cargo space of vehicle into data format of OBU interface. Certainly it has a consequence of need of OBU software (adding appropriate application) and adaptation the interface towards the driver (HMI) to be able to handle the application.

![Figure 4 Principle of interconnection of RFID reader network with on-board unit](image)

Hence for communication OBU with T&T system, it remains communication by means of mobile network GSM - data transmission in packet mode, i.e. GSM / GPRS. Directly, i.e. that application dedicated to T&T in OBU should communicates with T&T system, it is no possible because GSM / GPRS module in OBU (for security reasons) can communicate via one phone number (that is primary dedicated to send toll data). Consequently CE has to also have a function of an interagent that has to filter data received from OBU (evidently functionality of CE has to be accordingly extended). On principle it is shown on the Figure 5. From point of view of transfer rate and periodicity of data sending, the proposed system will communicate in real time - a communication delay can be caused on the side of OBU (the toll data transfer will have higher priority), by delay in GSM network and by filtering of received data from OBU in CE.

![Figure 5 Communication OBU with T&T system](image)
5. OVERALL PROPOSAL

Overall solution of T&T system based on toll OBU results from presented analyse and deduced characteristics and restrictions and partial conclusions. In addition to the primary function, OBU will have implemented additional application that will in charge of communication with RFID reader, with driver and with T&T central system.

Considering the volume of data transfer related to T&T is not crucial (approx. from hundreds of B to a few of kB), it can be assumed that the GSM / GPRS transmission will be suitable for this application. CE has to be supplemented on subsystem (as far as the hardware is sufficiently dimensioned, it will include just implementing the software application) that will filter data generated by OBU to toll data and T&T data and monitor selected performance parameters characterising costs of T&T service. Toll data will be processed the same way as it has been so far and T&T data will be redirected to deployed T&T system (that can serve as an system for fleet management because the data from OBU can contain identification of the shipment - via ID of RFID reader, ID OBU or vehicle’s licence plate, and also the time and position data or sensor data respectively). T&T system will be in charge of communication with CE (and then also with OBU), process and store the data and provide the processed data via client (end user) access.

T&T system (Figure 6) can be utilised by different users as hauliers, shippers, forwarding houses, logistics centres and freight terminals (e.g. because of planning of capacities), traders or manufacturers (e.g. for just-in-time production), perhaps even authorities.

It is evident that in the framework of one realised shipment, a number of subjects can have an access to certain data concerning a particular transport or load. So a set of procedures has to be defined that determines which of subjects will be an “administrator” of the shipment in T&T system and it will define access rights for other subjects to access the particular data.

For access of all mentioned groups of users it is necessary to choose the most versatile solution, so the T&T system should provide standard but secure web interface for all practically used platforms. User interface should allow not only providing of visual information, but also administration and setting up (e.g. defining of user interface and the range of data transmitted from RFID / sensor to OBU). Furthermore the obtained data should be possible to forward to existing information systems that the mentioned subjects dispose (e.g. ERP, CRM).

![Figure 6 Overall solution of T&T system](image)

6. CONCLUSION

The presented proposal presents a general solution, it is not restricted only to Slovak conditions, because the mentioned specifics of the Slovak electronic toll collection system are not crucial. Therefore the proposal is possible to apply and adapt to other autonomous toll schemes or different telematics systems based on
satellite navigation and mobile communication. The principle is that there is no need to deploy a new system, but the proposal is only based on the amendment of RFID technology and software upgrade.

The scope of the possible users is relatively broad. In commercial area it is potentially all subjects linked with road or intermodal transport as manufacturers, carriers, shippers, dealers, logistics centres, freight terminals and so on. This is the primary determination of the T&T system. Secondarily T&T system can serve state to tracking of goods flows, either for statistical purposes or objectives in tax and custom supervision. The generated data (data on traffic intensities, road segments utilisation, OD matrices, …) are interesting not only for government but also road owners and administrators.

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Abstract

Article deals with the realization of equipment were energy-efficient integrated circuits, which are connected with intelligent sensors. This device is equipped with motion, vibration, acceleration, temperature, humidity and other sensors. Our equipment collects data during transport in the logistics process of the selected organization. Connected storage media were used for data storage and of course an integral part forms and battery power with sufficient capacity were applied. The collected data will be used to improve the organization of its services and the ability to identify the failure of the service at a specific point in the logistics chain through smart sensor package.

Keywords: Intelligent sensors, collects data, postal parcel, measurement, IoT

1. INTRODUCTION

This article deals with a specific conceptualization of the monitoring of postal mails within the postal sector. The introductory part of the paper depicts the basic concepts of monitoring mail, forms and evolution of mail monitoring. Article also describe and analyze an existing solution for the monitoring of postal mails using intelligent sensors. The aim of science part of article is to describe the realization of its solution through intelligent sensors. This part is suitably supplemented by a description of the measurement methodology, implementation and interpretation of measurement results.

1.1. Evolution in the monitoring of postal items

Under the term monitoring of postal mails we can imagine set of activities and technologies, which are with their synergies necessary to achieve specific information about postal mails bounded by time parameter. In the past, attention was fixed upon, under the monitoring of postal mails, especially on the letter. The argument for the control of this group of consignments demonstrated with needs to monitor the quality of services provided by postal operator and the related control time delivery of postal items. In addition to the delivery time the actual realization of transport was checked i.e. at what point of the postal transportation network and at a particular time were postal mail located. This control respectively collection of information was realized primarily in fixed points of the postal transportation network. [1] The method of monitoring of postal mails can be realized in the following ways.

Processed and analyzed data obtained from monitoring are then used in the evaluation of the quality of services. This data also provides valuable information for elimination of bottlenecks in the transport process of postal mails.
A milestone within the monitoring of postal mails could be uses of location devices. These devices extend the possibilities for monitoring of postal mails by recording the current position through GPS coordinates during the transport. By its nature these devices are used primarily for monitoring of the parcel items.

The next and nowadays the final milestone in conjunction with the monitoring of postal mails, could be intelligent sensors and its using in transport and logistics services. In previous cases we have identified position or point at the postal transmission network as the most important parameter. The philosophy of intelligent sensors enriches the quality parameter of other elements that are directly related to the way of realization of transport. So in simple terms, how the consignment has been tampered with during the transportation. For this purpose, we can use the aforementioned intelligent sensors, which provides collecting information in connection with the influences acting on postal mails during the transport processes. As in the case of uses the location devices also smart sensors are inherently useful, especially in parcel shipments. [2]

As we already mentioned in case of letter mails, the monitoring of postal mails is realized for controlling and providing of data for eliminating bottlenecks transport process. Likewise, with intelligent sensors can be processed and analyzed information used to enhance the security content of processed and transported postal mails. The range of development of this technology in the postal sector is all the more appropriate in terms of growth in the number of parcels. [3] Annual growth is still growing at around 6.3%

Based on the information mentioned above we can summarize all methods in conjunction with monitoring of postal mails in following 5 points:

I. By manually collecting data - manually copy data from the shipment.
II. Automated and semi-automated - loading the data from the barcode by EAN reader.
III. Automated - loading data from the RFID tag through an RFID reader (active and passive RFID technology).
IV. Automated - retrieving GPS location coordinates via GPS module and recording the coordinates of time parameter to the internal memory or on-line sending coordinates via cellular modem.
V. Automated through intelligent sensors - reading diverse influences acting on the postal mail and recording of data with a time parameter of the internal memory or on-line sending this data via a mobile modem. [4]

### 3.1. Smart sensor package

Smart sensor package is the label named by us for tested Parcel item. This package consists with the tool for collecting and recording negative influences on the content of postal parcels. The proposal is made in two forms, namely the offline and online versions. The concept is more evident in the following Figure 1.

![Figure 1 The model of smart sensor package](image_url)
How we can easily deduced from Figure 1, the first option is used for data collection and evaluation to the realization of the transport function. The second option allows you to obtain and process data online, at doses at set time of intervals or after exceeding a set threshold for a particular sensor used etc.

The idea for the creation of this tool was an effort to push the limits in conjunction with the quality control of transport services. So we decided to build up a custom tools that would allow for the efficient collection of relevant data, which provide background information to reduce the risk of damage respectively damage to contents and packaging of parcel shipments. Among the following functionality is also to identify bottlenecks and measure the effects of negative impacts, testing the adequacy of packaging used etc.

3.2. Use the intelligent sensors in logistic

We realized secondary research in conjunction with the similar solutions that are used and implemented worldwide. The aim of this survey was to determine which logistic operators use devices equipped with intelligent sensors, in what area is most often used and for what logistical units are paired. Additionally we examined the types of sensors utilized in various solutions. The results of secondary research are given in Table 1.

Table 1 Analyze of uses intelligent sensors by logistics companies

<table>
<thead>
<tr>
<th>Společnost</th>
<th>Název služby/zařízení</th>
<th>GPS</th>
<th>Light sensor</th>
<th>Temperature sensor</th>
<th>Humidity</th>
<th>Barometric pressure</th>
<th>Accelerometer</th>
<th>Geofencing</th>
<th>Door alarm</th>
<th>Gyroscope</th>
<th>Shock</th>
<th>Compass</th>
<th>On-lin sending data</th>
<th>Scope of application</th>
<th>The primary area of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>FedEx</td>
<td>Senseaware</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>parcels, crafts, transporter</td>
<td>pharmaceutical sector</td>
<td></td>
</tr>
<tr>
<td>DB Schenker</td>
<td>Smartbox</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>sea, rail, air large container</td>
<td>Logistic sector</td>
</tr>
<tr>
<td>J. B Hunt Transport service</td>
<td>SEAGsens</td>
<td>UN</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>Package with drug or biological material</td>
<td>Pharmaceutical sector</td>
</tr>
<tr>
<td>Cargo/Terion</td>
<td></td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>truck, freight wagon</td>
<td>Logistic, Pharmaceutical sector</td>
</tr>
<tr>
<td>Swift logistic</td>
<td>VeriWise</td>
<td>YES</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>YES</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>truck, freight wagon</td>
<td>Logistic sector</td>
</tr>
<tr>
<td>Werner Global Logistics</td>
<td>Orbsomm</td>
<td>YES</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>UN</td>
<td>truck, freight wagon</td>
<td>Security, Logistic sector</td>
</tr>
<tr>
<td>Panalpina</td>
<td>ILC2000</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>UN</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>sea and air container</td>
<td>Logistic sector</td>
</tr>
<tr>
<td>Xpress Enterprise</td>
<td>SkyBitz</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>truck</td>
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</tr>
<tr>
<td>DHL</td>
<td>SmartSensor GPS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>parcels, crafts, containers, large containers</td>
<td>Logistic sectors</td>
</tr>
<tr>
<td>SmartSensor RFID</td>
<td></td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
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<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>parcels, crafts, containers, large containers</td>
</tr>
</tbody>
</table>

In the table below you can see the most important companies, which use intelligent sensors within their processes or in the provision of its services. From the analysis implies that these new technologies for monitoring logistics units are designed and intended primarily for the healthcare and logistics, with an emphasis on safety. Even though the internet of things currently shifting possibilities of the ICT uses to industry, area that deals with monitoring of logistic units is the privilege of large corporations operating in the exclusive areas of industry.
2. MATERIALS AND METHODS

The above-mentioned research was conducted in two forms, namely in the laboratory and in real condition of postal operator named as Slovak Post, a. s. From the large scale or number of laboratory testing and measurements the huge volume of data base was obtained. This information was the basis for us to evaluate the data in real traffic. The main variables that we examined were the data from gyroscopes, accelerometers and sensors combining temperature and humidity. Our aim was to test and verify our solution and determine whether the influences on the consignment are not excessively negative. For testing purposes was selected the processing centers of postal operator. In this place there are usually a top-tier influences on postal mails. Selected postal operator states that the packaging has to answer nature of postal parcel. Thus, the postal parcel must be modified to allow a fall from a height of 150 cm. This figure was subsequently evaluated in the context of laboratory testing.

2.1. Materials

As was mentioned above the testing in real conditions was carried out in the mail processing center of postal operator. It is a closed building and that was the reason why for this testing was used offline version of our device. The package and the device itself can be seen in Figure 2.

![Figure 2 Cover and smart sensor package](image)

2.2. Measurement procedure

The entire testing was under the supervision of competent person who is responsible for operations in this processing center of the postal operator. Additionally, this person provided additional relevant information about the individual workflows. On the basis of such was created plan of measurement and testing was realize. The entire measurement procedure reflecting the real operation is more evident in the Figure 3. Due to collect real data, testing was realize during full operation of processing center. At this time, it realized the collecting a processing of postal items. In order to reveal this part of transportation process were record values obtained from temperature sensor, accelerometer and gyroscope. This means the sensors, which are relevant for fulfilling the objectives of this testing. Number of experiment was set for 20 reps. Number of repetitions was determined having regard to the possible occurrence of abnormal values during testing. Latency data collection was set at 50 milliseconds, i.e. 20 series of data per second. All data were collected offline to the internal device memory. Also was realize manual recording time date on entry postal parcel to individual parts of processing parcels. This recording has been instrumental in the detailed evaluation of the collected data.
2.3. Results of experiments

It was acquired b 89, 742 sets of data from the testing. All data were analyze and gave the following information:

- 19 experiment showed similar values of realized measurement (similar values are meant values of dispersion 7%).
- 1 experiment showed in the last two parts of the transport processes of different values (in relation to unforeseen circumstances).
- Subsequent laboratory tests comparing the measured values, it is noted that neither on series of values doesn’t exceed a value representing a fall postal package from a height of 150 cm.

As already mentioned, one experiment showed standard values. These substandard results differ from the standard, not only the duration of treatment (extended by 4 minutes and 12 seconds), but especially in the results accelerometer and gyroscope. Different values were measure only in two last steps (i.e. steps 5 and 6). These two steps represent a slip of postal parcel from sorting lines. The following Figure 4 compares summarized value of 19 experiment to standard values and 1 experiment with non-standard values. The first part of figure presents illustration points after slipping postal parcels on gravitation slip. It is characterized by lean postal parcel at an angle that is equal to the angle of gravitation slip of sorting lines. The second part of figure presents illustration non-standard values at 1 experiments. The reason why the values are different lies in the following facts. The postal parcel does not slide after slip, but that postal parcels fell after slipping in the rotation until to the output tray.

Figure 3 Measurement procedure - step by step, shown in the illustration

Figure 4 Differences in measurement (slip sorting line)
Even though postal parcel fell unpredictably in gravity slip, so the measured values aren’t still responded laboratory values (i.e. a fall from a height 150 cm). The question arise only if the laboratory values are comparable, because the laboratory tests weren’t designed for multi-level falls in the rotation. The main reason for these values was a condition that can be called overflow sorting line. And it is also true that this condition is rare. Sorting lines was filled because one postal parcel locked output to the tray, which reported its overcrowding. Consequently, there was a faster rate of empting of the individual transport trays, once to remove the problem.

3. CONCLUSIONS

The current increasing trend in the parcel delivery opens the door to a new area of monitoring of transport postal parcels. We are not talking only about compliance with the time of delivery of postal items, as well as adherence to technological processes and security. Thus preventing the loss, theft or damage of postal parcels. This target is currently heading the only one path, and that is the philosophy of IoT. There are already several solutions, but which mainly serves as additional services for customers of the postal operator. As part of this research were realize just one of the first small steps, which aimed to monitoring the entire process chain. Our research has so far been realized only at one point in transport process of postal parcel. And it was processing center of postal items. At this point exist assumption that can cause negative impacts on the parcel. This assumption was not confirmed in any of the experiments. In the future we plan to realize new measurement using different sizes and different weights of postal parcels.

ACKNOWLEDGEMENTS

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Project VEGA 1/0721/15 Research on the impact of postal services and telecommunication convergence on regulatory approaches in the postal sector

REFERENCES

SIMULATION METHODS IN THE COMPARATIVE ANALYSIS OF CAR SPARE-PARTS DISTRIBUTION SYSTEMS

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Abstract

Car spare-parts must be frequently provided in after-sales service. Customers have great expectations in terms of the delivery and availability of spares. Orders realisation and flexible services are the most important among these expectations. The main aim of the paper is to consider two different distribution systems that occur in one entrepreneur. The reason of this consideration is to identify, which of the distribution systems is more effective regarding the order completion time and the level of customer service. In case of these aims realising, the simulation models analyses are proposed.

Keywords: Car spare-parts, distribution systems, simulation models, simulation methods

1. INTRODUCTION

In [1], Christopher defined the logistics spare-parts as: logistics spare-parts contains the market-oriented planning, realisation, and distribution, along with associated information-flows. Therefore, it means that efficient spare-parts logistics is necessary to be considered [2]. The Block Exemption Regulation (BER) introduced the classification of parts used for vehicle repair, defining sub-categories {O} and {Q} as original spare-parts. The next categories of spare-parts were distinguished in [3] as: (1) spare-parts in the "parts of comparable quality" category (marked with the letter {P}); (2) spare-parts (substitutes), which do not correspond to the previous categories (marked with the letter {Z}). The distribution of alternative {P} spare-parts is carried out by independent distributor in a multi-channel way. They reach the final customer from three sources: (1) directly from the distributor, (2) via the shop, (3) via the workshop. The article concerns the comparative analysis of two preferred models of the system of distributing alternative {P} parts of comparable quality and the option of direct deliveries to workshops. It is done using a simulation method. The latter model was chosen due to its largest market share (83%). The model 1 analysed in this paper is a model of distribution system is the distribution and sale with the use of mobile warehouses. The model 2 is a distribution system using transport via the supplier of goods from the supplier's warehouse or via the delivery company.

The paper is organized as follows. In chapter 2, essential conditions for the functioning of distribution system models selected for the analysis are discussed. Reference, mathematical and simulation models are included there. In chapter 3 the selected results of simulation experiments are presented and simulation models of distribution systems as regards the level of customer service are analysed. And chapter 4 concludes all results obtained in the research. The research process ends with the interpretation of the obtained results. The main aim of the article and the analysis is to identify which of the preferred systems is more effective as regards the order completion time and the level of customer service.

2. MODELS OF SELECTED DISTRIBUTION SYSTEMS

The model of the distribution system based on direct deliveries from the independent distributor’s plant branch with the use of "milk run supply" principles is analysed. Standard material-handling system can minimize the
total material-handling and inventory holding cost to the extent level [4]. In the considered company, every salesperson has their own customer base. The workers are equipped with GPS navigation system and a program that tracks and monitors the drivers. This indicates how much time the worker spent on the route, how much the worker’s rest break last, and, above all, it makes orders from customers easy to view. The sale of products takes place via a chain of 9 branches across Poland, and 5 authorised dealers operate on the same principles as the company’s branches and serve an area where no plants are located. Two distribution systems were suggested for the direct distribution model. The first one is a mobile warehouse system, whereas the second one is a distribution system using transport via the supplier of goods from the supplier’s warehouse or via the delivery company.

2.1. Reference models of selected distribution systems

IDEF0 is a method designed to model the decisions, actions, and activities of an organisation or system [5]. A modified IDEF0 (Integratd DEFinition Methods) methodology and a “swimlane” concept were used in the reference model. IDEF0 allows to build diagrams reflecting the processes, which may be treated as a documentation of the process and as a model itself. A “swimlane” concept is a mechanism determining the activities of participant co-operating in the system. The mobile warehouse system (model 1) assumes that the goods are distributed from the company’s branch and authorised dealers to customers based on van-selling principles (Figure 1a). During visiting the customer, the salesperson spends a lot of time on activities connected with the sale, i.e. presenting the offer, preparing an item from the vehicle, and issuing and printing an invoice (Figure 1a). Each of the sales representatives is equipped with a light commercial vehicle with a limited capacity of 3.5 tonnes.

In case of model 1, activity name and their duration time ([min]) are: A1 - greeting and presenting a subject of negotiation (2), A2 - the decision about a need of purchase (1), A3 - verification of direct accessibility (2), A4 - presenting the positions of the parties - active recognition of a customer’s needs (3), A5 - developing the argumentation - demonstrating an item in the mobile warehouse (1), A6 - finding a desired item of purchase (2), A7 - presenting the item of purchase (2), A8 - confronting the differences - determining the details concerning the item of purchase (3), A9 - the decision about purchasing the item of purchase (1), A10 - putting aside an item of purchase by a client - acceptance (1), A11 - putting an item of purchase back to a mobile warehouse - resignation (1), A12 - decision about continuing the process - the next item of purchase (1), A13 - decision about continuing a process - determining the conditions of purchase (2), A14 - preparing the printer and connecting an invoicing device (2), A15 - printing an invoice (2), A16 - receiving cash payment (2), A17 - refusal (1), A18 - arranging a date of the next meeting, goodbye (1).

In case of model 2, activity name and their duration time ([min]) are: A1 - greeting and presenting a subject of negotiation (2), A2 - decision about a need of purchase (1), A3 - verification of availability in an on-line catalogue (1), A4 - presenting the positions of the parties - active recognition of the Customer's needs (3), A5 - developing the argumentation - based on the on-line description (1), A6 - finding a desired item of purchase (1), A7 - presenting an item of purchase (1), A8 - confronting the differences - determining details concerning an item of purchase (3), A9 - decision about purchasing an item (1), A10 - confirmation of the order in an on-
line system (1), A11 - decision about continuing a process - the next item of purchase (1), A12 - decision about continuing the process - determining the conditions of purchase (2), A13 - on-line order generation (1), A14 - refusal (1).

The salespeople do not play the role of a seller with a mobile warehouse, but of a sales representative. They are equipped with a passenger car and tablets connected to the ERP system supporting the company’s functioning. An additional advantage is that a salesperson can monitor the warehouse stocks, knowing if a product of customer’s interest is available. The number of operations in relation to the first model is lower (Figure 1b). In the delivery system via the supplier of goods from the branch’s warehouse (model 2), automatically after receiving an order, order-picking and loading to the means of transport take place. The means of external transport or the appointed courier travel the same route in order to leave the ordered item at the customer’s delivery address not later than one day after. Unfortunately, such operations extend the order completion time. Two reference models of distribution systems assumptions are compared in Table 1.

<table>
<thead>
<tr>
<th>Table 1 Comparison distribution systems, source: own-work</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
</tr>
<tr>
<td>direct access to 646 product indices (on average) located in a mobile warehouse</td>
</tr>
<tr>
<td>the number of customers served at the level is 169</td>
</tr>
<tr>
<td>the number of indexes sold at the level is 621 pcs and 817 185 pcs of goods per year</td>
</tr>
<tr>
<td>accessibility to the goods offered at the level of 67%</td>
</tr>
<tr>
<td>if the item is unavailable and the customer maintains the order, the item is delivered after one week</td>
</tr>
</tbody>
</table>

2.2. Mathematic and simulation models of chosen distribution systems

According to [6] “a simulation model is the multi-modules software that creates a kind of functional simulator with the compatible computer, which allows to generate states of modelled system.” The requirements for above definition are fulfilled. Scheme of research procedure in the case of simulation models’ constructing are drawn, with slightly changes, after [7]. The simulation models, described in the paper, were developed in accordance to guidelines of Discrete Event System Specification that is precisely defined in [8].

Simulation models e.g. allow conducting experiments and testing “what-if ...?” scenarios, both in the case of already existing systems or - in the case of processes planning - long before implementation. Simulation models that appear in this classification - depending on the characteristics or attributes of models describing the state of the system at the time - can be divided into four types: dynamic, static, stochastic, deterministic [8]. Herein, dynamic simulation models are considered. In the case of dynamic models, the time factor is significant. System’s state changes with a simulation time and thus the properties and attributes of the system are dependent on a simulation time. As a simulation result depends on its duration, it is possible to obtain various effects.

There are many software tools that use the mentioned DEVS model. Some of them are: Arena, Dosimis-3, Tecnomatix® Plant Simulation, Flexsim etc. Some of these tools are made especially for simulating some aspects of logistics and production, whereas others can be adapted to achieve the necessary results.

In the research, presented in this paper, Tecnomatix® Plant Simulation 10.1 was used. Tecnomatix® Plant Simulation is a tool for digital numerical simulation models constructing and researching. Mainly, the software is used in simulations of manufacturing processes. According to the entrepreneurs who possess copyrights for Tecnomatix® Plant Simulation, it can be used in most industries [7].
2.3. Simulation model - model 1

As the first one, the simulation model that represents model 1 was prepared. It is based on reference model itself and its main form is given in Figure 1a. In the simulation model 40 highly-specialized sales representatives for 5 dealers and 2 sales representatives per one branch are assumed. Total amount of workers considered in the model is 58 persons. That means that assuming 252 working days, 56 items can be sold per one day. The exit strategy for A3 operation that is the verification of the direct accessibility to the goods offered by sales representatives is at the level of 67%. Whereas, for A13 operation (the decision about continuing the process - the next item of purchase) 46.7% or orders are positively realised. For the rest of operations, which need specific exit strategy, it was assumed to consider fifty-fifty strategies.

Figure 2. presents processing capacity of every A-set elements in the case of the model 1. As it can be specified, some operations are in waiting mode in long period of time. In this simulation model, it is because one simulation correspond to one sales representative. She / he cannot realise different activities in the same time. However, some activities are in blocked mode. It means that the adequate activity last too long and other customers and orders are waiting in a queue. Some other results connected to model 2 are given in Table 2.

Table 2 Selected standard measures the level of customer service in simulation analysis, source: own-work

<table>
<thead>
<tr>
<th>Measure</th>
<th>Equation</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>The percentage of currently unavailable items is 56.8% (in the simulation model it is coded as):</td>
<td>„Models.Frame.OrdersTime[5, Models.Frame.Drain.statNumIn] = Num_To_Str((”, Models.Frame.A5.statNumOut)/(Mode Is.Frame.Source.statNumOut)*100);“</td>
<td>0.6624</td>
</tr>
<tr>
<td>The percentage of the customer’s orders carried out completely is 18.5% (this one is coded as):</td>
<td>„Models.Frame.OrdersTime[7, Models.Frame.Drain.statNumIn] = Num_To_Str((”, Models.Frame.A16.statNumOut)/(Mode Is.Frame.Source.statNumOut)*100);“</td>
<td>0.6823</td>
</tr>
<tr>
<td>Linear: y = -0.3911x + 77.5350, R² = 0.6624,</td>
<td>Linear: y = -0.2006x + 6.6577, R² = 0.6823,</td>
<td></td>
</tr>
<tr>
<td>Logarithmic: y = -8.3749 ln(x) + 92.1640, R² = 0.9178,</td>
<td>Logarithmic: y = -4.0223 ln(x) - 0.0043, R² = 0.8288,</td>
<td></td>
</tr>
<tr>
<td>Polynomial: y = 0.0118x² - 1.0628x + 84.0280, R² = 0.7879,</td>
<td>Polynomial: y = -0.0042x² + 0.4427x + 4.3173, R² = 0.7462,</td>
<td></td>
</tr>
<tr>
<td>Power series: y = 94.2330x - 0.1157, R² = 0.9276,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exponential: y = 77.4410e⁻⁰.0056x, R² = 0.7227,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The percentage of orders carried out completely from the stock in the warehouse is 100%. And at last, time from the moment of placing the order by the customer to the moment of delivering the ordered goods is 17 min. and 8.52 sec. Simulation time was 2 hours and 29 minutes, which means that sales representatives could serve three times more customers or in other words the number of workers seems to be too plentiful.

2.4. Simulation model - model 2

As the second one, the simulation model that represents the delivery system known here as model 2 was prepared. It is based on reference model in Figure 1b. In general, the entrepreneur employs 220 persons: 2 highly-specialized sales representatives per one of 9 branches, who sell items in mobile warehouse system.
and 40 highly-specialized sales representatives for 5 dealers, which means the rest of workers are hired in branches. That means that assuming 252 working days, 43 orders can be realised per one day. The exit strategy for A3 operation that is the verification of the direct accessibility, accessibility to the goods offered is at the level of 67%. Whereas, for A12 operation (the on-line order generation) 50% of orders are positively realised. For the rest of operations, which needs specific exit strategy, it was assumed to consider fifty-fifty strategies. Figure 3 presents processing capacity of every A-set elements in the case of the delivery system. As it was specified before, also in the case of second model some operations are in waiting mode in long period of time. In this simulation model, it is caused by the fact that one simulation correspond to one warehouse worker who serves one customer / order. She / he cannot realize different activities in the same time. Herein, only one activity is in blocked mode. It is A3 operation: verification of the availability in the on-line catalogue. It means that the adequate activity last too long. It might occur that it is because of the numerous assortment exposed in the catalogue.

Table 3 Selected standard measures the level of customer service in simulation analysis, source: own-work

<table>
<thead>
<tr>
<th>Measure Type</th>
<th>Formula</th>
<th>Coefficient of Determination R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>$y = -0.5895 \times x + 71.6200$</td>
<td>0.5949</td>
</tr>
<tr>
<td>Logarithmic</td>
<td>$y = -10.0260 \ln(x) + 86.9880$</td>
<td>0.8426</td>
</tr>
<tr>
<td>Polynomial</td>
<td>$y = 0.0193 \times x^2 - 1.4394 \times x + 77.9950$</td>
<td>0.6734</td>
</tr>
<tr>
<td>Power Series</td>
<td>$y = 89.3040 \times x^{-0.1527}$</td>
<td>0.8406</td>
</tr>
<tr>
<td>Exponential</td>
<td>$y = 71.5710 \times e^{-0.0096x}$</td>
<td>0.6723</td>
</tr>
</tbody>
</table>

The percentage of orders carried out completely from the stock in the warehouse is 100%. And at last, time from the moment of placing the order by the customer to delivering the ordered goods is 15 min. and 34.88 sec. Simulation time was 2 hours and 11 min., which means that warehouse workers could serve three and a half times more customers or in other words the number of workers is too plentiful.

3. THE RESULTS OF SIMULATION EXPERIMENTS AND THE COMPARATIVE ANALYSIS

It should be explained that to check whether two variables describing the state of distribution systems (the percentage of currently unavailable items in simulation time and percentage of the customer’s orders carried out completely in simulation time) oscillate around their final values at the end of simulation process, the exact test was introduced. In model 1 the percentage of currently unavailable items in simulation time oscillate around the final value (56.80%). Only 1 element, after plenty of simulation experiments, does not belong to
partition 56.80% ± 3σ. The Fisher exact test statistic value is 1. The result is not significant at p-level: $p < 0.05$. Variables are independent. Whereas, in model 2, the percentage of currently unavailable items in simulation time oscillate around the final value (41.85%). Only 1 element does not belong to partition 41.85% ± 3σ. Percentage of the customer’s orders carried out completely in simulation time is also considered. In this case, the Fisher exact test statistic value is 0.630584. The result is not significant at p-level: $p < 0.05$. Variables are independent.

4. CONCLUSION

The main result of this paper is to the comparative analysis concerns, among others, the assessment of the level of customer distribution service. Simulation with using adequate models show that in two distribution systems some organizational change might occur. Simulation results show in the first model that sales representatives could serve at least three times more customers while in the second model even three and a half times more customers. In other words the number of workers might be thought as too plentiful. However, it needs additional research to define adequate conclusions in the last matter. Obviously, it is required into consideration how much the worker spent on the route, how much the worker’s rest break last etc. From a practitioner perspective, the considerable investments in spare-parts availability signify that very small improvements in this area may lead to substantial cost savings. Notwithstanding, introducing of proposed changes would mean some savings for the company. It should be emphasized here that proposed changes tend to reduce the number of employees and increasing the efficiency of their work.

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LITERATURE

INTERNET OF THINGS AND ITS IMPACT ON SUPPLY CHAIN EFFICIENCY

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Abstract
The purpose of the present paper - which is conceptual in nature - is to initiate discussion of the need for and feasibility of the measurement of the impact of IOT projects on supply chain efficiency. PESTEL factors relevant to supply chains are discussed, with a focus on the IOT. The main areas of IOT applications in logistics and supply chain operations and management are described. Existing literature in this field is reviewed, and the methods used so far to measure supply chain effectiveness are explained. The paper ends with a proposal for a new methodology for the measurement of the effectiveness of IOT deployments in the supply chain, addressing specific key performance parameters, such as reliability, speed, costs, flexibility, assets and environmental footprint, and levels of the supply chain: assets, operations, processes and business model. The article is not an exhaustive treatment of the subject; instead, it aims at initiating a scientific debate on the possible methods of measuring changes in supply chain effectiveness due to the implementation of IOT solutions. Only the initial stages of research into this topic are presented.

Keywords: Supply chain, IOT, efficiency

INTRODUCTION
The Internet of Things and its applications in logistics and the supply chain are important topics discussed by practitioners and theoreticians alike. The use of IoT throughout the supply chain radically transforms every aspect of supply chain management. It ensures the accessibility of enormous amounts of data and the ability to act on this data in real time. However, no methodology has yet been developed to measure the improvement in supply chain effectiveness due to the deployment of IoT. Scientific goal of this paper is to propose such a methodology, following a discussion of the factors affecting supply chains, the areas in which IoT can be deployed in the supply chain, and the methods of measuring the effectiveness of supply chains.

1. THE IMPACT OF THE MACROENVIRONMENT ON SUPPLY CHAINS
A supply chain does not operate in a vacuum, but rather in a dynamic, constantly changing environment. This environment shapes the structure and operation of the supply chain to a significant degree. According to the PESTEL model, the following groups of factors in the more distant environment of the supply chain can be distinguished: politics, the economy, society, technology, natural environment and regulatory regime. In this classification, the Internet of Things (IoT) is part of technology. However, it is useful to discuss its impact on supply chains in a broader, holistic context.

The influence of politics is the consequence of the interplay of economic interests of various states and alliances to which they belong. Insofar as the economy is concerned, the growing role played by Brazil, Russia, India, China, Korea and African countries has significant impact. Supply chains leading to and from these countries will play an increasingly important role. A notable demographic factor is the aging of Western European societies. This translates into consumption patterns. Given the growing role of African and Asian consumer markets (which are not affected by this process), the geographical potential of supply chains can be expected to change. Increasing urbanisation is yet another important consideration. Currently, over 50% of the world's population live in cities [2]. For supply chains, this means that the trend has to be factored into models of the distribution of goods. Technological progress is another important determinant of supply chains. IoT
has the greatest potential to drive progress. The application of IoT technology in logistics is a breakthrough innovation, set to transform the logistics industry radically. When the full potential of IoT is brought into play, logistics data becomes thoroughly transparent and data streams from different sources can be integrated as never before. Better risk management across the supply chain is one of the outcomes of this integration. IoT also created unprecedented opportunities for improvement in asset utilization in the supply chain and the use of environment-friendly solutions. This translates into greater economic and social value for the company and for society as a whole. The natural environment has become increasingly important in the development of supply chains. In recent years, many executives managing international businesses have pursued initiatives to reduce the carbon footprint of logistics and supply chain operations. Logistics accounts for approximately 5.5% of greenhouse gases, of which 89% is associated with transport [3]. Businesses try to reduce their consumption of energy from non-renewable sources, as well as their consumption of water, which will become a scarce resource. Measures are also being taken to reduce congestion, particularly in large cities. Regulation creates the framework for the operation of supply chains. Regulatory initiatives designed to protect the environment are gaining ground. To give a specific example, in January 2008, the Commission of the European Union adopted a directive requiring EU countries to generate 20% of their energy from renewable sources, and set the minimum share of biofuels at 10% [4].

2. THE INTERNET OF THINGS IN THE SUPPLY CHAIN

The term “Internet of Things” was introduced for the first time in 1999 by Kevin Ashton in a Procter & Gamble (P&G) presentation [5]. The term IoT refers to data-processing devices connected to the global network, capable of communicating with one another without human intervention. Currently, no more than 1% of all physical devices that could be connected to the Internet are in fact connected [6]. It is expected that over the next decade IoT will generate USD 8 trillion in revenues from innovation, better asset management, logistics and supply chain operations, increased productivity of labour and enhanced customer experience. IoT brings benefits to logistics operators, their clients and end users. It helps improve quality and predictability, and drive down costs (including environmental costs). With IoT, it becomes possible not only to monitor assets in supply chains, but also to process enormous amounts of data transmitted by devices connected to the Internet. Proper use of this data helps businesses streamline their legacy logistics operations and processes. The main IoT application areas in the supply chain include: fleet management, vehicle movement, tracking of assets and energy consumption, production monitoring, monitoring of people, equipment and real estate (e.g. distribution centres, warehouses), as well as risk management in supply chains. Vehicles are assets that are especially “ripe” for IoT deployment in the supply chain. IoT creates opportunities for improving traffic security and its optimisation. IoT also creates unprecedented opportunities for tracking of traffic, transport conditions and cargo security. It is the latest generation of track-and-trace solutions, which make it possible to track goods meter by meter, second by second. Modern sensors, such as the Smart sensor from DHL, can monitor temperature, humidity, light intensity and unexpected events. IoT technology can also significantly enhance the operation of distribution centres, which are important supply chains links. It creates many opportunities for effective management of the flow of information and products, inventory levels, security of people and equipment, and energy consumption in distribution centres. IoT also helps with optimisation of asset utilisation. With all vehicles and equipment in a distribution centre connected to a central system, their use can be monitored. IoT also enables efficient energy management in a distribution centre. Standard lighting accounts for 70% of energy consumption. With networked heating, ventilation, air conditioning and lighting devices, energy consumption can be controlled in line with demand. This kind of solution helps reduce CO2 emissions and overhead costs of the distribution centre [7]. Since IoT is so important for the effectiveness of the supply chain, methods for its measurement before and after the implementation of an IoT solution need to be developed.
3. METHODS FOR MEASURING THE EFFICIENCY OF SUPPLY CHAINS

Efficiency is defined as a “positive outcome, effectiveness, efficacy, productivity” [8] and can refer to “the best outcomes of production, distribution, sales and promotion.” Efficiency can also mean “the evaluation of outcomes with respect to the purpose and utility of action [9].” International methodological standards include the following measures of the outcomes of innovation: the share of new products in sales, the share in sales of products in the launch phase, the effects of the efforts to promote innovation, and the impact of innovation on the efficient use of factors of production [10]. These indicators cannot be used to evaluate the impact of innovation on the supply chain. Indicators measuring the impact of innovation on the general operation of an enterprise are also used. Supply chain efficiency measurement requires comprehensive indicators, reflecting the performance of entire supply chains, rather than their individual elements. Dimensions of efficiency, such as quality, costs and time, are commonly employed in studying supply chains [11]. Authors of the A.T. Kearney report entitled “Insight to Impact” distinguished traditional and “new” efficiency categories. They listed the following traditional categories of efficiency: quality, time and operating costs. To this list they added new supply chain efficiency categories, the result of interactions between the traditional categories. These include: responsiveness, leanness and agility, that is, the speed with which the system, supported by the intelligent use of information, is able to attain the optimal cost structure [12]. Two approaches to the measurement of the efficiency of supply chains are dominant in the literature: the Balanced Scorecard adapted to the needs of supply chains, and SCOR [13]. The application of the Balanced Scorecard approach to the evaluation of supply chain performance has been proposed by P. C. Brewer and T. W. Speh [14] and by H. J. Bullinger et al [15]. The indicators relate to four Scorecard perspectives and three levels of the supply chain, namely, operations, processes and the supply chain. However, analysis of the literature has shown that most of the indicators constructed in this way relate to logistics internal to the organization, while ignoring the achievements of the entire supply chain [16]. The SCOR (Supply Chain Operations Reference) model consists in comparing standard supply chain processes with the best practices established on the basis of the experience of SCC companies. SCOR was developed to analyse supply chains and enable the participants (manufacturers, suppliers, distributors and retailers) to assess their efficiency and to introduce improvements in the flow of goods, labour and information SCOR is based on six distinct management processes: Plan, Source, Make, Deliver, Return, and Enable. Supply chain performance measures can be built on the basic SCOR processes. A. Gunasekaran and others have created supply chain performance indicators by considering the processes of planning, purchasing (supply), production and delivery on the operating, tactical and strategic levels of the supply chain [17].

The SCOR model uses a supply chain strategic matrix to identify the strategic features of a given supply chain [18]. Within this matrix, two perspectives can be distinguished: the client's perspective and the internal perspective of the supply chain. The matrix helps determine the current and target states for each performance attribute (property) of the supply chain. It is considered normal that a supply chain can achieve top scores only for some performance attributes. These should be the attributes that are most important from the perspective of the given supply chain.

Most publications on supply chains focus either on the dimension of innovation, or on the dimension of efficiency. There is a dearth of studies combining the two perspectives. The exception is the work of J. Trienkenes and collaborators [19]. The authors of this study have developed an innovation-efficiency matrix. It contains the main innovation and efficiency categories for a fruit supply chain. The innovation categories (product, process, marketing and organizational innovation) are based on Eurostat and OECD data. Efficiency categories for the fruit supply chain - efficiency, responsiveness, quality and agility - are based on research done by other authors. Efficiency indicators depend on the specific nature of a given industry, company, client or key success factors. Because of the diversity of conditions affecting the supply chain, the choice of the key success factor depends on the specific supply chain and its unique features.
4. PROPOSAL OF A METHODOLOGY FOR THE MEASUREMENT OF THE EFFICIENCY OF IOT DEPLOYMENTS IN THE SUPPLY CHAIN

It seems that the best way to measure the efficiency of IoT deployments in the supply chain is to use the effectiveness of innovation in the supply chain measurement matrix, described by the author in earlier studies. This method can be used to measure the efficiency of a supply chain both before and after IoT deployment, which can give an insight into the growth of supply chain effectiveness after such a deployment. The presented matrix is the result of literature review discussed above. The matrix features key performance parameters, such as reliability, speed, costs, flexibility, assets and ecology (environmental footprint), and levels of the supply chain: resources, operations, processes and business model. The matrix is illustrated by Figure 1.

The matrix gives the possibility of measuring efficiency performance for each supply chain level combined with each key performance parameter. Performance indicators for each supply chain level combined with each key performance parameter have to be defined according to supply chain character, sector, and goals to be achieved by a given supply chain.

Examples of performance indicators are given in Table 1. Once the indicators of the efficiency of innovation for supply chains operating in a given industry have been determined, one can measure the efficiency of IoT deployments in the supply chain. The first step is to collect the necessary data, and enter it in the supply chain innovation effectiveness matrix. Two matrices should be generated. One should contain “input” data, reflecting the situation before the deployment of IoT, and the other should contain “output” data, reflecting the situation after the deployment of IoT in the supply chain under study.

<table>
<thead>
<tr>
<th>CRITERION of EFFICIENCY</th>
<th>SUPPLY CHAIN MANAGEMENT LEVEL</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Resources</td>
</tr>
<tr>
<td>RELIABILITY</td>
<td>Performance of the supply chain (on the levels of resources, operations, processes and the business model) in delivering the right product to the right destination at the right time in the right condition and packaging, in the required amount, with the required documentation, to the right customer</td>
</tr>
<tr>
<td>SPEED</td>
<td>The speed with which the supply chain delivers (on the levels of resources, operations, processes and the business model) products to customers</td>
</tr>
<tr>
<td>AGILITY</td>
<td>The agility with which the supply chain (on the levels of resources, operations, processes and the business model) responds to changes in the marketplace, so as to maintain or gain competitive advantage</td>
</tr>
<tr>
<td>COSTS</td>
<td>The costs associated with the operation of the supply chain (on the levels of resources, operations, processes and the business model)</td>
</tr>
<tr>
<td>ASSETS</td>
<td>The efficiency of the organization in managing fixed assets and working capital (on the levels of resources, operations, processes and the business model) in order to meet demand</td>
</tr>
<tr>
<td>ECOLOGY</td>
<td>The ecological footprint of the supply chain (on the levels of resources, operations, processes and the business model)</td>
</tr>
</tbody>
</table>

Figure 1 Effectiveness measurement matrix
Source: original research based on: [18] [19] [20].
<table>
<thead>
<tr>
<th>Supply chain management level</th>
<th>Criterion of efficiency</th>
<th>Resource</th>
<th>Operations</th>
<th>Processes</th>
<th>Business model</th>
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<td>Management</td>
<td>Reliability</td>
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<td>means of production</td>
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<td>- time needed to allocate</td>
<td>- number of situations</td>
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<td>- resource costs</td>
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<td>resources for non-routine</td>
<td>in which resources were</td>
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<td>(eg. labour,</td>
<td>assets tied up in</td>
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<td>operations (reaction time)</td>
<td>used flexibly to</td>
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<td>meet market demand</td>
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Source: [21]
CONCLUSIONS

The methodology presented in this article can be used to measure the efficiency of a supply chain before and after IoT deployment. The measurement takes into account such parameters as reliability, speed, costs, agility, resources and ecology (environmental footprint), and levels of the supply chain: assets, operations, processes and business model. Though this is a conceptual paper, and no research has been done yet to prove the usefulness of the proposed measures, it is hoped that it will stimulate a scientific debate of the question whether the availability of a common methodology would ensure comparability of data within an industry, as well as between industries, taking into account their distinguishing characteristics, and whether, based on the above data, it will be possible to develop a set of best practices for the the implementation of IoT in the supply chain.

REFERENCES

SEARCHING OPTIMAL HUB LOCATIONS IN POSTAL LOGISTIC NETWORK

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Abstract

The article deals with the process of searching the optimal locations of logistic hubs in conditions of postal logistic network of Slovak Post. The research adopted in this article uses allocation models within graph theory to obtain results for addressed optimization problem. The optimization is based on demographic and economic characteristics of Slovak republic. Selected allocation models are applied on the road infrastructure with objective to determine the optimal location of postal hubs. The results can serve as a basis for modification of the used model for the simulation of logistic networks in the postal sector.

Keywords: Postal network, allocation models, p-median, fixed charge facility location

1. INTRODUCTION

Appropriate location decision is a key to optimally solve variety of public and private problems, since poor location can result in various negative scenarios. We can consider such decisions as critical, or strategic. In private sector it can lead to increasing costs, loss of competitive advantage and market share. Location theory provides many different approaches, procedures and solution to support decisions of locating facilities, either building new ones or relocating existing. The choice of solution depends exclusively on the nature of the problem, known inputs, decision variables and the outputs we want to achieve. In location models, demands and candidate locations are discretized to simplify the solution. These models also assume that there is an underlying network for the problem, consisting of certain infrastructure, such as transport or other logistic connections. The distance between demand nodes and facility locations is not necessarily the physical distance. It could be also the travel time, travel costs, etc.

Postal operation represents an extensive technological system with a considerable degree of integration for different types of services. The main business activity of postal operator is reliable, regular, and fast transport of postal items. The transport is performed among the stationary postal facilities with different levels of postal item processing. Customer demands the delivery time to be minimal and guaranteed under the terms of the universal service and the nature of postal item, respectively. Moreover, the effort of postal operators as business entities is put forth, so that operations are carried out with minimal cost. Apart from the postal item processing technology, transport itself is an equally critical factor of time and cost. Transport is affected by the location of postal facilities and connections among them - the postal logistic network. [1]

The design of a suitable postal logistic system is the most important issue for providing elementary functions of the postal enterprise. A correct technology decision depends on the chosen postal infrastructure model and specific technological methods and processes. The designed model takes into consideration demands of the outside postal environment and requirements of the high level automation equipment in the conditions of postal enterprises. [2]
2. **ANALYSIS**

On the basis of essential postal technology, terms it is important to analyze main areas, which influencing the whole technological process of the postal items processing. The analysis determines the critical part of the whole optimization process - the choice of suitable construction variant of the postal logistic network.

The most suitable construction variant of the postal logistic network is selected from experiences of the postal enterprises in two European countries, which are comparable to Slovakia in geomorphological character and demographical structure. The chosen countries are Switzerland and Denmark. The construction variant of the transportation network that seemed to be the optimum for these countries conditions is hierarchical three-level model of postal logistic network (Figure 1). [3]

![Hierarchical three-level model of postal logistic network](image)

**Figure 1** Hierarchical three-level model of postal logistic network [3]

2.1. **Analysis of the models suitable for allocation of hubs in postal logistic network**

The number and location of postal processing centers in the postal transport network is determined mainly by logistic functions of the entire postal system. The decision on where and how many top-level nodes to be located can be considered as strategic, and, therefore, it needs to be taken based on the results of the optimization process.

The graph theory is highly used in the optimization of transport networks. It enables us to describe and to abstract these networks and formulate different tasks to solve them. One of those tasks is finding the optimal location of facilities. Allocation models can be helpful in this case. The role of such mathematical models is to find answers to these key questions [4]:

- How many facilities need to be located?
- Where should each facility be located?
- How large should the facility be?
- What are the demands or how large is the area to be covered by an individual facility?

Postal transport network centers perform supplying function. To find the location, it is convenient to use discrete network allocation models. One of the basic parameters for solving problems of such type is the very distance between nodes. From this point of view, it is possible to subdivide allocation models into two categories: models based on maximum distance (set covering, maximum covering, p-center) and models based on total or average distance (p-median, maxisum, fixed charge facility location). [5]

Models, based on the total, or covering distance seem to be the most appropriate for the issue addressed in this article. When locating facilities, these models do not take into account the maximum distance between the facility and demand node, but rather the total / average distance between the facilities and all demands. They ensure that the average distance between any vertex and facility location will be minimum possible. Thus, we decided to use the p-median allocation model and uncapacitaed fixed charge facility location model.
The p-median problem is one of the basic questions of location theory and is as follows: The spatial distribution and the amount of demand for a certain service or facility are known. The task is to find locations for a given number of facilities that satisfy the demand. The facility locations are optimal, if the weighted travel efforts from the demand points to the nearest facilities are minimized. The problem is uncapacitated, which means that a facility can match any amount of demand necessary. [6]

The objective of the uncapacitated fixed charge location problem is to minimize total facility and transportation costs. In so doing, it determines the optimal number and locations of facilities, as well as the assignments of demand to a facility. [7]

3. OBJECTIVE AND METHODOLOGY

After choosing the construction model of the logistic network, it is necessary to determine the number and placement of each node at all levels of the postal network. That is the main objective of this article. For reasons to reach the real results, the postal optimization process is realized in conditions of the Slovak postal enterprise - Slovak Post.

The existence of logistic network of Slovak Post determined to use methodology based on variant-oriented optimization process. Therefore, a two-phase optimization method has to be created, which at first (optional phase) re-evaluates existence of middle level nodes and after (second phase) suggest the number and placement of the highest level nodes of the postal logistic network - hubs.

We can search optimal position of hubs in the existing postal network in the Slovak republic or we can create new postal logistics network based on main demographic and geographic data. There is a three-level structural variant of postal network implemented. The lowest level consists of regular post offices. These are connected only to the middle-level modes. The middle-level nodes perform function of mail concentrator and ensure a certain degree of mail processing. The postal items are then forwarded to high-level nodes, which are connected to each other. The process works similarly in the opposite direction - from higher to lower level nodes. [8] This process ensures the covering of the whole territory of Slovakia. In this article we will try to find the location of hubs in existing postal logistic network of national postal operator in Slovakia - Slovak Post, a.s. and we will use second phase of optimization only.

The underlying infrastructure can be represented by simplified model of a postal network, abstracted by a graph G=(V, E, c, w). The set of vertices (nodes) V consists of all 41 existing middle-level nodes. The set of edges E represents road connections between nodes. The labels of edges c(e) have value of the shortest distance in kilometers or travel time in minutes (we will use only value - distance in km). When determining the weight of nodes w(v), we use the demographic and geographic characteristics of individual nodes and the covering region which they serve. We consider the following attributes: number of villages (or cities) in the middle-level region, number of villages (or cities) with postal offices in the middle-level region, number of citizens in the middle-level region total area of the middle-level region, total distance between the middle-level region center and each village (or city) in the middle-level region and total distance between the middle-level region center and each village (or city) with postal office in the middle-level region. [9,10]

Above mentioned input data are applicable for almost any type of allocation model. The uncapacitated fixed charge location model uses another two specific characteristic variables, which are necessary to be set prior to obtaining the final solution. One of those are fixed costs for the location and build of facility at certain node. We consider the standardized model of postal sorting center, which would have the same construction for all locations. The basic value is set to 800 000 EUR, which resulted from similar projects implemented in practice in recent past. Another required input variable is the cost coefficient per distance unit per demand unit. Analyzing the available internet resources, we set the final value of required coefficient is 0.04873 EUR per kilometer per demand unit. [11]
4. RESULTS

The p-median model locates p facilities to minimize the demand-weighted average distance resulting in minimizing of total costs. The cost of serving demands at specific node is given by the demand at node and the distance between demand node and the nearest facility to that node. The task of the uncapacitated fixed charge location model is to find the number and location of high-level nodes in the network while minimizing the costs of building the facilities and serving the demands of network. When we applied this to models on postal logistic network we obtained these results.

4.1. P-median model

By application of p-median location model we found out that the minimum number of facilities (hubs) for given input values are achieved when locating three facilities at nodes representing the covering regions of cities Trnava, Martin and Prešov. The establishment of this set of high-level nodes in these locations ensures that the all demands / requirements of the nodes of the entire Slovak territory will be satisfied. The final solution for p-median model are presented below (Figure 2 and Table 1).

![Figure 2 Results of p-median allocation model][11]

<table>
<thead>
<tr>
<th>Table 2 Obtained solution for p-median model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final results of model</td>
</tr>
<tr>
<td>Number of facilities</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

4.2. Uncapacitated fixed charge location model

By application of uncapacitated fixed charge location model we found out that the minimum costs for given input values are achieved when locating three facilities at nodes representing the covering regions of cities Galanta, Martin and Prešov. The establishment of high-level nodes in these locations ensures the covering of all demands of the entire Slovak territory while minimizing the building and transport costs. The assignment of demand nodes to individual located facilities corresponding to the final solution are presented below (Figure 3 and Table 2).
Figure 3 Results of uncapacitated fixed charge location model [12]

Table 2 Obtained solution for uncapacitated fixed charge location model

<table>
<thead>
<tr>
<th>Number of facilities</th>
<th>Total fixed costs</th>
<th>Total demand weighted transport costs</th>
<th>Total costs</th>
<th>Average weighted distance</th>
<th>Covered demands</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2 740 200 €</td>
<td>6 609 581.26 €</td>
<td>9 349 781.26 €</td>
<td>47.057 km</td>
<td>100 %</td>
</tr>
</tbody>
</table>

5. CONCLUSION

Based on above mentioned characteristics and parameters of both models, we can observe their similarities and differences. Both models were applicable on the same network, which is represented by complete weighted graph G = (V, H, c, w) to simplify the calculations. Both had the same set of nodes and edges as well as evaluation (weight) of nodes and edges. Input variables include a set of nodes with demands to be served, set of candidate nodes for facility location, the demand value of individual nodes and the distance between each pair of nodes.

The input variable of p-median location model was also the number of facilities to be located on network. Algorithms solving this model were looking for mathematically optimal solution for given number of facilities and finish after finding it. This model did not count with the cost of building up the facilities; it tried to find the solution with minimal transport costs.

The uncapacitated fixed charge location problem did not have a specified number of facilities on input, which increased the variability of solution. The input variables included costs per distance unit per demand unit, which were relatively difficult to determine. Also the costs of building up facilities may differ in each node. However, in addition to mathematically optimal solution, this model brings significant degree of economical optimality compared to the p-median location model. Such optimality is required when strategic decisions are made, similar to locating the postal processing and distribution centers. Therefore, for the solution of decision problem addressed in this article we will use both models the uncapacitated fixed charge location model and p-median location model. Since the current layout of middle-level covering regions is obsolete, it would be necessary to deal with the issue of changing the covering area and reducing their number. After such optimization the presented model can bring even better results. Application of p-median and uncapacitated fixed charge facility location model on selected infrastructure resulted in finding the location of three hubs. They are Trnava, Martin and Prešov (for p-median model) and Galanta, Martin and Prešov (for uncapacitated fixed charge facility location model)
The obtained optimal results and used calculations can serve as a cornerstone for further search of optimal solution by allocation models in the field of postal logistic networks.

ACKNOWLEDGEMENTS

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REFERENCES


A QUALITATIVE ANALYSIS OF USING SWIBŻ SYSTEM INTO CREATION OF POLISH PORT COMMUNITY SYSTEM

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Gdynia Maritime University, Department of Logistics and Transportation Systems, Gdynia, Poland, EU

Abstract

The paper provides a qualitative analysis of the proposal to introduce SWIBŻ into creation of Polish Port Community System. The key information from SWIBŻ system would be widely used by national and international administration institutions in order to achieve expected level of shipping monitoring and control. The article highlights the possible role of SWIBŻ system as the most complex and intelligent system for PCS creation. The analysis of the SWIBŻ system has to identify ways to introduce it into the Polish Port Community System. Analysis run by the author indicates pros and cons of using SWIBŻ system into creation of PCS. Common use of this system by national marine administration would be a significant step in the way to create Polish Port Community System.

Keywords: Port community system, SWIBŻ system, Polish port community system

1. INTRODUCTION

In an article, the author outlined the need for a full empirical analysis to determine the possibilities of use SWIBŻ informatics system operated by Polish Marine Authority to create polish port community system. It would, therefore, have seemed appropriate to conduct a benefit analysis of the current option to create the communication system. Unfortunately, since last years, even less statistics and quantitative data was not available to undertake a rigorous benefits analysis. Consequently the author decided to use a qualitative analysis method and selected information system analysis as a suitable approach to evaluate SWIBŻ system in the absence of hard statistical data. There is also lack of hard statistical data of port community system because it does not exist in the Polish area [1].

2. PORT COMMUNITY SYSTEM

Therefore is a wide range of approaches to information system analysis. But first we will clarify what we mean by a port community system. J. Rodon and J. Ramis-Pujol define a port community system as: “an electronic platform that connects multiple systems operated by a variety of organizations that make up a seaport community” [2]. PORTEL, definite port community system “as a collaboration platform that facilitate the exchange of electronic information regarding commercial and administrative matters that have a business-to-business character in port environment” [3]. Moreover EPCSA completes this definition and explains PCS as “a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the efficiency and competitive positions of the sea and airports’ communities” [4]. Studies of port community systems have generally concentrated on benefits gain by the end users of the system (see [5,6,7]) and on specific investigations into pcs’ implementation [8,9,10,11,12], and promoting data exchange with port community system (see [13,14]. Among the general studies looking at benefits for public institutions are L. Long, M. Klopott, J. Mikišniška, for Customs [15,16] and CORDOVA F.,DURAN C. for strategic and operational knowledge management of port community [17]. Empirical studies on port community system include one by Y. Keceli, H. R. Choi, Y. S. Cha, Y. V. Aydogdu [18,19,20], which gathers data on state severe resistance of the port users which causes failure of the port community system implementation or delays and additional costs.
Port community system in this connection means that most of the organizations engaged in the movement of goods - for instance shippers, forwarders, haulers, rail companies, shipping lines, main seaports, feeder seaports, sea and inland terminals, depot companies, logistic operators, customs authorities, maritime administration, financial institutions, cargo insurers and, last not least, the port authority - feed into an extract from a system which handle the flow of information. Port community system connects public marine institutions and private companies engaged in sea-borne trade. Presently, many documents are sending by internet via e-mail. It becomes a common practice. The delivery of data and information in such ways must be re-typed into the port’s information systems, which is time consuming and vulnerable to typing errors. Port community system must allow for the all stakeholders to make service requests and input their information directly into the port information system. Thus, the system decreases paperwork, improves data quality, enables data and information connections among different stakeholders, and improves and supports the operation in whole transport and logistic chain. The main idea of port community system is to produce data as seldom as possible and to use them as often as possible.

3. SWIBŻ SYSTEM

There are SWIBŻ is a communication system based on data and information flow which come from AIS (Automatic Identification System) [21], SafeSeaNet, PHICS (Polish Harbors Information and Control System) [22] and VTS (Vessel Traffic System). Thanks to link up the above-mentioned systems it is easy to monitoring and controlling traffic of vessels which are calling to polish seaports. Moreover SWIBŻ system as integrated national information system makes some functions:

- The system allows to support operational acts in polish maritime area in such circumstances as [23]:
  - Monitoring of vessel traffic and on its safety of exploitation, exploration and research of water resources in the polish marine area.
  - Running acts to protect live and assets on sea and combat marine spills.
  - Offering of Maritime Assistance Services for vessels who needs supporting or giving a shelter against the storm.
  - Alarming on crisis situation during cooperation with local Pomeranian Central Crisis Management.
  - Alarming on crisis and antiterrorism acts in the framework of ISPS code for cooperation with Central Contact Point, Reginal Contact Point and Safety Port Officers and operational services of important national resorts.
  - System SWIBŻ is collecting, processing and transmitting data and information to some users whose place of origin is national and international.
  - System of data records movement and survey of vessel traffic in polish maritime area. The communication system, also, records data concerning conventional and unconventional vessel traffic.
  - The system is an element of National SafeSeaNet System - electronic information exchange between Polish Administration and European Union Marine Administration. The information exchange concerns on vessel traffic and same distinctly described data and information.
  - Supporting of some institution and companies which act in sea-borne trade, especially such as: Fuel Station, Port Authority, Departments of Shipping Services and so on.

The SWIBŻ system is the main data base of Polish Marine Administration and takes the data and information from the following additional data bases: VTS, AIS, Small ports, position of the vessel in the seaports, Dysport, PHICS 2008, iMARE SSN, iMare DMIS, SSN, EMSA Vessels, data base of vessels, Navtex messenger, LRIT and VHF.

The system uses the following data and information [24]:

- The Information from European System SafeSeaNet.
- Flow of data AIS from polish coastal stations.
- Data from VTS Gdansk Gulf system.
- Information from Lloyd’s Vessel Register.
- Navigational warnings and sailing news comes from BHMS.
- Weather forecasting made by IMGW.
- Declarations received by operators of users of the system.
- Information from European Satellite System which monitoring marine spills by the CleanSetNet system.
- Data from hydro-meteo automatically sensors which are located in the Gdansk Gulf area.
- Data from radar’s system located in the Gdansk Gulf.

The user of the SWIBŻ system has to definite type of incidents and describe procedure of acting with some types of incidents (service of incidents). The user of system may to create some incidents manually or automatically base on the data recorded from appliances, from other communication systems or data base. When some data concerning incident will put into the SWIBŻ system then the system serve the incident according with precisely definite procedure for this type of incidents i.e. some information are sending to some users of the system, and system is waiting for writing some decision which will be undertaken by its addressee.

4. THE METODH OF ANALYSIS

For the purposes of this research, it was identified the specific stakeholders of the SWIBŻ system and theirs tasks within the system. Methodology of the analysis looks as follows:

- Developing a stakeholder’s map with the major stakeholder groups.
- Classifying the individual or organization submissions under each of these stakeholder group (in Table 1).
- Preparing a stakeholder impact matrix (in Tables 2 and 3).

Table 1 Classifying the public and private units’ submission under each of these stakeholder group

<table>
<thead>
<tr>
<th>SEAPORTS</th>
<th>MARINE AUTHORITY</th>
<th>OTHER PUBLIC INSTITUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gdansk seaport</td>
<td>Ministry of Maritime Economy and River Transport</td>
<td>Centrum of Navy Operation of Polish Marine</td>
</tr>
<tr>
<td>Gdynia seaport</td>
<td>Gdynia Marine Authority</td>
<td>Centrum of Pomeranian Crisis Management</td>
</tr>
<tr>
<td>Szczecin and Swinoujsce seaports</td>
<td>Szczecin Marine Authority</td>
<td>Marine Mobile Group of Customs Administration</td>
</tr>
<tr>
<td>Hel seaport</td>
<td>Slupsk Marine Authority</td>
<td>Centrum of Survey Radio localization</td>
</tr>
<tr>
<td>Wladyslawowo seaport</td>
<td>Gdynia Harbor Master Office.</td>
<td>National Coordinator of Navigation Protection</td>
</tr>
<tr>
<td>Leba seaport</td>
<td>Ustka Harbor Master Office.</td>
<td>PRIVATE COMPANIES</td>
</tr>
<tr>
<td>Ustka seaport</td>
<td>Darlowo Harbor Master Office.</td>
<td>Marine pilots</td>
</tr>
<tr>
<td>Darlowo seaport</td>
<td>Gdask Harbor Master Office.</td>
<td>Tugs companies</td>
</tr>
<tr>
<td>Kolobrzeg seaport</td>
<td>Hel Harbor Master Office.</td>
<td>Crewing companies</td>
</tr>
<tr>
<td>Trzebiez seaport</td>
<td>Wladyslawowo Harbor Master Office.</td>
<td>Marine training companies</td>
</tr>
<tr>
<td>Swinoujsce seaport</td>
<td>Kolobrzeg Harbor Master Office.</td>
<td>Shipowner's agents</td>
</tr>
<tr>
<td>Dziwnow seaport</td>
<td>Trzebiez Harbor Master Office.</td>
<td></td>
</tr>
<tr>
<td>Elblag seaport</td>
<td>Swinoujscie Harbor Master Office.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1 clearly demonstrate the wide range of stakeholders who are within the existing SWIBŻ system. The stakeholders and the main tasks of the system identified here are based only on the interviews with persons employed by the Polish Marine Authority. In reality, a much wider range of stakeholders and their tasks have been described in SWIBŻ system. Unfortunately, many of SWIBŻ system stakeholders’ use it’s from time to time. Exchange of data and information is run by the following public and private organization, see Figure 1.

The Tables 2 and 3 provide a summary of the direct research of the stakeholders and their tasks in SWIBŻ system. The main variables of interest (e.g. concerning the characteristics of vessels traffic, passengers’ traffic, cargoes traffic - mainly dangerous «hazmat» cargoes) are shown in the columns, and the main stakeholders are shown in the rows. The potential data and information flow among the stakeholders of the SWIBŻ system are shown in the Tables 2 and 3 from a particular stakeholder’s point of view.

Table 2 Stakeholders data and information flow matrix of SWIBŻ system - arrive vessel to seaport

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>24h arrivals and departure (agency)</th>
<th>24h arrivals and departure (last port / next)</th>
<th>Arrivals and departure by cargo</th>
<th>Arrivals and departure by general cargo</th>
<th>Arrivals and departure by hazmat cargo</th>
<th>Arrivals and departure with definite</th>
<th>Current list of tankers</th>
<th>Current list of vessels with passengers</th>
<th>Current list of vessel with hazmat cargo</th>
<th>Current list of vessel with hazmat short</th>
<th>Current number of vessels in VTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrum of Navy Operation of Polish Marine</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>MRCK SAR</td>
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<td>x</td>
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<td>x</td>
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<tr>
<td>Center of Pomeranian Crisis Management</td>
<td>x</td>
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<tr>
<td>Marine mobile group of Customs Administration</td>
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<td>x</td>
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<tr>
<td>Harbor Master Office</td>
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<td>x</td>
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<tr>
<td>Special departments of Marine Administration</td>
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<td>National Coordinator of Navigation Protection</td>
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<td>Centrum of Survey Radiolocalisation</td>
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<tr>
<td>Marine Authority</td>
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</tr>
</tbody>
</table>
Table 3 Stakeholders data and information flow matrix of SWIBŻ system - departure vessel from seaport

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>List of tanker vessels</th>
<th>List of vessels currently moored</th>
<th>List of vessels leaving passengers</th>
<th>List of vessels historically berthed</th>
<th>List of vessels having passengers</th>
<th>List of vessels with security in last ten ports</th>
<th>Masters</th>
<th>Number of vessels in VTS area</th>
<th>Number of visits by capacity vessel</th>
<th>Number of visits by vessel type</th>
<th>Passenger traffic in harbor</th>
<th>PEC holders</th>
<th>Pilots</th>
<th>Port State Control (PSC)</th>
<th>Vessels passing a reporting line</th>
<th>Vessel passing a reporting (Gulf)</th>
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<tr>
<td>Centrum of Navy Operation of Polish Marine</td>
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Overall, this analysis indicates that there would be a positive effect of using SWIBŻ system in creation polish port community system. Many data and information as well as connection among public marine institution and some private companies just exist in the closed informatics system. Describe SWIBŻ information system like any other management information system is primary a tool to increase the present and future efficiency of the stakeholders, to utilize resources more effectively to reduce costs of traditional documentary flow. Comparing this advanced system with the traditional manner of data collecting and processing, the benefits achieved are obvious. The scope of data reporting is enlarged and a faster processing is possible, that means more and more actual facts concerning vessel traffic, cargo traffic and passenger traffic will be continuously at the disposal of the stakeholders. The author, hence, recommended to the SWIBŻ system should be used in creation a polish port community system because it gives many opportunity, saves money and time for company which will be created the information system.

5. CONCLUSION

For the analysis of the effects of using SWIBŻ system, indicated that the system shall be use for creation polish port community system because provides on-line all-important data and information and may give the quicker sustainable growth of polish sea-borne trade. Unfortunately, there will be many problems which may accrue
during creation polish port community system. One of them is the exchange communication between various public and private users. The problem is not only highly technical - integration of many different information systems used by private companies and public institutions but first of all many private companies may not be inclined to open parts of their data banks to others - mainly due to competitive reasons. Problem of the port community system integration exist also from the public institution side because their can collect data and information which are precisely described within the polish law system. In this situation, the principle difficulties in setting up those advanced information structures are the conflicting interests of various pcs users participating in the movement of different kinds of goods. The aim at different objectives which is reflected in specific operational requirements, i.e. the information standards and needs of each party direct involved in the logistic supply chain must be examined at an early stage in order to define a common basis. Moreover, a cost-benefit analysis should underline the financial assessment before starting into the implementation of polish port community system.

REFERENCES


[21] AIS allows for the monitoring of vessels throughout their voyage, and indeed while the vessel is in seaport as long as the AIS transponder is switched on. Moreover, the system is still subject to a slight delay between the time the transponder emits the individual signal of vessel and the time this registers on the system and thus registers the vessel’s position.

[22] PHICS is Polish National System and connected directly with SWIBŻ system. The system allows for controlling vessels calls to polish seaports, registering of passengers on board, monitoring hazardous materials stored on vessel’s board, controlling foreign vessels located in the polish seaports, controlling and monitoring marine certificates.


MODEL OF LOGISTICS COST ACCOUNTANCY

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Abstract

The primary tool allowing for the logistics costs record keeping is a well-functioning logistics costs account, which should be identified with a system allowing for determination of the level of costs incurred in connection with the implementation of logistics processes in a given unit of time [1]. On the other hand, to be able to achieve the goals of the logistics costs account (The basic functions of the costs account include: evidence, registration, statistical information, planning, optimization, control, price-setting and analytical functions.), the account should be available in many forms and sections. Forms of the logistics costs account are dependent on the requirements and needs of business practice for the acquisition of information necessary to conduct a proper evaluation and to take rational economic decisions [2]. The diversity of purposes of the logistics costs account contributed to the creation of different forms and sections of the cost accounts [3]. The problem lies in the selection of an appropriate costs account. The theory and business practice have not developed a single, universal solution that would meet all the requirements for the costs account.

The aim of the article is to propose a model of the costs account of logistics operations, based on the analytical breakdown of expenses by type, which is also an example of the extension of the existing account by a current, additional system of settlements focused on logistics.

Keywords: Logistics costs, logistics costs account

1. INTRODUCTION

To propose a costs account aimed at obtaining information on costs in the area of logistics activities of a company, which on the one hand meets the requirements arising from the statutory regulations concerning the record and settlement of costs, and on the other hand, implements its objectives set by the users of information in the field of logistics activities, is not a simple and straightforward task. Difficulties arise already for the conceptual understanding of the essence of the logistics costs account. The definition of the logistics costs account that would enable to understand the essence of the problem should be relatively simple and straightforward. An attempt to include in the definition all the activities related to the execution of logistics activities generating the logistics costs is from the beginning doomed to failure, because the scope which is covered by the logistics activities of business entities is subject to continuous evolutionary changes and leads to raising a legitimate allegation of incompleteness of such way of defining the logistics costs account.

2. ANALYSIS OF LIMITATIONS AND OPPORTUNITIES RELATED TO THE LOGISTICS COSTS RECORD

The logistics costs are a primary concept in relation to the logistics costs account and therefore should be first explained thoroughly and in detail. Instead, an attempt to present sense of the logistics costs account should include only its essence, without an additional indication of the scope of the logistics activities, and therefore for the purposes of this study, a definition created based on a formula developed by V. Skrodzka was proposed. Therefore, the logistics costs record is understood as a system allowing for determination of the amount of costs incurred in connection with the implementation of logistics processes in a given unit of time.
J. Twaróg [4] mentions two basic principles that should guide a properly structured model of the logistics costs account:

- the costs account system should reflect the material movements, which means that it should be able to identify the costs that accompany the customer service,
- the system should allow for the separation of the costs and making the analysis of revenues by the types of customers and market segments and distribution channels.

The proposed principles were created based on the analysis of the weaknesses of the traditional costs accounts. This problem is due to a significant increase in the general management cost and difficulties related to this issue in assigning this category of costs to any cost carriers. [5]

The problem lies in the selection of an appropriate costs account. The theory and business practice have not so far developed a single, universal solution that would meet all the requirements for the costs account. To a large extent, an obstacle is a great variety of business subjects and the related different approaches to the specific costs of logistics, methods of accounting, calculating and analysis. Any analysis of the logistics costs has a chance to fulfil its role under the condition that in the creation of the costs account the relevant standards relating to accounting and grouping of costs will be applied. Only a detailed knowledge of the causes of and relationships and proportions of the various components, may allow the actual use of the costs account to rationalize the logistics processes.

The business practice significantly contributed to a distinction of the following possibilities of shaping the logistics costs account:

- a partial extension of the applicable costs account which in its overall structure remains unchanged. In this case, the shaping of the logistics costs account is associated with recording the types of costs with a greater diversification and improved recording of internal logistics services costs,
- occasional supplementing of the costs account by a logistics-oriented special account. With this method of the logistics costs account keeping, normally not present costs of logistics services are added as a supplement to the first method,
- extension of the existing costs account by a current, additional system of settlements focused on logistics. [6]
- In this solution, we are dealing with the improvement of the classical costs account, which on the one hand, is focused on implementing the information needs of the area of production, and on the other hand makes it possible to meet the demand for information of the logistics.

The process of creation and application of the logistics costs account is usually accompanied by more difficulties than facilities. This results in a situation that the hopes for its introduction should be considered as unfulfilled. According to the author, the primary sources limiting the usefulness of the logistics costs account application in the business practice include:

- human factor,
- legal regulations,
- technical considerations,
- financial considerations,
- organizational considerations.

Analyzing the constraints that determine the level of suitability of the logistics costs account, noteworthy are mainly two issues, namely the limitations on the part of the human factor and typical organizational limitations. In the case of the human factor, it does not matter whether it concerns the regular employees or executives. Everything results from the approach of employees to their duties. A very important problem seems to be the right motivation, without which it is difficult to enforce any action and the necessary degree of commitment into the recording matters, and then the analyzes of logistics costs. Also, the previously mentioned organizational
constraints, affect the effectiveness of the used logistics costs account. In this area in particular there are no precisely delineated duties and responsibilities in terms of recording and the lack of giving an appropriate rank and importance to the logistics costs analysis is highlighted. Other sources of limitations do not affect, in a decisive way, any reduction of possibilities and expediency of the cost analyzes based on data provided by the costs account, expanded by the logistics costs record.

Legal regulations on accounting do not allow for the possibility of direct taking into account the logistics costs in a mandatory system of costs accounts and financial statements, but they do not limit expandability and raising the level of complexity of the applicable costs account by means of analytical solutions.

Technical capabilities of the applied financial and accounting programs also do not constitute a barrier in the way of recording and presenting the enterprises logistics costs data. The implementation of the costs account logistics concept in practice usually requires only taking the measures aimed at adding appropriate analytical accounts to the traditional system of accounts.

Due to the low cost of the software used to record and analyze the logistics costs, the financial considerations also have no impact on the performance and usefulness of the costs accounts in a company. Despite these risks, a rationally used logistics costs account can be considered as a fundamental tool to support business management. It should be noted that the solutions proposed by the theory, sometimes differ significantly from the solutions developed by the business practice. This is generally due to the fact that the theoretical solutions are too complex and it is hard to translate them into a mandatory system of recording.

The literature and economic practice contributed to the development of the following three methods of the logistics costs recording:

- fast, one-time diagnosis,
- systematic, full recording,
- random registration of costs.[1]

The fast, one-time diagnosis is not about the recording of costs, including the logistics costs, but about determining their level in the context of the total costs incurred, using the estimation methods. Those estimates are supposed to answer the question, as to what is the level, or what is the amount of total costs, or one of their subsystems, in the examined period. As in case of any operation involving only the estimation, also in this case, the results of this method are burdened with a large margin of error. A further disadvantage of this method of the costs registration (although in this case it is difficult to speak of an actual registration costs within the meaning of accounting), is the possibility of the estimation distortion due to the impact of part of the factors at the time of diagnosis. In some situations, the disadvantage of this method may also be due to the subjectivity of perception of the person conducting the estimates. In turn, the advantages of the method certainly include the short time of its conduct, and the low cost of the diagnosis.

The opposite of the fast, one-time diagnosis is a systematic, full recording. It involves extracting from among all costs incurred during the period, only those components that are accepted as logistics costs by the given economic entity. To be able to keep records in accordance with the discussed method, it is necessary to precisely determine which costs are considered as the logistics activities costs. The other issues to be solved involve the division classifying the logistics costs, to meet the information requirements of the costs account and identification of specific technical solutions enabling the logistics costs recording. This method is certainly more complicated and expensive than the one-time diagnosis, but its benefits usually compensate for these limitations. The positive sides of the full recording include the ability to:

- obtain data on the logistics costs in the adopted sections classifying them,
- tracking current information on the logistics costs,
- immediate response in the event of adverse developments within the logistics activities costs.
The third method of logistics costs recording is the random costs registration within which general logistics costs are divided into two groups. The costs of the first group are recorded on the basis of a complete recording, and for the other group the one-time diagnosis is applied. It happens that the economic entities completely forgo the costs account using the one-time diagnosis and keep only a complete record within the selected area or areas of logistics activities. This method is used if you wish to focus your attention solely on the area which seems to be strategic from the point of view of the amount of the incurred logistics costs and possible reduction opportunities. The disadvantage of the random registration of the logistics costs is a limited range of data for the areas covered by the record, which can lead to irrational decisions in relation to the global logistics costs.

In turn, taking into account the technical methods of recording the logistics costs, it is possible to use one of the three solutions. The first of them is to record manually, i.e., without the help of appropriate computer programs. Due to the archaic nature of this method, caused by too much effort to use it, and essentially limited possibilities of its further use, it is rejected as an object of analysis. A similar decision was taken in relation to other solution, namely the record using additional programs, operating outside the basic financial and accounting program, through which all business operations related to the management are recorded. The disadvantage in this case is the need to record when using the two different computer programs. This solution is conducive to generating errors, primarily consisting in bypassing the logistics costs registration and focusing solely on registration for tax purposes. The third way, which appears to be optimal due to the smallest amount of work necessary for its application, is based on recording of logistics costs by using typical financial and accounting programs tailored in terms of the additional information requirements.

Thus, the full record of the logistics costs is associated with the registration of economic operations involving this category of costs in the appropriate accounts. The record can be kept on nominal and off-balance accounts. However, largely the registry of costs is kept on the nominal accounts which are subject to appropriate modification. This change consists in the introduction to the nominal accounts of the subsequent analytical accounts in order to refine the information and bring out of the entries in the accounts this part of the cost which is really related to the logistics activity.

3. PROPOSAL OF THE UTILITARIAN MODEL OF THE LOGISTICS COSTS RECORD

Due to the fact that most of the incurred logistics costs involve the operating expenses, the design of the proposed model of the logistics costs registry starts with a basic recognition of the operating expenses by type. **Table 1** shows the recognition of the operating expenses in the accounts under group 4.

**Table 1** Numbering of the accounts of costs by type

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost type</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Depreciation</td>
</tr>
<tr>
<td>401</td>
<td>Usage of materials and energy</td>
</tr>
<tr>
<td>402</td>
<td>External services (Due to the logistics costs record by means of account No. 402 (external services), the scope and values of the logistics activities can be determined by a business entity itself (insourcing) or outsourced.)</td>
</tr>
<tr>
<td>403</td>
<td>Taxes and fees</td>
</tr>
<tr>
<td>404</td>
<td>Wages and salaries</td>
</tr>
<tr>
<td>405</td>
<td>Social security contributions and other payments</td>
</tr>
<tr>
<td>406</td>
<td>Other costs by type</td>
</tr>
</tbody>
</table>

Source: own elaboration
The next step is to enable the separation of the group of generic costs the costs related to the logistics or not logistics activities. It is also possible a situation where a given cost can be partially attributed to the logistics costs, while in the remaining part it is not a logistics cost. For this purpose a detailed description of entries of the subsequent costs by type by two numeric designations for analytical accounts is made. Individual accounts of the costs by type (400 to 406) should be extended by analytics (0 and 1), where the digit 0 will mean that a given cost is not a logistics cost and the number 1 will assign to this category of costs. Table 2 shows an example of the accounts designation in accordance with the proposed analytics extension.

Table 2 Sample numbering of the accounts of costs by type broken down into logistics and non-logistics costs

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>400-X-0</td>
<td>Depreciation of office equipment in the management board units</td>
</tr>
<tr>
<td>400-X-1</td>
<td>Depreciation of the finished goods warehouse</td>
</tr>
</tbody>
</table>

Source: own elaboration

The new solution will reduce in a significant way one of the major shortcomings of the previously used models of the logistics costs records, namely frequently omitted, usually by mistake, logistics costs records. With the proposed solution it is necessary to distinguish the cost on the basis of their adherence to the logistics activities for each nominal operation and confirmation of the decisions taken, by giving adequate (0 or 1) analytical designation. The second advantage is the ability to exercise more effective control over the conscientiousness of employees involved in the logistics costs recording, through the easier way to extract a cost which was assigned the status 0, meaning not associated with the logistics activities, to find in this group possible costs which should have the status 1.

The next step in the model creation is the division by type of the costs which were classified as logistics costs, according to the criterion of the goods movement stages and the cost centres, according to which the following categories can be distinguished:

- **- costs of the procurement logistics** - 10
- **- costs of the production logistics** - 20
- **- costs of the distribution logistics** - 30
- **- costs of the waste management and complaints logistics** - 40

Table 3 shows examples of reference numeric designations of the logistics costs, broken down by the goods movement stages and the cost centres.

Table 3 Sample numbering of the logistics costs accounts broken down by the goods movement stages and the cost centres

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>400-X-1-10</td>
<td>Depreciation of a car used for the purpose of the department purchases</td>
</tr>
<tr>
<td>400-X-1-20</td>
<td>Depreciation of a warehouse building of the production in progress</td>
</tr>
<tr>
<td>400-X-1-30</td>
<td>Depreciation of a car used for the purpose of the distribution department</td>
</tr>
<tr>
<td>400-X-1-40</td>
<td>Depreciation of equipment used for waste disposal</td>
</tr>
</tbody>
</table>

Source: own elaboration

To refine the scope of information on the logistics costs within the various stages and cost centres, it is required to enter the next level of analysis, within which concrete feasible operations will be presented. Tables 4, 5, 6
and 7 present the breakdown classifying the logistics costs in the individual stages together with the associated activities.

**Table 4** Classification of accounts the purchases logistics costs

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>40X-X-1-10-01</td>
<td>Transport costs</td>
</tr>
<tr>
<td>40X-X-1-10-02</td>
<td>Costs of inspection and acceptance of inventories</td>
</tr>
<tr>
<td>40X-X-1-10-03</td>
<td>Costs of orders organizing</td>
</tr>
<tr>
<td>40X-X-1-10-04</td>
<td>Costs of purchases planning</td>
</tr>
<tr>
<td>40X-X-1-10-05</td>
<td>Cost of information services managing the inventory purchases movement processes</td>
</tr>
<tr>
<td>40X-X-1-10-06</td>
<td>Other costs of the purchases stage</td>
</tr>
</tbody>
</table>

Source: own elaboration

**Table 5** Classification of the production logistics costs accounts

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>400-X-1-20-01</td>
<td>Costs of inventory movement between the technology seats</td>
</tr>
<tr>
<td>400-X-1-20-02</td>
<td>Costs of collecting and maintaining materials inventories</td>
</tr>
<tr>
<td>400-X-1-20-03</td>
<td>Costs of information streams handling controlling the inventory movement</td>
</tr>
<tr>
<td>400-X-1-20-04</td>
<td>Other production stage costs</td>
</tr>
</tbody>
</table>

Source: own elaboration

**Table 6** Classification of distribution logistics costs accounts

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>40X-X-1-30-01</td>
<td>Transport costs</td>
</tr>
<tr>
<td>40X-X-1-30-02</td>
<td>Costs of the distribution channels organization and operation</td>
</tr>
<tr>
<td>40X-X-1-30-03</td>
<td>Cost of collecting and maintaining inventories of finished products within the distribution channels</td>
</tr>
<tr>
<td>40X-X-1-30-04</td>
<td>Cost of servicing the information streams controlling physical processes of the finished products distribution</td>
</tr>
<tr>
<td>40X-X-1-30-05</td>
<td>Other costs of the distribution stage</td>
</tr>
</tbody>
</table>

Source: own elaboration

**Table 7** Classification of waste disposal and complaints logistics costs accounts

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>40X-X-1-40-01</td>
<td>Transport costs</td>
</tr>
<tr>
<td>40X-X-1-40-02</td>
<td>Costs of waste collection</td>
</tr>
<tr>
<td>40X-X-1-40-03</td>
<td>Costs of waste disposal</td>
</tr>
<tr>
<td>40X-X-1-40-04</td>
<td>Costs of waste storage</td>
</tr>
<tr>
<td>40X-X-1-40-05</td>
<td>Other const of the waste stage</td>
</tr>
<tr>
<td>40X-X-1-40-06</td>
<td>Costs of maintenance and operation of the complaint department</td>
</tr>
<tr>
<td>40X-X-1-40-07</td>
<td>Other complaint costs</td>
</tr>
</tbody>
</table>

Source: own elaboration
Presented in Tables 4, 5, 6 and 7 classifications of the accounts within the various stages of movement and cost centres, will certainly significantly contribute to detail the information about the logistics costs within the adopted criterion. However, according to the author, a complement of the logistics costs recording model within the operating costs is the latter criterion detailing the logistics costs according to division into fixed and variable costs. The criterion the costs variability, including the logistics costs, makes it possible to perform a series of analyzes. This classification is in fact the basis of management accounting, proposing a number of useful economic tools, which enable in-depth analysis of logistics costs. For this reason, within the proposed model it was decided to take into account this classification criterion. Table 8 shows examples of the logistics costs broken down into fixed and variable costs.

**Table 8** Example of the logistics costs classification, taking into account the criterion of the costs variability over time

<table>
<thead>
<tr>
<th>Account number</th>
<th>Cost specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>40X-X-1-10-01-0</td>
<td>Salary costs under the employment contract, for an employee of the purchasing department involved in the supplies organization</td>
</tr>
<tr>
<td>40X-X-1-30-01-1</td>
<td>Costs of waste collection</td>
</tr>
</tbody>
</table>

Source: own elaboration

Due to the fact that the costs associated with the business management include not only the operating costs but also other operating costs and financial costs, the same situation also applies to the logistics costs. Therefore, in this model, it is proposed that the other operating costs and financial costs, among which the logistics activities costs will appear, are subject to the same schedule of analytics as the operating costs. The account of extraordinary losses, according to the author, does not require analysis allowing for the identification of logistics costs, because records of transactions on this account concern extraordinary and random events, not related to normal business activities, including the logistics activities of the company. According to the author, a common mistake is including the total logistics costs of the extraordinary losses, because in this way the actual level of the logistics activities costs is distorted.

For completeness of data on the logistic costs incurred for the given period, it is proposed that the cost of lost revenue which arose as a result of an inefficient logistics system, are recorded in the off-balance accounts.

**CONCLUSION**

The presented multi-sectional model of the logistics costs recording should largely meet the information requirements of the users of this information.

Of course, assessing the proposed model it cannot be said that it gives the possibility to obtain full information about the logistics costs, since it would require a much more complex model of records, which, however, instead of the additional advantage, would cause many organizational difficulties. The proposed accounting model of the logistics costs should not be regarded as a cure for all ills of the business management, but only as a useful tool, which should support managers in making rational decisions from the point of view of the business economics.

**REFERENCES**


SESSION E:
ECO-LOGISTICS
THE POSSIBILITY OF TRANSPORTATION OF OVERSIZED ITEMS

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Abstract

The Czech Republic has been historically a major producer of engineering products that includes unique products, although their size usually exceeds standard dimensions or weight. These types of products have high value added and are important for export. In the heavy machinery it is e.g. mining and metallurgical equipment, and other components for installation of turn-key investment units. So called light engineering also produces machinery and equipment, which can be categorized as oversized items. Locations with manufacturing plants that produce products for the chemical, energy and also the automotive industry are located all over the Czech Republic. Important areas of production are especially the Ostrava Region, the Pilsen Region, The Central Bohemia Region, the Usti Region and also the South Moravian Region. The transportation of these oversized items is from logistical, transportation and organizational point of view such a complicated process into where not only a manufacturer and a carrier enter. Also relevant government authorities and other organizations are having high influence. Although the transportation of oversized items is only a small part of the total volume of traffic to and from the Czech Republic, it is a very important part, specifically for export. It is necessary to pay a special attention to this type of transportation also in terms of possibility of using different transportation modes.

Keywords: Oversized item, waterways transport, air transport

1. INTRODUCTION

The transport of oversized items is a specific problem. Even here, selection factors which are identical to those applicable to other goods, i.e. price, reliability, constant characteristics of the goods during transport, transport time and safety, etc., exist. Further, it is necessary for each individual item to also assess its flexibility, usual frequency of operation, universality and sensitivity to climatic conditions.

However, other factors come into play during transport of oversized items, i.e. the dimensions and weight of the transported item. These specific factors may result in the exclusion of some of the transport modes with regard to the technical parameters (load capacity, width of transport route, clearance height and organisational problems).

Currently, there are products made in the Czech Republic that are characterised particularly by large weight and dimensions; these are large investment units, mining and metallurgical equipment, textile machines, machining tools, technological equipment for the textile industry, etc. It is not always possible to only use one type of transport for the entire transport route. It is therefore important to create a transport model for oversized items within which a combination of transport modes shall be accepted, and thus achieve higher transport efficiency, and consequently also a higher opportunity for domestic manufacturers to export these products.

Although the share of this type of cargo is very small in terms of the total transport volume of exports and imports in the conditions of the Czech Republic as these types of products have very high added value. Exports exceed imports. Waterway transport is mainly used for exports; however, in some isolated cases, upon assessment of the required criteria, it is highly advantageous to also use air transport.
2. TRANSPORT OF OVERSIZED ITEMS FROM AND TO THE CZECH REPUBLIC

The engineering industry substantially impacts the economic significance of the individual areas, it logically also links with the metallurgical, chemical, energy, and automotive industry, distributed all over the Czech Republic. The engineering industry substantially impacts the economic significance of the individual areas. The heavy engineering industry is mainly concentrated near iron works. [10] The important branches are transport engineering, production of machinery and equipment for industry, electrical engineering and electronics. It concerns products with a high added value. Transport of oversized items has a 0.1 % share of total exports (all modes). [8] The financial share is much higher. For exports to the USA, the transport of oversized items is a fundamental area.

Table 1 Total export and import CZ - USA (mil. USD)

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export</td>
<td>3 344.1</td>
<td>3 930.6</td>
<td>3 922.9</td>
<td>4 344.8</td>
<td>4 462.2</td>
</tr>
<tr>
<td>Import</td>
<td>1 684.7</td>
<td>1 832.3</td>
<td>1 943.3</td>
<td>2 302.4</td>
<td>1 978.5</td>
</tr>
</tbody>
</table>

Source: https://www.census.gov/foreign-trade

3. TRANSPORT OF OVERSIZED ITEMS

When preparing the transport of oversized items, i.e. after identification of an item as oversized, it is necessary to analyse the possible selection of the transport mode, respectively, combination of transport modes. This analysis must not only contain the technical parameters of the means of transport, but a no less important component is also the detailed analysis of the transport route. An oversized item cannot be transported using ordinary means of transport because it exceeds the set parameters in terms of length, width, height and weight. The division is - heavy (they exceed the maximum permissible weight) and oversized (they exceed the maximum permissible dimensions).

When using the road, i.e. the width, load capacity and height of the road bridge clearance heights, radii of the bends, width and load capacity of bridges, width and height of underpasses, width and height of tunnels, width and height of limiting technical equipment (e.g. toll gates), longitudinal bank of the road, permissible speed limit. When using railway transport, the decisive parameters are corridor width, load capacity, bridge clearance height, radii of the bends, bridge load capacity, width and height of the tunnels, width and height of the technical equipment on the railway line, permissible speed limit and longitudinal bank of the railway line. No significant technical limitations exist for inland waterway transport in terms of the width and height of the corridor required for transport, and for this reason, it is normally used to transport oversized items if it is not possible to use the above-stated transport modes.

It is further necessary, in the event of using marine transport, to assess the parameters of the handling equipment at the selected port and availability in terms of time.

In some cases it is possible to use air transport for transport of oversized items, which has a higher significance as compared to the other transport modes in terms of delivery speed and reliability.

Figure 1 Schema of logistic chain - combined transport of oversized items
Source: Authors
3.1. Inland waterway transport

The most important watercourse in the Czech Republic in terms of cargo transport is the Elbe waterway and part of the Vltava waterway from the confluence of the Elbe and Vltava to Prague. It is a transport connection to the sea ports of Hamburg, Bremerhaven and Rotterdam and also the network of European inland waterways. It is optimal to combine waterway transport with other modes of transport particularly for the reason that the manufacturing enterprises and industrial centres are usually not located near the waterways. From this viewpoint, the Ústí Region, but also the Central-Bohemian Region and Prague have the best locations; in future, this will also include the Pardubice Region after the realisation of the Přelouč II Lock.


From the total volume of exports in inland waterway transport, the transport of oversized items has a share of 48%, while imports amount to approximately 10% of exports.
credible forecast of weather conditions - in the case of the Elbe waterway, this concerns the navigation depth,
• costs of connecting transport to / from the port,
• costs of trans-shipment of the oversized item at the port,
• costs of waterway transport from the port.

The technical parameters for transport of oversized items using the inland waterway are as follows. On the Elbe waterway, it is possible to operate boats with maximum dimensions of 135 m length and 11.4 m width with a maximum cargo weight of 1,200 t.

3.2. Railway transport

Transport of an oversized item by railway is strictly limited mainly by the passage profile, i.e. the width and height of the transported item; an important factor is also the permitted axle pressure. In railway terminology, the oversized item is designated as extraordinary freight - it may be accepted for transport only subject to special technical or operating terms and conditions between all the carriers involved in the transport.

Extraordinary freight categories:
• consignments that exceed the load bed dimensions - the dimensions exceed the size of the bed of the given railway set,
• consignments with extraordinary weight (more than 25 t),
• consignments of extraordinary length, which exceed a length of 3.5 to 12 m, [12]
• other consignments.

Table 2 Transport of extraordinary consignments in 2015

<table>
<thead>
<tr>
<th></th>
<th>Total export and import (thousands t)</th>
<th>Extraordinary freight (thousands t)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ČD Cargo</td>
<td>58 102</td>
<td>232.4</td>
<td>0.4</td>
</tr>
<tr>
<td>DB Schenker</td>
<td>-----</td>
<td>-----</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>

Source: Authors
Note: This primarily concerns export and transport to the ports of Lovosice, Ústí nad Labem, and onwards via the waterway.

3.3. Road transport

Figure 3 Transport of oversized items, road R 10, 14.9.2011. Photo: H. Bínová

In road transport in the Czech Republic, an oversized item [14], which exceeds the following data at least in one parameter, is classified as cargo - maximum length of set 16.5 m, maximum width 2.55 m, maximum
height 4 m and maximum weight 48 t. The maximum load of one axle 8-10 t according to the design of the axle. If the value of any of the given consignment parameters is higher, the consignment is considered as oversized and its transport is subject to special regulations. In the EU, these parameters are identical, only with the exception of maximum weight, which must not exceed 44 t in the EU.

During transport of the oversized item, it is not possible to improvise and change the route; its preparation is a very complicated matter. It contains: [9]

- **Research and design of the route.** It is necessary to analyse the parameters of the oversized item and the parameters of the designed routes including weight and temporary restrictions. It is further necessary to compile a draft schedule and discuss it with competent transport units along the route. It is necessary to negotiate road closures and the draft transport engineering measures with the Police of the CZ,

- **Technical escort prescribed for a transport operator registered in the CZ.** If the oversized item exceeds the weight limit of 95 t, then two technical escorts are required. If the oversized item is transported by a foreign transport operator, it is necessary to provide a Czech technical escort, the driver of which is acquainted with the draft route and authorised to perform this activity on the territory of the CZ.

### 3.4. Air transport

Air transport has significant position in cargo transportation. Remarkable is the speed of transfer. Cargo is transported by air on daily bases in scheduled cargo lines or in mixed variations of the aircraft, which transports both passengers and cargo. In comparison with other transport modes, air transport costs are higher. On the other hand, high costs are compensated, in addition to the speed of transport, with lower rate of incidents like thefts, losses and damage, and lower costs for transshipment and storage - shortened logistic chain is applied. Due to high speed and ability to transport large volumes of loads, air transport is also important in the transport of oversized goods. [5]

In general, it is not possible to determine maximal dimensions or weight, which can be transported by air. To transport shipment a regular cargo line can be used. Limits are set by the type of aircraft, which operates on selected line: its size, shape and entry port dimensions are ultimate. Each load must be considered individually. For example, load which is 3 m height may be suitable for one aircraft, but due to its width may not fit into another. Air loads are typically transported within ULD (Unit Load Device) which represents special pallets or containers with standardized sizes. Most common pallets dimensions are 244 x 318 cm and 244 x 600 cm. Container AMJ has its inner volume limited by 306 x 230 x 240 cm. Cargo aircraft may transport even loads overlapping 100 tons. Frequently used Boeing B747-400F is designed to transport 120 tons of load.

A total of 5 regular cargo airlines serve to and from Prague airport. China Airlines Cargo connects Prague with Dubai and Taipei with freight Boeing 747. Airline Ukraine International Cargo operates the line between Kiev and Liege. FedEx flights to Paris. Outside of winter period it operates in cooperation with TNT Company cargo flights to Katowice. Newest cargo line is set on skyway between German Cologne, Prague and Budapest operated by UPS Airlines.

In case, when final destination or its region is not covered by regular cargo line, it is possible to order individual delivery known as charter flight. For charter flight it is possible to order virtually any type of aircraft. For oversized load with heavy weight is possible to use specially designated cargo aircraft. Biggest aircraft of such type is Ukrainian Antonov An-225 Mrija, which can carry 350 tons - 70 personal cars can be fitted into its interior. Boeing Company designed specially for large freights its Boeing 747-8 Freighter. Its newest version was presented in 2005. Boeing 747-8 Freighter can carry 150 tons of load, which is stored within 853 cubic meters of space.
Over-sized cargo securement on its way is always contingent on individual solution and point of departure and target destination. For each milestone, it is necessary to optimize processes of all subjects in supply chain and its secure program. Most commonly situation is, that final destination is elsewhere than destination airport, which requires to include inter-modal systems, such as air-road conjunction. Combination of transportation reflects natural transport solutions, but nowadays faces also high requirements on fast time demands with its key contribution represented by aircraft. In may 2016 Antonov An-225 Mrija transported from Prague to Australia a giant 117 tons heavy generator of Pilsen company Brush Sem. Generator with its length of 8.8 meters, with over 3.5 meters and height almost 3.2 meters was loaded by two special 40 meters long ramps. Air transport was chosen because of urgent need of Australian company. Antonov on its way to Australian airport in Perth had to land for 3 times to refuel.

![Antonov An-225 Mrija](image)

**Figure 4 Loading of Brush generator into Antonov An-255 Mrija [16]**

Each load must go through security check. If load is too big to fit into X-Ray scanner, an additional checks must be taken:
- check of load with explosives detection systems,
- check of load with trace explosive elements detector,
- physical load check,

Over-sized shipments are excluded from security control in case they are sent by Regulated agent, Known consigner or Account consigner. In such case, check is executed directly in manufacturing process or during handover from external vendor. Technical assistance is provided as well. Those statuses allows complication free delivery, regulated by EU, and enable to skip security check. Shipments from uncertified companies must be "secured" by additional controls [7] which results into longer transfer times and higher costs. In opposite, freights from known companies are considered as safe by default. Such company must follow European regulations (EU Regulation No 185/2010) as well as to be responsible to fulfill regulations of each individual airport and its security rules, is empaneled by airport operator and certified by Civil Aviation Authority of Czech Republic.
4. PROBLEMS OF TRANSPORT INFRASTRUCTURE FOR TRANSPORT OF OVERSIZED ITEMS

In some cases, it is necessary to modify part of the transport route and include such costs in the costs of transport of the oversized item.

4.1. Break-even point

Generally the break-even point means such quantity of company products, where neither profit is gained nor a loss is suffered; total revenue is equal to total costs. If the company reaches this production limit, the revenues shall be equal to the costs.

Formula for calculation of the break-even point: [2]

\[ Q = \frac{N_{\text{fix}}}{c - n_{\text{var}}} \]  

\( c \) \( \ldots \ldots \ldots \) (P) Price per unit  
\( Q \) \( \ldots \ldots \ldots \ldots \ldots \) Number of units (CZK / time)  
\( N_{\text{fix}} \) \( \ldots \ldots \ldots \) (TFC) Total fixed cost (Number of units / time)  
\( N_{\text{var}} \) \( \ldots \ldots \ldots \) (V) Unit variable cost

The input data to ensure the break-even point in the given relationship are:
- average transport price,
- transport time,
- loading / unloading time,
- technical downtime,
- average fixed costs of the means of transport / day.

4.2. Analysis of the transport costs of oversized items

Transport of an oversized item is planned in advance before the actual transport, in some cases already during manufacture, also for reason of possible transport in parts. By combination of multiple types of transport modes, it is possible to find the best economic method for transport of an oversized item.

The transport cost of an oversized item is set on the basis of many factors, e.g. current fuel and energy prices, transport distance, size / weight of the oversized item, necessary modification of the route, necessary number
of handling operations and trans-shipments, cost of the technical escort, police escort, charges for recalculation of bridges, eventually, bridge support costs (road transport), etc.

Combined transport costs include loading unto the means of transport at the manufacturer’s, road / railway transport costs, trans-shipment at port, storage costs, waterway transport cost from the Czech Republic to the sea port, insurance, assistance services.

4.3. Advantages and disadvantages of transport of oversized items by waterway

Advantages - some oversized items cannot be transported without waterway transport from the Czech Republic to Hamburg. Waterway transport has the advantage that the transport route has only minimum limitations for transport of the oversized item and has large capacity means of transport available, which make the transport of oversized items possible, and which cannot be transported by road or railway; it can be used to transport very heavy items of small dimensions thanks to the supporting frames, which are installed in the vessels. The Elbe has a suitable passage profile.

Table 3 Comparison of road and combined transport (road / water) from ČR to Hamburg

<table>
<thead>
<tr>
<th>Line</th>
<th>Specification oversized items</th>
<th>Transport costs</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length [m]</td>
<td>Width [m]</td>
<td>Height [m]</td>
</tr>
<tr>
<td>Ostrava - Hamburg</td>
<td>15</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Brno - Hamburg</td>
<td>15</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>4</td>
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<tr>
<td></td>
<td>15</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Hradec Králové -</td>
<td>15</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Hamburg</td>
<td>15</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Pilsen - Hamburg</td>
<td>15</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>4</td>
<td>3</td>
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<tr>
<td></td>
<td>15</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ČR - Hamburg</th>
<th>Length [m]</th>
<th>Width [m]</th>
<th>Height [m]</th>
<th>Weight [t]</th>
<th>Usable</th>
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<td></td>
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</tr>
<tr>
<td></td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>200</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>20 - 25</td>
<td>3 - 5</td>
<td>3 - 5</td>
<td>50</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>20 - 25</td>
<td>3 - 5</td>
<td>3 - 5</td>
<td>100</td>
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</tr>
<tr>
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<td>20</td>
<td>3 - 5</td>
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<tr>
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<td>3 - 5</td>
<td>200</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>5</td>
<td>5</td>
<td>150</td>
<td>yes</td>
</tr>
</tbody>
</table>

Source: [4] with facts from company Heavy Trans, s.r.o.
Waterway transport has a positive impact on the economic and business sector. It is more ecological than road and railway transport. CO₂ emissions in transport: inland waterway 33.4 grams / tkm; railway 48.1 grams / tkm; road 164 grams / tkm.

In comparison with transport by rail and road, it has a lower noise emission. [3]

Air Transport produces on average 3.15 tons of CO₂ per one ton of burned jet fuel.

The following table shows a comparison of the costs of transport of fictive oversized items on the Czech Republic - Hamburg route. Of the total volume of fictive items, only 3 oversized items can be transported by road from the manufacturer to the sea port of Hamburg. The transport cost rises with increasing dimensions.

Use of railway transport is possible only in combination with another type of transport. When comparing transport costs, road transport is more advantageous than railway transport. However, it is necessary to point out that road transport costs do not include external costs, which according to the study by PLANCO Consulting, are five-fold higher than in the case of waterway transport. [13] For overall evaluation of the advantage of the individual types of transport, it is thus necessary in addition to the price factors to also analyse these external factors that are not paid by the transport operator or contractor at present, but are paid from the state budget.

The most positive factor in air transport of oversized cargo is shortened logistic chain. For complex solutions it is possible to choose offers from many companies specialized in air cargo transport logistics. High costs of air transport are compensated with lower total costs of storage, transshipment and security. Main disadvantage of air transport is the limitation of shape and size of transported freight resulting from the constrained cargo spaces in aircraft. Antonov Mrija is able to transport on top of the fuselage freight up to 70 meters in length and 8 meters in diameter. Inner space allows to fit freight with maximum length 4.4 meters and width 43 meters. Other limitation is the fact that the airport of arrival usually does not match with final destination, therefore it is necessary to combine various types of transportation. Even if an airport is close to the destination, it may not have the required runway length. Mrija needs a runway at least 3000 - 3500 meters long. Airport may not have the necessary equipment for loading and unloading of oversize cargo, thus it is inevitable to acquire it from a third party.

Disadvantages - the only disadvantage is the unreliability of the waterway, which is caused by low water, which is moreover unpredictable in time. The Elbe waterway is not navigable over its full length and it is not navigable all-year-round, and it is moreover not possible to predict when navigability shall be guaranteed.

5. MODEL SOLUTION FOR TRANSPORT OF OVERSIZED ITEMS

The manufacturers of oversized items must solve transport to the customer in such a manner as to guarantee the delivery deadline, maintain the characteristics of the product (quality) and minimisation of costs. The entire transport process is influenced by a larger number of factors than apply to the standard type of cargo; it is thus necessary to have the essential professional knowledge and experience with such type of transport, which can only be provided by a team of experts. It is possible when designing the transport process of an oversized item to use a scheme showing the individual activities and decision-making processes.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Multi-criteria matrix (columns - criteria, lines - variants) [15]</th>
</tr>
</thead>
<tbody>
<tr>
<td>k₁</td>
<td>k₂</td>
</tr>
<tr>
<td>v₁</td>
<td>A₁₁</td>
</tr>
<tr>
<td>v₂</td>
<td>A₂₁</td>
</tr>
<tr>
<td>v₃</td>
<td>A₃₁</td>
</tr>
<tr>
<td>v₅</td>
<td>....</td>
</tr>
<tr>
<td>v₆</td>
<td>A₆₁</td>
</tr>
</tbody>
</table>
In the general procedure of multi-criteria assessment of the variants, it is necessary to determine:

- a set of criteria (important to achieve the result) - these are criteria where higher values are preferred to lower values:
- criteria weights (also with the help of expert methods); the criterion weight is determined by one expert or a group of experts,
- sample criteria.

**Table 5 Mathematical models of the weight of selected criteria**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Importance</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>the biggest</td>
<td>price</td>
</tr>
<tr>
<td>k - 1</td>
<td>............</td>
<td>reliability</td>
</tr>
<tr>
<td>k - 2</td>
<td>............</td>
<td>time</td>
</tr>
<tr>
<td>1</td>
<td>the smallest</td>
<td>safety / security</td>
</tr>
</tbody>
</table>

Source: Authors

It is further necessary to assess the achieved results - assess the individual variants as well as synthesis of these partial assessments into an overall, i.e. multi-criteria, assessment. During assessment, the weights of the individual criteria may be reviewed or the variants may be modified, respectively, increased in number. It is necessary - to assess the risks (by risk analysis), to assess and determine the optimal variant and determine the ranking of the individual variants.

In the event that the selected variant is not fully compliant with the procedure according to the preceding steps, it is necessary to review any of these steps.

**Multi-criteria assessment methods [6]**

The weight of the individual criteria can be expressed by means of a vector of the weights of the criteria:

\[
v = (v_1, v_2, \ldots, v_k); \sum_{i=1}^{k} v_i = 1; v_i \geq 0
\]  

The individual variants can be evaluated on the basis of preferential relations:

- the higher the importance of the criterion, the larger its weight in ratio to the rest of the criteria,
- choice of weight must be consulted with the principal, and set priorities in this way. If it is not possible to set priorities, it is necessary to allocate the same weight to each criterion, i.e. the total of all weights must be 100 points, and each criterion (quantity n) thus has a weight of 100 / n.

It is also necessary to consider whether ordinal information (only determining the ranking of the individual variants) or cardinal information (informs about the difference between the individual variants) is necessary to make the final decision.

To determine the order of the weights, it is possible to use the ranking method, where the \( i \)-th criterion is allocated the number \( b_i \) (only setting of the ranking of criteria according to importance):

\[
v_i = \frac{b_i}{\sum_{i=1}^{k} b_i}; \quad i = 1,2,\ldots, k
\]  

\( v_i \) - weight of the \( i \)-th criterion, where \( i = 1,2,\ldots, k \)

\( k \) - numbers (points), which are allocated to the ranked criteria

\( b_i \) - number, which is allocated to the \( i \)-th criterion
The total of the $b_i$ number series in the denominator can be calculated using the following formula:

$$\sum_{i=1}^{k} b_i = \frac{k(k + 1)}{2}$$

(4)

### Table 6 Evaluation of selected cargo transport criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Type of freight transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Road</td>
</tr>
<tr>
<td>Costs</td>
<td>low</td>
</tr>
<tr>
<td>Speed</td>
<td>high</td>
</tr>
<tr>
<td>Reliability</td>
<td>middle</td>
</tr>
<tr>
<td>Flexibility</td>
<td>high</td>
</tr>
<tr>
<td>Frequency</td>
<td>high</td>
</tr>
<tr>
<td>Universality</td>
<td>high</td>
</tr>
<tr>
<td>Sensitivity on climatic conditions</td>
<td>high</td>
</tr>
<tr>
<td>Safety / security</td>
<td>high</td>
</tr>
</tbody>
</table>

Source: Authors with facts from [1]

In the model of economic transport costs for each edge, the transport cost in the section defined by the individual graph edges are adjusted by the criteria for the parameters of the given transport route section (capacity, reliability, speed, safety, trans-shipment method, storage charges, etc.). The scheme of this model is shown in the next figure.

![Figure 6 Model of economic transport costs for each edge](image)

Source: Authors

In some cases, however, route length is not in first place, and optimisation of the selected route in terms of the time and price combination take precedence. Although the shortest route search model is the simplest, it is however necessary to search just for the combination stated above.
6. CONCLUSION

Transport of oversized items is a difficult task that requires teamwork. During the process of transport planning, several decisive moments exist. The objective is to get the oversized item to the destination in Europe or even overseas.

Figure 7 Transport mode selection scheme for oversized items
Source: Authors
If a comparison of the characteristics of the individual transport modes is made, it is possible to state that inland waterway transport is irreplaceable because it is not fraught with limiting parameters (excluding wholly exceptional cases), which would exclude this type of transport. In the economic assessment of the costs of the Czech Republic - Hamburg route, the cheapest combination is road transport to an inland waterway port and inland waterway transport to the sea port.

Inland waterway transport has always been considered as the most important transport mode for oversized items and it still has this status. However, cases exist in which the transport price is not the most important criterion, respectively delayed delivery could entail a substantial financial loss. In such case, particularly for overseas transport, it is also possible to opt for air transport.

An important criterion of air transport is its reliability in terms of the delivery deadline, unlike inland waterway transport in the Czech Republic, which exhibits substantial unreliability in this aspect. The advantage of inland waterway transport continues to be the lower price level as compared to the rest of the transport modes.

The issue therefore remains the problem of navigability of the Elbe waterway, which is not only currently, but also historically a significant transport connection with Western Europe.

ACKNOWLEDGMENT

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THROUGHPUT OF POLISH AIRPORTS ACCORDANT TO THE OBJECTIVES OF EU PROJECTS APPLICATIONS

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Abstract

From 2004 to 2013, a number of projects aimed at the development of transport infrastructure in Poland were completed. Some of them were aimed at supporting trans-European transport (TEN-T) network, as well as at increasing regional development by creating investment areas, growing life standards by better inhabitants’ mobility, decreasing unemployment rate, and so on. 81 projects were accomplished that were directly concerned with the development of airport infrastructure with financial support from European Union (EU).

In this paper, I aimed to describe the projects supporting the development of airports in Poland. I focused on the increasing passenger throughput that was assumed when applied for EU founds. This assumption was compared with current (2015) use of airports and the potential possibilities for increasing demand. Based on this hypothesis, herein the investments are presented.

Keywords: Airport market, airport throughput, demand, EU projects, Poland, NUTS-2

1. INTRODUCTION

Air transport is currently a significant component of transport net. Without any doubt, it can be said that it influences the development of countries, regions, unions, and World. There are three main elements that cause air business to operate: airlines, air control system, and airports. Each of them is a very interesting field for research. Airports can be examined from both economic impact and technical solutions point of view. For example, numerous studies concerned with airport throughput have been conducted. Majority of them present case studies from different airports around the World and present the current challenges with the throughput from technical point of view. The analysis covers passenger throughput including building terminals and inside processes such as check-in, security, boarding, passport control, and so on; traffic and parking system; ground handling and airside throughput [1, 2, 3]; and environmental throughput [4, 5, 6, 7]. These studies present the solutions to throughput problems of operating airports, examine various mathematical and statistical models for throughput forecasting; however, it is also crucial to investigate the estimated potential airport throughput when planning, building, and opening new airport. It seems to be extremely important if the idea of airport construction or rebuilding is supported by EU funds. It should be noted that transport infrastructure planning and financing are controversial political topics at national and increasingly at international level [8].

2. LITERATURE REVIEW

All kind of measures that lead to introduce the airport infrastructure throughput are based on the forecasting of passenger and cargo flow and number of operations. When a new airport is designed, the forecasting based on past data is not possible; therefore, a very detailed potential demand analysis should be introduced. The first step is to clarify the factors influencing the air passenger demand. According to the literature and some business reports [9, 10], these factors can be grouped as local, national, and global levels. First, the local factors influencing air passenger demand consist of population, economic activity, and air carrier service and market strategies. Second, the national factors influencing air passenger demand consist of economy, cost of air travel, and technological advances in communications. Finally, the international factors influencing air
passenger demand consist of economic growth indexes and cost of air travel. Lyneis [11] claimed that the air travel demand can be affected by external and internal factors. Assumption about future demand and performance are essential for business decisions. He considered airfare as the internal factor and gross domestic product (GDP) and population as the external factors. People play a dominating role in the city life; the scale of population will determine the air travel demand [12]. Regardless of the distribution and names of variable groups, there are similar indicators mentioned and used for modeling.

Based on his matrixes, Jankiewicz [10] confirmed the strong correlation between the number of passengers and GDP, the average salary, industrial production, and population. Bafail et al [13] have developed a model for forecasting the long-term demand for domestic air travel in Saudi Arabia based on several variables such as total expenditures and population to generate model formulation. Another study for air travel demand forecasting was conducted by Grosche, et al. [14] According to them, there are some variables that can affect the air travel demand, including population, GDP, and buying power index. They considered GDP as a representative variable for the level of economic activity. Suryani et al. [15] utilized system dynamics for air travel demand indicating that airfare impact, level of service impact, GDP, population, number of flights per day, and dwell time play important roles in determining the air passenger volume, runway utilization, and total additional area needed for passenger terminal capacity expansion. They also claimed that the forecast of air travel demand should support long-term planning to meet the future demand during the planning horizon.

Forecasting of air travel demand is also one of the element to be considered when applying for a financial support for airport development / rebuilding or construction. A particular example of such support is EU funds. European Commission assumes that airports have a central role in the connectivity provided by airlines to passengers and freight customers within the EU, and further afield and are also increasingly regarded as engines of economic growth in their own right.

Despite of the fact that the research on airport throughput are common, it appears that there are few studies linking the issues of effective use of money allocated for the development of airport capacity equipment and its current and future bandwidth.

3. THE AIM AND METHODS

In this paper, I aim to present the ranking of capacity throughput of regional airports in Poland after 2014 and make a hypothesis that the throughput is enough for current and forthcoming demand. I used secondary dataset for simple statistical analysis that was collected from airports management. It covers data from 2004 to 2015 and consists of the number of passengers and the maximum passenger capacity throughput of the airports. Moreover, data collected from Main Statistical Office and Ministry of Infrastructure and Development allowed to include number and value of EU projects completed until 2014 into analysis. To present the trend of passenger number increase, I used the logarithmic trend line. The curved line that is most useful when the rate of change data quickly increases or decreases and then stabilizes is described as optimally fit. Moreover, it may be used for the negative and / or positive data.

Although 13 Polish airports have been studied, because information on the amount of financial support of “operational” and “regional” programs was available for the regions (NUTS-2) only and not for airports themselves, the passenger throughput in the regions is presented. There are two key reasons: (1) simple spatial analysis (Figure 1) confirms that the time availability for the airports in Poland covered area of the NUTS-2 in which airport is situated and (2) the regional authorities for NUTS-2 were decision-making units, which decided about building / expansion of the airports. The only exception was support for Warsaw Chopin Airport (WAW) and Modlin Airport WMI airports in Mazowieckie region. Radom airports were excluded from the analysis, as they had not received EU support until 2014.

In this study, I hypothesized that the use of EU funds for expansion of airport facilities in Polish regions has contributed to the stabilization of the level of passenger throughput for the long term.
4. AIRPORT ENLARGEMENT PROJECTS IN POLAND FROM 2004 UNTIL 2014

From 2007 to 2014, 69 airport projects supported by EU funds had been implemented in Polish regions. Their aim was to improve the quality of air transport in Poland by both the construction of new infrastructure as well as the expansion and modernization of those that existed. Direct actions of the projects included purchases of the equipment necessary for airport operations. Project financing came from two main streams of assistance: operational program “Infrastructure and Environment” (37% of founding of total projects expenditure) and regional operational program (42% of founding of total projects expenditure). Twelve regions, (NUTS-2) where currently the airports are located, have been benefited. The largest number of projects was implemented in Podkarpackie region, and the highest value of total investments was in Mazowieckie region, whereas the highest share of EU founds in eligible costs was in Lubuskie region (Table 1).
Table 1 Number of the projects and expenses for the projects concerning airport infrastructure development in Poland due to NUTS-2 division

<table>
<thead>
<tr>
<th>NUTS-2</th>
<th>Number of projects</th>
<th>Total expenses (in PLN)</th>
<th>Eligible expenditure (in PLN)</th>
<th>EU financial support (in PLN)</th>
<th>% of support in total expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolnośląskie</td>
<td>2</td>
<td>398 496 577.62</td>
<td>290 903 762.90</td>
<td>139 835 960.79</td>
<td>35%</td>
</tr>
<tr>
<td>Kujawsko-pomorskie</td>
<td>11</td>
<td>70 474 493.02</td>
<td>54 282 064.92</td>
<td>41 695 243.26</td>
<td>59%</td>
</tr>
<tr>
<td>Lubelskie</td>
<td>3</td>
<td>476 014 362.54</td>
<td>210 678 464.70</td>
<td>144 439 823.53</td>
<td>30%</td>
</tr>
<tr>
<td>Lubuskie</td>
<td>3</td>
<td>4 753 237.79</td>
<td>4 749 561.29</td>
<td>4 037 127.08</td>
<td>85%</td>
</tr>
<tr>
<td>Łódzkie</td>
<td>4</td>
<td>215 743 240.18</td>
<td>156 415 587.02</td>
<td>124 323 491.84</td>
<td>58%</td>
</tr>
<tr>
<td>Małopolskie</td>
<td>7</td>
<td>679 106 661.91</td>
<td>512 896 670.61</td>
<td>271 168 390.62</td>
<td>40%</td>
</tr>
<tr>
<td>Mazowieckie</td>
<td>5</td>
<td>1 301 700 206.44</td>
<td>835 420 426.08</td>
<td>366 464 884.03</td>
<td>28%</td>
</tr>
<tr>
<td>Podkarpackie</td>
<td>15</td>
<td>394 411 183.31</td>
<td>311 520 314.52</td>
<td>198 000 731.36</td>
<td>50%</td>
</tr>
<tr>
<td>Pomorskie</td>
<td>7</td>
<td>483 469 202.83</td>
<td>363 015 197.11</td>
<td>204 140 972.57</td>
<td>42%</td>
</tr>
<tr>
<td>Śląskie</td>
<td>4</td>
<td>460 256 459.29</td>
<td>366 252 905.29</td>
<td>186 095 763.53</td>
<td>40%</td>
</tr>
<tr>
<td>Wielkopolskie</td>
<td>5</td>
<td>384 447 966.84</td>
<td>299 991 674.61</td>
<td>139 774 050.57</td>
<td>36%</td>
</tr>
<tr>
<td>Zachodniopomorskie</td>
<td>3</td>
<td>146 120 707.39</td>
<td>110 989 912.72</td>
<td>61 092 309.39</td>
<td>42%</td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
<td>5 014 994 299.16</td>
<td>3 517 116 541.77</td>
<td>1 881 068 748.57</td>
<td></td>
</tr>
</tbody>
</table>

In total, Poland has benefited from over 1.881 billion Polish zloty of EU funds for the development of air transport infrastructure.

5. AIR PASSENGER THROUGHPUT IN POLAND

The implementation of all projects determined the increase level of air passengers’ throughput of Polish airports and regions (Figure 2).

![Figure 2 Change in passenger throughput 2009 / 2015](image)

As for percentage change of passenger maximum throughput (Figure 2), the capacity of 4 out of 13 airports was doubled (Dolnośląskie-113%, Mazowieckie-120%, Małopolskie-161%, and Łódzkie-233%). Three airports can service 67%-79% more passengers (Pomorskie, Podkarpackie, and Kujawsko-Pomorskie). Lubuskie and Zachodniopomorskie recorded a slight increase of capacity possibilities (4% and 18%). According to the data, in Śląskie region, the possibility of passenger capacity has decreased by 10%. Nevertheless, one should bear...
in mind that the declared capacity has also its drawbacks. These figures are declared by the airport authority, which are often subjective.

Figure 3 The maximum annual passenger throughput and number of passengers in 2015 in Polish NUTS-2

With respect to the number of passengers (Figure 3), currently, Mazowieckie region can handle the largest number of passengers. This could be because there are two airports in this region including WAW, which is the biggest one in Poland. In other regions, the annual throughput level does not exceed 5000 passengers. This confirms that all investments but one were to support the mobility for local inhabitants. WAW airport seems to be the only example of investment for increasing whole national air market.

Expansion of projects and gaining on their financial support, should contribute to increasing their possibility of passenger service in long term (approximately 10-15 years). Therefore, full or almost full bandwidth utilization in 2-3 years after upgrading airport indicates a bad project planning and ineffective use of funds.

Figure 4 The gap in possible annual air passenger throughput and throughput used in 2015 in Polish NUTS-2
If the assumption is that the maximum annual throughput for each NUTS-2 is 100% it is possible to count the gap that allows to describe the level of free terminal capacity (Figure 4). The highest utilization of possible passenger throughput in 2015 was in Śląsk region in Katowice (KTW) airport (76%), Pomorskie region (74%) with airport in Gdańsk (GDA), and Dolnośląskie with Wrocław Airport (WRO 71%). In turn, the lowest use of airport capacity was recorded in Lubuskie (Zielona Góra-Babimost - IEG 10%) and Łódzkie region (LCJ - 14%).

Table 2 Trends in yearly change of the number of passengers in the period 2004-2015 with the forecast trend until 2025*

![Graphs showing trends in yearly change of the number of passengers for different regions.](image)

* in case of Lubelskie region the forecast could not be done as the data covered only two years from the future - Lublin airport started to operate on Dec 2013.

Some remarkable conclusions can be drawn from Table 2. Based on simple logarithmic trend line, it is possible to notice that in all regions but Mazowieckie, the tendency in yearly changing of the passengers’ number has declined. The forecast for the next 10 time units is that this trend will continue. In four regions (Kujawsko-Pomorskie, Lubuskie, Łódzkie, and Małopolskie) the trend line declined below 0% during the next years. It means that in those regions, the number of passengers will drop. In the remaining regions, yearly number of passengers will increase, however, from one year to another, the level of this growth will be lower and lower.
The top-ranking airports are not these with the highest financial support. The Pearson correlation between free capacity (x) and project value (y) is \( r_{xy} = -0.168 \), which confirms the lack of linear dependence. Considering the level of free capacity (Figure 4) and the trend lines (Table 2), I could point out some additional conclusions. In the regions marked as green, there seems to be a stable situation about the airport passenger throughput. Although Śląskie, Pomorskie, and Dolnośląskie regions have a high capacity bandwidth, declining annual growth in passenger numbers will make the throughput not to exceed in the long term. In Mazowieckie region, the growth in the number of passengers will contribute to higher utilization of airports; however, the current throughput secures sufficient space for new passengers in the future. In those cases the financial support for airport capacity exceeded was reasonable and well spent.

The second conclusion which can be drawn is that in the regions marked as orange, the problems with capacity might appear. First (Zachodniopomorskie and Podkarpackie), decreasing growth of passengers is not enough for optimal utilization of capacity. Moreover, in Kujawsko-Pomorskie, there will be a problem with the declining number of passengers and increasingly non-use capacity.

The third group of regions marked as red is the most problematic one. It seems that, in Małopolskie, Łódzkie, and Lubuskie regions, airport capacity was clearly overinvested. In addition to the current very low usage of capacity, there will be a drop in the number of passengers in the nearest future. This may cause the problems with the maintenance of buildings and facilities of airports.

6. CONCLUSION

The primary aim of this study was to present the possibilities of passenger throughput of Polish airports after extension supported by EU funds and its assumption for the long term. Without any doubt, it can be said that, with the help of EU funds, the total airport capacity in Poland has increased. Nevertheless, the basic results appear not to support the hypothesis that the use of EU funds for expansion of airport facilities in Polish regions.
has contributed to the stabilization of the level of passenger throughput for the long term. It seems that the
decision of capacity enlargement in some regions was not preceded by detailed analysis.

Although this paper approaches the topic of passenger throughput and expansion of capacity, a number of
open questions remain calling for more detailed investigation. First, a good seasonality measure should be
incorporated into the analysis to deliver more consistent and better results. The dataset used in this study
consists of regions with different throughput structures. On the one hand, there is the biggest airport in Poland
and the passenger stable traffic growth over the years, and on the other hand, it includes regions with traffic
only in a specific period within the year. Using Gini Coefficient to determine the seasonality coefficient of
airports and adjusting the capacity utilization rates accordingly could be a possible solution to this problem.

Second, we must bear in mind that as presented in literature review, the number of variables can influence the
air passenger demand. Therefore, together with simple forecasting analysis, it would be advisable to measure
the factors that are significantly important for the future demand with the help of regression analysis.

Finally, the airside was ignored in this analysis. Even though this paper suggests that the airside and terminal
side will be analyzed separately, it would give a good idea on the efficiency and interdependency of the whole
airport system.

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CONCEPTUALIZATION OF EXTERNAL KNOWLEDGE REVERSE FLOWS

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Abstract

Research in reverse logistics was previously focused mainly on manufacturing enterprises and on tangible reverse flows. However, with steady increasing proportion of services in GDP and with servitization of products, direction of further research in reverse logistics could aim on service sector and on intangible reverse flows, i.e. on information and especially on knowledge. The concept of gathering information from and about customers is not new and has been investigated by marketing researchers for a long time. Nevertheless, information about (dis)satisfaction of customers, their experience with products or complaints was gathered mainly in order to increase satisfaction, improve the experience or reduce the number of complaints. As one of the main purposes of reverse logistics is to reduce reverse flows, among others faulty products or services, this can be done by designing better products or services. However, companies need to obtain knowledge from customers in order to innovate products or services. Therefore, the purpose of this article is to introduce a conceptual framework the will help to analyze the current research that focuses on using knowledge from customers to reduce reverse flows. Using the designed framework, further research project will be introduced and briefly discussed.

Keywords: Reverse logistics, customer knowledge management, information, conceptual framework

1. INTRODUCTION

Recent development in logistics follows the general development trends based on information systems, social networks, globalization (on the supply and the demand side), servitization, big data and more. Interestingly, practice of reverse logistics (RL) does not keep this pace nor the research is. The common denominator of these trends is increased possibilities of information and knowledge that can be obtained from customer however the research on using customer knowledge seems to be scarce. Although reverse flows seem to have a rich potential for obtaining customer knowledge, reverse logistics research partially neglects the role of knowledge management [1], information systems [2], [3], performance management [4] and quality management [5], [6] Consequently, the theory lacks the understanding of mechanisms how customer knowledge embedded in reverse flows can be obtained or used in order to help the company with designing and innovating new products (or services) and thus increasing performance.

Therefore, the goal of this paper is to introduce a conceptual framework that grounds the forthcoming research focused on using information from customer produced in and by the reverse flows. Consequentially, the nature of this paper is theoretical. The data that were used for designing the conceptual framework come from research articles that were focused on Customer Knowledge Management and on using information from customers for the knowledge management purposes. The reason was that no usable research in the reverse logistics discipline was found. The conceptual framework that introduces the future study in this article originates and follows the outputs of the reverse logistics research that was done by my colleagues and me in the past 5 years. This stream of this research developed from investigating how companies support information and knowledge management in reverse flows.

This rest of the text is divided into four sections. The next section introduces the background of the researched phenomena, specifically the nature of information in reverse logistics and customer knowledge management.
The third section presents and describes the conceptual framework. The fourth section discusses the implications for the forthcoming research and the fifth section concludes the article.

2. BACKGROUND

In this paper, the reverse logistics (RL) is understood as: “The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal” [7], and is treated as part of the closed-loop supply chain (see [8]). For the purpose of this study, knowledge management (KM) is defined as: “the effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environment to enhance an organization’s intellectual capital and performance” [9, p. 12]. The rest of this section contains the background and context needed to reason the content of the conceptual framework focusing on two topics. Firstly, as information is necessary antecedent of knowledge, the background of information management in RL is introduced. Secondly, customer knowledge management as an approach that can be used for understanding the reverse flow of knowledge from customer is discussed.

2.1. Information Management in Reverse Logistics

The scattered research development in information management (support) in RL was reviewed in different published research [2]. Since then, several review studies were published focusing on research in RL at general level. Agrawal et al. [10] found two articles dealing with information management, Govindan et al. [11] found one article focusing on information systems, and Hosseini et al. [12] identified lack of emphasis on ICT in some studies. Clearly, the role of ICT and importance of information management in RL do not get the proper attention. Although the researchers dealing with RL (e.g.[13]) would conform to utmost importance of information in RL coming either directly from customer or through the supply chain channels, actual empirical research is far from being developed. While even if the information management research in RL was vital, it cannot imply anything about using knowledge management or customer knowledge in RL.

2.2. Customer Knowledge Management in Reverse Logistics

Similarly to information management the review covering infrequent knowledge management research in RL was created for the purpose of previous studies and presented in [1]. Not a single article focusing on using customer knowledge in RL was found: Hosseini et al. [12] even described the “immaturity and low investment in knowledge management and information system” as one of the major barriers associated with RL. They also highlighted that studies have overlooked the potential of design of products and management of knowledge. In other disciplines scholars had started focusing on customer knowledge soon after the emergence of knowledge management concept (e.g. [14]). These efforts led to establishing customer knowledge management (CKM) (see [15]), which can be understood as knowledge management that is not focusing on general human knowledge but on customer knowledge. In general, customer knowledge can be distinguished into three types: knowledge about, for, and from customer [16]. For the conceptual framework, knowledge from customer is essential, as it can provide ideas for product and service development [17].

In CKM distinguishing the term knowledge from information or data is crucial, as it can distinguish CKM from customer relationship management (CRM) that focuses primarily on customer data and information. CKM focuses primarily on how to use knowledge from customer [15], [17], and not only on transactional data, as CRM does[14]. Therefore, the theoretical differences between CKM and CRM as stated by García-Murillo and Annabi [17] can be summarized in Table 1. However, according to Salomann et al. [16] the CKM and CRM initiatives are pursuing the same goal: “the delivery of continuous improvement towards customers”, and according to them CKM can be treated as a closed loop knowledge cycle between various CRM processes.
### Table 1 Differences between CRM and CKM according to [16]

<table>
<thead>
<tr>
<th>Differentiating factor</th>
<th>CRM</th>
<th>CKM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direction</strong></td>
<td>One way</td>
<td>Two way</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td>Technology</td>
<td>Personal</td>
</tr>
<tr>
<td><strong>Information</strong></td>
<td>Data</td>
<td>Customer experience</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Identify profitable customers, customized marketing</td>
<td>Gather customer ideas, identify service improvement areas, new product development</td>
</tr>
<tr>
<td><strong>Employee role</strong></td>
<td>Little</td>
<td>Gather knowledge from conversation with the customer</td>
</tr>
</tbody>
</table>

CKM could lead to product and service innovations, competitive intelligence, customer loyalty, and better collaboration [14]. Moreover, Shieh [18] found positive correlation between several CKM dimensions (team learning, sharing intellectual capital, collaborating innovation, and creating customer value) and organizational performance.

Summarized, CKM can be treated as part of KM, distinguished on general level from CRM in using knowledge instead of data and information. In the context of reverse logistics, knowledge from customer can be understood as reverse knowledge flows, and knowledge for customer as forward knowledge flows. Therefore, the conceptual framework, which is based on CKM, directly relates to the reverse flows, especially when information (and knowledge originating from it) is according to RL definition inherent part of reverse flows.

### 3. CONCEPTUAL FRAMEWORK

Based on the background of the study presented in the previous section and on the previous research, the conceptual framework was designed and is presented in Figure 1. In the framework, which should guide the future research dealing with using knowledge from customer for product or service innovations, the focus is on customer behavior, details of knowledge flow from the customer to producer, and use of the customer knowledge (i.e. output of knowledge reverse flows) on the producer side. Thus, referring to the previous section 2.2 only the knowledge from customers is relevant.

Customer behavior in the context of product returns was studied in detail in various studies in reverse logistics, the most recent e.g. [19]. However, the reasons and behavioral patterns concerning the provision of feedback were not studied in high extent.

The knowledge from customer can get to the producer generally through three channels. Firstly, it is direct engagement of the producer with the customer, mainly in the personal or electronical form. Personal forms of obtaining knowledge from customers can consist of serving (selling to) the customer or communicating with the customer in any personal way. Electronical forms can include any communication through company social networks or websites (e.g. [20]), formal documents such as complaints, or electronic surveys. Secondly, the knowledge from customer can flow through the supply chain where the main medium can be information systems that are used for supply chain management purposes. Thirdly, companies can use external knowledge sources, such as various social networks (other than their own) or web aggregators.

The last part of the framework deals with the ways where and how can be the knowledge from customers used. The connection with knowledge management in the form of customer knowledge management is straightforward and consists mainly from using customer knowledge for organizational learning. Similarly, using customer knowledge in customer relationship management was found inherent for the discipline [18]. Customer knowledge can play vital part in quality management in order to improve the quality of product or services based on the customer experience. Similarly, as process management and process innovations can
be understood as part of quality management, the customer knowledge can be utilized in process improvement. In closed loop supply chain management, the customer knowledge can be used for decreasing the volume of reverse flows, mainly through better product design and forward logistics. Performance management can benefit from customer knowledge by designing new performance metric according to customer experience.

![Diagram of the conceptual framework of external knowledge reverse flows]

**Figure 1** The conceptual framework of external knowledge reverse flows

### 4. DISCUSSION

The reason, why the reverse logistics perspective was chosen is because scholars seem to omit the fact that the reverse flows can generate rich information content about the reasons why product returns happen, what is customer experience and that it could bring new perspectives on the phenomena (of using knowledge from customers for product and service innovations). The conceptual framework will therefore guide the forthcoming research which will try to investigate if, how, and why the producers gather knowledge from customers and how the knowledge is used in innovations. The framework will serve as an initial guidance for content analysis which will be starting point of the research project. The whole research design is presented in **Figure 2**.

The nature of the research is mixed as it combines content analysis of research studies that covers the content of the framework. The next step in the research will be case study research which will have either explanatory or exploratory nature which will be decided according to the results of the content analysis. If the content analysis reveals enough concepts about the researched phenomena then the explanatory research will be needed as the identified concepts will be explained. The exploratory case study will be needed if the content analysis will not find enough evidence. Next stage will follow similar logic, meaning that if the explanatory research will successfully reveal reasons why and how the customer knowledge is used then it will be possible to test it on a larger sample by a survey. Otherwise, more exploration will be needed on larger sample. The final stage will consist from follow-up interviews in order to enrich the quantitative data obtained through the survey.
5. CONCLUSION

This article introduces a conceptual framework of a research project that will investigate the relationship between the knowledge from customers that originates from reverse flows and the product or service innovations. In order to fulfill this goal and elaborate the conceptual framework, design of the future research was described. The design consist from several stages which follow mixed method research design including content analysis literature review, exploratory and explanatory case study, confirmatory and exploratory survey and descriptive qualitative interviews.

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SEQUENCING OF ORDERS IN MULTIVERSION PRODUCTION SYSTEM

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Abstract

The article discusses the basic characteristics of multiversion production and also presents the problem of production of different product versions on the same production line. The car production is selected as an example of the multiversion production process. Three main branches of the production plant (the body shop, the paint shop and the assembly line) are characterized. Based on exemplary manufacturing process, it is presented, how determining proper sequence of tasks, carried out in the production system, may affect production optimization. This paper presents a problem of sequencing cars, known from the literature as the Car Sequencing Problem (CSP). It also presents the range of reduction of the CSP problem relative to the problem, which occurs on a real production line. For comparison, the structure of an exemplary industrial plant is shown. Based on the presented scheme of the cars production, the importance of use of the buffer warehouses in selected production system is highlighted. Thus, it is given the suggestion to reformulate the CSP issue. In the final part of the article, a sample method of optimization of analyzed production process, focused exclusively on paint shop, is given. This method aims to provide a minimum number of changeovers of robots painting car bodies, which, by minimizing setup times, increases the number of produced cars. It also has an impact on minimizing consumption of paint and solvent used to clean the nozzles of robots whenever a changeover occurs.

Keywords: Multiversion production, tasks sequencing, buffer warehouses, optimization of production

1. INTRODUCTION

Current society is characterized by a high degree of development, which translates into a level of material needs. A tendency to resign from the standard and clichéd solutions for more specific and sophisticated products can be observed. It leads in turn to increased demands for both quality of provided services and delivery time. Individualized customer’s needs and the growing demand for different variants of the same product impose on a company the necessity of products differentiation [1]. Unpredictability of orders made by clients, makes today a move away from the Make To Stock production (MTS) to Make To Order production (MTO). It is aimed at minimizing the time between order and delivery of the final product to the customer [2]. For a company, this enforces the need to adjust the individual machines, devices and robots included in the production line for a multiversion production. This requires not only the flexibility of the production system, which should be taken into account in a design phase of the system [3, 4, 5], but also an efficient management and production control system [6]. Thus, on the same production line it is possible to produce different versions of the product, tailored to the customer demands. In modern production systems a variety of products (assortment) or different varieties of the same product (versions) are manufactured. Those production systems are known as mixed-model production systems.

Often used example of multiversion production is car production. On production lines several different vehicle models are usually manufactured and, for each model, different versions can be distinguished, for example in terms of color or additional accessories. As part of this article the stages of a car production will be presented, with an indication of the problems occurring at these stages. In addition, it will be discussed the issue of cars sequencing (the Car Sequencing Problem, CSP) as an example of illustrating the problems of appropriate organization and production planning.
2. CHARACTERISTICS OF MULTIVERSION PRODUCTION

The mixed-model systems are the result of evolution of systems adapted to produce only one product (a single-model production system). In 1913, Henry Ford, founder and then president of Ford Motor Company, as first used in his factory in Highland Park, in Michigan, linear assembly line, which was an absolute revolution in attitude to the mass production. The approach proposed by Henry Ford reduced the price of the model T in 10 years from about 900$ to 290$. Thus, the industrialists’ interest in mixed-model systems has increased significantly. Manufacturing of products for daily use, ranging from shoes to furniture and even food, was carried out on a massive scale, so goods so far considered as luxury, have became widely available products, also for less affluent sections of society. And to this day the mixed-model systems are widely used and constantly developed, especially due to their ergonomics, versatility and flexibility. Among the benefits that provide these systems, from the point of view of manufacturers, there can be distinguished [7]:

- ensuring the regularity and continuity of production process,
- elimination of bottlenecks and downtimes,
- full quality control assurance at each stage of production,
- shortening the manufacturing cycle time,
- efficiency increase,
- optimization of communication between the branches of the production system,
- ease of using the system,
- relatively low production costs,
- safety improving at work,
- ergonomics of the environment.

A characteristic feature of the mixed-model systems is a constant flow of materials, to ensure in assumed cycle time, enough time to complete all the operations resulting from the production plan as well as the high level of workstations utilization. It is achieved by assembly line balancing and sequencing of production orders. In the case of MTS production sequencing of orders can be carried out at the beginning of a production process. However, in the case of MTO production it is necessary to ensure the possibility to change the sequence of orders in a course of the process, simultaneously maintaining the continuity of production. It is possible through the use of buffer warehouses between workstations. This solution has been used in the production of cars.

3. THE CAR MANUFACTURING PROCESS AS AN EXAMPLE OF MULTIVERSION PRODUCTION

Production of cars consists of several steps that are following each other according to a specific order - sequentially. Although the models of vehicles, that are currently produced on the line, are similar to each other, it is possible to distinguish some features, that are characteristic for the particular types of a given car model. Customer buying a vehicle can determine not only the color of this car, but also many elements of equipment, for example: a sunroof, air conditioning, embedded navigation and others. This indicates that production of cars can be classified as a multiversion production.

In the initial phase of cars production, in the body shop, robots and operators are welding the various parts of the vehicles to form right structure of a car. Then the connected parts are sent to a paint shop, where they are painted by robots equipped with spray guns. Therefore, at their way out from the body shop, cars should be arranged in a specific order, depending on color which they will be painted on. In the last phase, in the assembly line, various components are added to the vehicles, adequately to the selected options [8]. A different number of additional components may characterize each configuration.
In the following sections there are presented characteristics of two plant shops of car production line: the paint shop and the assembly line, from a perspective of the constraints which affect sequencing vehicles along each part of the line.

3.1. Paint shop

The paint shop is equipped with robot stations, which are retooled every time the color changes. The capacity of a production line for the paint shop depends not only on the number of the cleaning guns for each change of color, but also on a periodic cleaning of paint guns. Two examples of color sequences, presented in Figure 2, show the effect of cars alignment with the frequency of the cleaning guns. It is assumed that along the line there is located only one robot and its gun is cleaned periodically every three cars. As can be seen, in both cases, the nozzle should be cleaned at the beginning of the next production day, because of the planned change of color. In addition, in the first case (Figure 2 - SEQUENCE A) it is necessary to clean the gun twice - the first time due to the periodic cleaning, the second time due to change of color. However, in the second case there is only one cleaning included both periodic cleaning and cleaning due to a color change. This example illustrates the importance of proper planning of car sequences on the line. The appropriate sequence of cars plays an important role in a production optimization [8, 10, 11].

Both cleaning of spray guns and retooling cause delays, which sum is the greater the more often robots are retooled. As a result, periodic cleanings and color changes increase not only the consumption of a solvent, but also the consumption of paint. During flushing of spray guns, some paint, which remains in the nozzle and on the walls, will not be used, because of its removal during the cleaning process. It proves that the consumption of paint increases. A similar situation takes place when the periodic washing of nozzle will not be taken into account during the sequencing of cars, as shown in Figure 2 (SEQUENCE A).

Therefore the aim of the paint shop is to minimize the number of color changes (the number of necessary cleanings), allowing to reduce both costs and production time [8, 10, 11].

3.2. Body shop and assembly line

In the body shop and the assembly line there is a problem of an appropriate arrangement of car sequence. It is related to a produced type of a car model - the vehicle can be three- or five-door and the decision about it
is made in the body shop. The car can be also equipped with additional components which are installed in the assembly line [10].

Therefore the aim of the body shop and the assembly line is to smooth a workload along a line by balancing an effort in different working stations [8]. Balancing of the assembly line is achieved through distribution of operations between workstations, so that idle time is minimal [9]. From the perspective of the Car Sequencing Problem, balancing of the assembly line means an even distribution of a workload along the car production line, which requires extra assembling operations (installing additional components). It allows avoiding overload of the station in assembly line [8].

4. THE CAR SEQUENCING PROBLEM

The sequencing can be regarded as a short-term decision-making process. The aim of sequencing is to define the order, in which the different variants of products will be carried out. This sequence should be determined in such a way, that the demand for all products planned in the Master Production Schedule (MPS) has been met. The sequencing problem arises for example in the multiversion production of automobiles or bicycles, because there are many variants of products. The sequencing of production variants smoothes the load of the production system (which is most commonly used on the assembly line) by mixing the order, in which the products will be manufactured. Such an approach allows for maintenance of stability and for work standardization. The sequencing enables carrying out the production in order of customer orders. It is easier to optimize the operation of the system designed to multiversion production, when the workstations are multifunctional and work in several variants of production. The planning of sequences of product variants provides greater flexibility in the production process.

As has been mentioned earlier, production of cars can be classified as a multiversion production. This implies the requirement to plan an appropriate sequence of cars on the production line to optimize production, both in terms of costs and time needed for machines and robots retooling or in terms of productivity [10]. This problem has been defined in the literature as the Car Sequencing Problem (CSP). It has been shown that this problem belongs to the NP-hard problems, so there are not any known algorithms that solve the problem in a polynomial time [12, 13].

The Car Sequencing Problem was first introduced in 1986 by Parello [14] and a formulation of this problem was slightly different from modern understanding of the CSP problem. The issue described by Parello concerned scheduling a set of vehicles on the assembly line to meet imposed assumptions about the throughput of the line. In 2005 the French Society of Operations Research and Decision Analysis organized a ROADEF Challenge 2005 with the Car Sequencing Problem as a subject. The organizers required to take into account not only capacity constraints imposed by the assembly line, but also paint batching constraints (the paint shop) and two categories of capacity constraints - high and low priority constraints. Thereby to solve the CSP problem proposed by Renault it had to include all three plant shops (Figure 1): the body shop, the paint shop and the assembly line [8], but this problem omits the existence of a buffer warehouse between stages and inside individual shops and lines. However, this buffers occur in the actual production lines, so it is important to take this into account in the search for a solution of the real CSP problem, because buffer warehouses play an important role in the planning of production and in the sequencing of production orders.

5. BUFFER WAREHOUSES IN CAR PRODUCTION SYSTEM

The buffer warehouses are elements of production processes, often used to ensure continuity of a production. They could occur in the form of physical devices and their main purpose is to store components, spare parts, tools and many others. These devices are widely used, for example in: production lines, distribution centers, wholesaler’s and can also be used for archiving documents in the office [9].
From the point of view of orders sequencing the most important buffer warehouses in car production are parallel buffers (Figure 3).

**Figure 3** Production line with parallel buffers strategy [9]

When a structure with parallel buffers (Figure 3) is used, the decision of locating the vehicle on a buffer line is taken at the end of the incoming line. In turn, the outgoing line is successively filled with cars taken from the parallel buffer line, according to defined priority, for example FIFO strategy (First In - First Out).

This type of buffer is mainly used in the paint shop (Figure 4). Usually, buffers occurring before and after the paint shop are also qualified as buffers and are so-called the Body Distribution Centers (BDC). The sequencing of orders in the "input" BDC is carried out due to optimization aims of the paint shop, while the sequence of cars in the "output" BDC is adapted to requirements of the assembly line.

**Figure 4** Structure of the paint shop

6. THE SAMPLE APPROACH TO THE CAR SEQUENCING PROBLEM

One of the applied and relatively simple solution of the Car Sequencing Problem is the approach based on historical data and probability issues. However, this solution is dedicated exclusively for the deployment of the bodies in the first buffer warehouses (BDC in). The approach is to determine, what is the probability that a body will be painted on one of the available colors. For this purpose a so called bank of colors and bank of
bodies are created. The bank of colors includes all available colors. The bank of bodies provides the information, how many bodies, from the available resources produced within the last \( n \) jobs, are painted on particular color. Then for every color the obtained probability is assigned and the bodies, which will be painted on the color with the highest probability receive the highest priority. Thus, those bodies are so disposed in buffer warehouse, that they as the first left the buffer. The discussed approach is noteworthy because of its simplicity. However, this solution does not include the sequencing of the cars in other buffers and does not take into account the problems of assembly line optimization, what is directly related to the buffer BDC out.

7. CONCLUSION

In conclusion, the use of the mixed-model systems in industry allows a production of products in different versions, tailored to customer needs and relevant to personalized orders. Definitely it increases the company's competitiveness on the market. The appropriate management of the production process and ensuring maximum utilization of workstations among others things through proper production plan are important. Unfortunately, due to the unpredictability of orders, production plan should be verified on an ongoing basis. In order to ensure the continuity of production, the mixed-model systems are equipped with buffers, allowing changing the sequence of orders. This issue is classified as a NP-hard problem, hence the research for the solution of this problem is still conducted. The example of approach to the problem of orders sequencing was presented in this article, however it is only the basis for the future discussion.

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Abstract

Decisions about the location of the company or logistic hub are a complex process that requires thorough analysis of various factors. The aim of this paper is to identify the most important factors which influence the location of the storage facility. The theories and methods of choosing localization are discussed in the theoretical part of paper. In empirical research, via method of AHP, the attractiveness of the localization of various Polish cities was compared. Selected municipalities were collated in terms of the following criteria: price of land, access to infrastructure and to qualified personnel, costs of labour, distance to sales and supply markets.

Keywords: Warehouse, location factors, Analytic Hierarchy Process

1. INTRODUCTION

The location of a new production facility, warehouse or a distribution centre, requires careful investigation of a variety of conditions which may impact the efficiency of the entire venture [1]. Decisions concerning the location of one’s own logistical facility are always long-term in nature. This stems from the fact that the cost of constructing or acquiring an appropriate facility or warehouse is always high and it is settled throughout many years of expected usage [2].

Literature on the subject contains many theories and methods pertaining to the selection of the location of logistical nodes. The first person to deal with location theory was von Thünen, who created a model in which respective types of agricultural production were arranged around metropolitan areas. The main assumption of this model (the ring theory) was that the type of production performed on agricultural farms is influenced by the amount of costs related to transport [3]. Von Thünen’s model concerned mainly agricultural activity. Location theory in the field of industry has been formulated first by Launhardt, who postulated that an optimal location is the one that minimizes transport costs per unit of production [4]. Launhardt’s research was continued by Weber, who claimed that an enterprise’s optimal location is the one allowing to achieve the lowest transport costs based on specific assumptions [5]. Another standpoint was presented by Lösch, who claimed that the main criterion for locating enterprises should be the maximization of profit and viewed the optimal location as the one ensuring maximum sales with the lowest possible total costs. According to Lösch companies seek locations near the most absorptive markets [6].

The theory was also significantly developed by Hoover and Florence who stressed the importance of the role of concentration of production in industry location. Moreover, Hoover developed a classification of costs in which he paid particular attention to changing the means of transport during shipping as well as related handling works which may impact the general transport costs [7].

Modern location theories often assume that not only economic premises are significant, but also psychosocial factors. When compared to classic theories, modern location theories examine the issue of location in a significantly wider scope. In addition to sales and supply markets and transport costs, which are the main factors shaping the optimal location in classic theories, modern theories also comprise psychological factors and advantages stemming from cooperation within a region or sector [8]. The behavioural approach refers to
the limited rationality of the governing bodies, the incomplete scope of knowledge possessed by them as well as their lack of expertise to properly utilize such knowledge. Such views were held by Törnqvist and Ramström who viewed direct personal contacts of representatives of various organizations as the main factor impacting the location of economic activity [9]. Another theory of location is the one authored by Klaassen, who claims that investors locate enterprises in attractive regions, i.e. those with emerging or existing growth poles [10].

This paper’s research objectives are both cognitive and methodological in nature. The cognitive objective is to specify the factors significant for making decisions about the location of logistical facilities from the point of view of entrepreneurs. The methodological aim concerns the use of the AHP method in order to establish a ranking of selected cities with regard to their attractiveness in scope of logistical (economic) activity location.

2. MATERIAL AND METHODS

The source material for the research originated from primary and secondary sources. Accumulation of primary data included conducting a survey questionnaire among 20 entrepreneurs. The aim of the survey was to acquire an opinion of entrepreneurs as to the factors significant with regard to making a decision on locating new facilities. By contrast, using secondary GUS (Central Statistical Office of Poland) data and resources collected from the Internet allowed to acquire information necessary to perform an analysis of the attractiveness of cities with regard to locating new facilities with use of the AHP method.

Warehouse location was evaluated based on the AHP (Analytic Hierarchy Process) method. The AHP method is a multiple objective ranking procedure focused on the hierarchical analysis of the decision problem [11]. The method is based on the multiattribute utility theory [12] and allows to rank a finite set of variants $A$ from the best to the worst. Through the definition of the overall objective, evaluation criteria, subcriteria and variants the method constructs the hierarchy of the decision problem.

On each level of the hierarchy, based on the pair-wise comparisons of criteria, subcriteria and variants, the DM’s preferential information is defined in the form of relative weights $w_r$ [11]. Each weight represents the quantified strength of the compared element against another, on the standard “1 - to - 9” measurement scale, in which: 1 corresponds to the elements that are equally preferred; 3 and 5 denominate - weakly and strongly preferred element, respectively, while 7 and 9 represent strongly and absolutely preferred element, respectively. The intermediate judgments like: 2, 4, 6, 8 can be also used. All weights have a compensatory character, i.e.: the value characterizing the less important element (1/2, 1/5, 1/9) is the inverse of the value characterizing the more important element in the compared pair (2, 5, 9) [13].

The algorithm of the AHP method focuses on finding a solution for a, so called, eigenvalue problem [Satty, 1980] on each level of the hierarchy. As a result a set of vectors containing normalized, absolute values of weights $w_a$ for criteria, subcriteria and variants is generated. The sum of the elements of the vector is 1 (100%). The absolute weights $w_a$ are aggregated by an additive utility function. The utility of each variant $i - U_i$ is calculated as a sum of products of absolute weights $w_a$ on the path in the hierarchy tree (from the overall goal, through criteria and subcriteria) the variant is associated with. The utility $U_i$ represents the contribution of variant $i$ in reaching an overall goal and constitutes its aggregated evaluation that defines its position in the final ranking. The final result of the AHP method algorithm is the ranking of variants from the best to the worst based on the decreasing values of their overall evaluations.

The important element of the AHP algorithm is the investigation of the consistency level of matrices of relative weights $w_r$ on each level of hierarchy. Through the calculation of a, so called, consistency index $CI$ one can measure how consistent is the preferential information given by the DM. If the value of $CI$ is close to 0 the preferential information given by the DM is considered to be almost perfect. The acceptable level of $CI$ is below 0.1 [14].
3. RESULTS

The first stage comprised research conducted on the basis of the survey questionnaire. It involved 20 entrepreneurs in the period between December 2015 and April 2016. The most numerous group of respondents was constituted by representatives of production companies. The scope of economic activity of the surveyed enterprises was as follows: 75% of surveyed companies had an international footprint, 15% of respondents conducted activity only in Poland and 10% were regional enterprises.

In scope of the research the persons responsible for locating facilities and/or warehouses had to decide which of a set of predetermined factors have, in their opinion, the strongest influence on the selection of a location for a facility (warehouse). The factors have been evaluated on a scale of 1 (factor not impacting the selection of a location) to 5 (factor with significant impact on the location of the company). The average rating of the entrepreneurs has been presented in Table 1.

**TABLE 1 Evaluation of the significance of location factors according to the respondents**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Average rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour cost</td>
<td>4.58</td>
</tr>
<tr>
<td>Access to road transport facilities</td>
<td>4.53</td>
</tr>
<tr>
<td>Possibility to expand the facility</td>
<td>4.47</td>
</tr>
<tr>
<td>Utility infrastructure</td>
<td>4.11</td>
</tr>
<tr>
<td>Access to qualified personnel</td>
<td>4.05</td>
</tr>
<tr>
<td>Price of production resources</td>
<td>3.94</td>
</tr>
<tr>
<td>Local fees</td>
<td>3.84</td>
</tr>
<tr>
<td>Vicinity of supply market</td>
<td>3.78</td>
</tr>
<tr>
<td>Vicinity of sales market</td>
<td>3.63</td>
</tr>
<tr>
<td>Tax provisions</td>
<td>3.63</td>
</tr>
<tr>
<td>Price of land or lease cost</td>
<td>3.58</td>
</tr>
<tr>
<td>Possibility to integrate with other entities</td>
<td>3.58</td>
</tr>
<tr>
<td>Cost of utilities</td>
<td>3.47</td>
</tr>
<tr>
<td>Access to rail, air and maritime transport</td>
<td>3.16</td>
</tr>
<tr>
<td>Local community acceptance</td>
<td>3.16</td>
</tr>
</tbody>
</table>

Source: Own research

The factors which achieved the highest average ratings according to entrepreneurs are labour cost, access to road transport facilities and possibility to expand the facility. The lowest average score was attributed to the cost of utilities, price of land or lease cost, infrastructure other than road infrastructure, possibility to integrate with other entities and local community acceptance (Table 1).

Factors omitted in the survey, but significant from the point of view of respondents are: existence of Special Economic Zones, subsidization (e.g. European Union grants), succession, attachment to place of residence, use of existing structures, topography, soil conditions, atmospheric conditions, access to water, image of the location and distance from inhabited areas.

The second stage of research involved the use of the AHP method in order to formulate a ranking of selected cities with regard to their location attractiveness related to constructing or acquiring new warehousing areas. The surveyed sample consisted of 5 Polish cities: Nidzica, Konin, Legnica, Tarnów and Świdnik (variants from V1 to V5). The analysis was conducted for the year 2016.
The objective of the multiple criteria analysis of Polish cities is to evaluate them from different perspectives. The multiple criteria evaluation of cities is envisaged by the author of the paper as an extensive benchmarking analysis, resulting in the recognition of the diversification of access to transport infrastructure, land prices, distance from supply and sales markets, access to qualified labour and the costs of labour.

The decision maker (DM) in the analyzed decision making process is represented by the entrepreneur. An entrepreneur being the decision-maker in this analysis conducted production activity in central Poland and considered establishing a new warehouse in one of the five locations enumerated above. What was important to the entrepreneur was to create a ranking of 5 cities with consideration of the following criteria:

- C1 - access to infrastructure (road, maritime, rail, air),
- C2 - price of land (purchase / lease),
- C3 - distance to sales / supply markets,
- C4 - cost of labour (taking into account the average wages in the region),
- C5 - access to qualified personnel.

Computational experiments have been carried out with the application of AHP method implemented in the specialized software called MakeItRational. In the first stage the hierarchical structure of the decision problem has been defined, including the definition of the overall goal, criteria and variants. In the next step the model of the DM’s preferences has been constructed. This has included the definition of the importance of individual criteria and the recognition of the DM’s sensitivity to changes of their values. On the basis of pair-wise comparisons between criteria the relative weights \( w_r \) ranging between 1/9 to 9 have been generated.

The results of calculations of relative weights \( w_r \) for criteria, applied in the evaluation of Polish cities, have been presented in Table 2. This matrix is characterized by pair-wise coherence. In the course of comparing the criteria the author has considered the preferences of entrepreneurs with regard to the advantages of individual factors. It can be seen that criterion 4 (cost of labour) is more important than all others (relative weights are higher than 1).

**Table 2 Relative weights \( w_r \) for criteria generated by the AHP method**

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>1/6</td>
<td>5</td>
<td>1/2</td>
<td>2</td>
</tr>
<tr>
<td>C2</td>
<td>6</td>
<td>1</td>
<td>1/2</td>
<td>1/7</td>
<td>1/4</td>
</tr>
<tr>
<td>C3</td>
<td>1/5</td>
<td>2</td>
<td>1</td>
<td>1/6</td>
<td>1/3</td>
</tr>
<tr>
<td>C4</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>C5</td>
<td>1/2</td>
<td>4</td>
<td>3</td>
<td>1/3</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Own research

In the next step the eigenvalue problem has been solved, which resulted in the generation of normalized absolute weights \( w_a \) on all levels of the hierarchy i.e. for criteria and variants in the form of weight vectors all, above mentioned components of the hierarchy. As can be observed in Figure 1, the most important criterion - with the highest value of weights \( (w_a = 0.44) \) is criterion 4 - cost of labour. The next places are held by: criterion 1 - access to infrastructure and criterion 5 - access to qualified personnel. Criteria 2 - price of land and 3 distance to sales / supply markets belong to the least important characteristics. Their absolute weights are 0.04 and 0.06, respectively, which is presented in the graphical form (see Figure 1).
Further analysis lead to mutual comparisons of variants for all individual criteria. The relative weights of individual variants specify the relative position of a given variant (city) in relation to its competitors (other cities), evaluated by the specific criterion. The values of the relative weights also reflect the direction of preference of this criterion. Similarly to previous computations a vector containing normalized, absolute values of weights for variants has been generated.

In the next step for each matrix on hierarchical levels, i.e.: criteria and variants, consistency indexes $CI$ have been computed. In all matrices the values of the consistency indexes $CI$ have not exceeded 0.1, which proved that the acquired preferential information has been appropriately defined. This allowed the author to continue the computational experiment.

The next stage consisted in aggregating the absolute weights $w_a$ of the elements of the hierarchy tree by means of an additive utility function. As a result the utility of each variant $U_i$ has been calculated. Figure 2 presents the final ranking of variants (cities) from the best to the worst based on their decreasing utilities. Thus, city with the highest utility is placed at the top of the ranking, while the city with the lowest utility is placed at the bottom. The utility of each variant also provides information on its participation in achieving the overall goal of the analysis.

In accordance with the analysis conducted on the basis of the Analytic Hierarchy Process method the city with the most advantages with regard to the examined factors was Legnica (Figure 2). This result stemmed from the fact that it achieved a very good score with regard to access to qualified personnel and infrastructure, i.e. the factors with the highest weights. The city ranked second with regard to location attractiveness was Nidzica, in spite of its unfavourable infrastructure. The vital factor here was an especially advantageous cost of labour when compared to other cities. In the survey research the cost of labour was indicated by the respondents as the key factor determining the location of facilities. The third place was taken by Tarnów, which achieved the best result in scope of access to qualified personnel. In accordance with the analysis Konin ranked fourth despite achieving a good result in scope of access to qualified personnel and favourable infrastructure. The reason for such a low rank was a rather high cost of labour when compared to other cities. The last place in the ranking was occupied by Świdnik. This stemmed mainly from high wages and significant distances to supply and sales markets.

It is also worth mentioning that Legnica prevailed over the other cities with regard to access to infrastructure and distance to supply and sales markets. The advantages of Nidzica were low costs of labour and the price of land, while Tarnów stood out because of its qualified personnel. Konin and Świdnik did not achieve any advantage over the other cities in scope of any of the examined factors.
4. CONCLUSION

The theoretical section of the paper presented various location theories which were formulated and developed in order to clarify and plan the spatial organization of various categories of economic activity.

Empirical research based on the opinions and ratings given by 20 entrepreneurs allowed to specify the most important factors taken into account in relation to making decisions about locating logistical or production facilities. In the respondents’ opinion the most important factors are cost of labour, access to road transport facilities and possibility to expand the facility.

The second stage of research consisted of using the AHP method and considering the preferences of entrepreneurs in order to select 5 criteria, i.e. access to transport infrastructure, land prices, distance to supply and sales markets, access to qualified personnel and costs of labour. Those criteria served as the basis for the comparison of 5 cities (Legnica, Nidzica, Tarnów, Konin and Świdnik). The AHP analysis conducted for the purposes of preparing this paper allowed the author to create a ranking of those cities with regard to their attractiveness as locations for new logistical facilities. Legnica was ranked first owing to its wide access to infrastructure and closeness of supply and sales markets.

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NETWORKS AND TOOLS FOR SUPPLY CHAIN OPTIMIZATION IN AUTOMOTIVE INDUSTRY

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Abstract
The car manufacturers worldwide are under the roughest business environment. Its sales are affected by a financial crisis that mutes a customer’s ability to buy new cars. Due to those unfavorable conditions it is important to take all available tools in order to mitigate crisis effects. The paper basically describes Supply Chain Management including some types of networks its weaknesses as well as optimization models in automotive industry. As a result of globalization, more and more supply chains originate in low-cost countries, primarily in Asia and Eastern Europe, while largely continuing to terminate in North America and Western Europe. As a result, traditional organizational structures and business practices are being challenged. Next, some suggestions for optimization of the procurement, production, transport and warehouse management is described in the paper.

Keywords: Automotive industry, procurement management, warehouse, production management

1. INTRODUCTION

As the automotive industry shifts from a traditional local business model to a global one, OEMs and suppliers are among those experiencing the most disruption.

Major automotive players are in various stages of transformation from a localized “buy / make / sell” model to a global “buy / move / make / move / sell anywhere” model. This transition is being undertaken in order to achieve greater scale and cost efficiencies while capitalizing on rapidly expanding markets. Companies must maintain or enhance supply chain flexibility and customer responsiveness despite these major shifts in the automotive industry [1].

During the last 15 years Supply Chain Management (SCM) has developed from a veritable procurement strategy to an important part of integrated business models. By the use of SCM in some subareas distinctive improvements have been achieved, but the potential is by far not utilized. The accelerated globalization of economy, the increasing customer requirements, the short product life cycles and new information technologies are new challenges for SCM and inter-corporational networks. Especially in Automotive Industry, where they have to deal with a wide range of products and product variability, high customer requirements and many suppliers SCM is one of the most important factors to stay competitive [1], [2].

This article will now focus on Supply Chain optimization, an inter-corporational orientation of operative and strategic business processes to satisfy customer requirements along the whole Supply Chain. Due to the companies focus on their core competences many complex production-networks were established. To ensure the competitiveness of the involved companies, Supply Chain Optimization focuses on the optimal planning and control of all material, information and financial flows. Mathematical models and software tools support the cooperation between the consumers and suppliers and afford a smoothly and optimized flow of business processes [2], [3], [4].
2. TYPES OF NETWORKS IN AUTOMOTIVE INDUSTRY AND THEIR WEAKNESSES

In automotive industry production networks, those connect geographical separated production plants of one or more companies are reality for many years. The networks consist of the Original Equipment Manufacturer’s (OEM) production plants and of his worldwide suppliers. The objective of the networks is to optimize material and information flows between the plants. Due to the worldwide partners in a production network the legal frameworks are totally different and it is often a hard challenge to conclude contracts. [1]

In Figure 1 you can see a simplified description of a production network between an OEM and his suppliers.

Contrary to production networks a distribution network has a totally different scope of duties. The point of view of these networks is focused on the optimization of the distribution structure and organization. It is common that independent companies act as a partner of the OEM and distribute in many regional stores the products to the customer [5], [6].

The following figure shows a simplified distribution network of a French OEM.

Figure 1 Simplified production network

Figure 2 Distribution network
The third common combination of networks concerns the procurement. OEMs like VW or BMW use procurement networks to optimize procurement processes, to gain economies of scale and scope and to create market power. In automotive industry procurement networks are usually closely connected with production networks. [7]

**Figure 3** shows the procurement process of a factory and some different transport structures that are discussed at the point transport management.

Weaknesses in automotive industry networks frequently occur of the high number of process partners in the supply chain. In general a coordinating department with detailed information about processes does not exist and a continuous responsibility for the whole process is also missing. The absence implementation of process standards is a further barrier for global network management. Non-integrated information systems, missing capacity adjustments and complicated accounting systems complete the problem list. [6]

### 3. INSTRUMENTS FOR NETWORK OPTIMIZATION

According to the objectives of networks, network management has to deal with different requirements. To optimize networks the management has to provide appropriate instruments. At the beginning analyses should be enforced to show existing dependency and cooperation models between the factories and suppliers in a structured way. In automotive industry the procedure is as follows. Analyses record all incoming material volume and logistic costs related to the different production plants, car series, procurement region and groups of parts. These analyses also show management ratios like transport and handling time as well as costs, the turnover volume, available capacity, stock amounts and capital lockup. In contrast to these standard logistic analyses supplier based analyses show the outgoing material volumes and costs of each car series. Analyses related to the groups of part record all supplier, transport and handling costs, while procurement analyses show the procurement volume and amount for each production plant and car series. After the recording and structuring of all analyses and information, decisions about network optimization can be reached by the use of simulations. In general improvements are the result of modified standard processes and parts allocation, of optimized network elements and intensified supplier integration. [7]

Another essential instrument for network optimization is process management that plans, controls and executes logistic processes. The objective of process management is to organize the company’s intern process chains, from the processing to the waste disposal department, in an optimized and efficient way. Other instruments for a successful network optimization and smoothly material and information flow are consolidated planning and controlling systems, capacity databases to coordinate lead times and utilization, coordinated management information systems and workflow systems [7], [8].
Figure 4 shows a short summarization of possible optimization instruments.

4. SUGGESTIONS FOR OPTIMIZATION MODELS IN AUTOMOTIVE INDUSTRY

The following part of this article will give some suggestions for optimization of the procurement, warehouse, production and transport management in automotive industry.

4.1. Procurement Management

Due to the increasing horizontal and vertical product range in automotive industry and the thereby occurring rising number of parts, suppliers, complexity and costs, procurement management plays a very important role in staying competitive. As a result of the rapid grow in total revenue many OEMs focus on the implementation of a strategic procurement process. In this case the primary objective is to optimize the worldwide processes. To achieve that it is advisable to analyse the whole procurement volume, the suppliers and the different material groups. After the interpretation of the results and the identification of the strategic procurement processes decisions concerning product development and supplier management processes, cost optimization models or Make-or-Buy decisions could be made. Cross-functional teams can be introduced to analyse the interfaces inside the company but also between the supplier and the OEM. [9]

To assure an optimized and increased process quality it is reasonable to introduce some supplier management software to simplify the procurement process. The Mercedes Car Group introduced a Supplier Management Base (SMB) that is aimed to make capacities, stocks, demands and supplier data transparent to provide the supplier’s production processes with actual information. This system makes it much easier to prevent bottlenecks and bullwhip effects and is also reducing the reaction time in case of an existing bottleneck by an automated reclamation process. [10]

Other instruments for procurement process optimization could be the introduction of Quality Gates to increase the process stability or Process-Owners that are responsible for a smoothly process flow.
4.2. Production Management

For years simulation is an important tool in production planning. Depending on the production structure analytical models are an alternative or an extension for simulation application. By the use of simulation software it is possible to model complex structures in a few days or even in a few hours. After analysing the simulation results, the responsible persons for the process can start to optimize the process by changing batch sizes, free and blocked floats and other parameters [10].

One example for software that is used in automotive industry is RFID software for Complex Event Processing from TIBCO Software Inc. With this software it is possible to integrate all relevant information of RFID in the existing supply chain data flow to track the products during the entire supply chain. So it is possible to synchronise and optimize the production process or to use Just-in-Time and Just-in-Sequence models.

Another instrument to reduce the complexity of production programs is the introduction of some Assemble-to-Order or Build-to-Order concepts. These concepts are characterised by the capability to quickly build standard or mass-customized products upon receipt of spontaneous orders without purchasing delays, forecasts or inventory. [12]

One very simple but very effective optimization tool, which is used since the seventies in Japanese automotive industry, is the KANBAN system. This system is based on the pull-strategy and is exclusively orientated on the demand of a consumptive production area. Autonomous control cycles on workflow-level are the core element of this flexible production control system. The KANBAN system can reduce stocks and lead times and an improvement of material availability, production efficiency and delivery reliability can be reached. [13]

4.3. Transport Management

One of the major problems in transport is the long delivery stop during the loading process. The challenge is to organise the loading process in a physical way that minimize the delivery stops and loading times. Material supply in some base frames or optimized handling equipment for direct loading could be helpful.

For an effective transport optimization it is also necessary to integrate a standardized production planning and control system (PPC-System) or an intranet platform to generate all data concerning material flows between suppliers and the OEM [14], [15]. This tool provides a transparent database and helps to review all important information. To optimize transport it is also necessary to divide the delivery volume in a classical ABC-classification. For A-goods a direct delivery are appropriate while for B-goods milkruns or the disposal of the whole delivery volume to an area forwarder are possible opportunities. C-goods are normally distributed via Cross-Docking-Platforms [16].

4.4. Warehouse Management

To optimize costs and long required waiting time for stocks, the implementation of a Warehouse Management System (WMS) is advisable. Such systems control the transport flows in warehouses between the different areas.

Another suggestion to optimize warehouse processes is the generation and optimization of picking orders. Product and demand analyses should find out for which products chaotic and for which products regulated picking systems are efficient [17].

To optimize warehouse processes it is also recommended to divide the products in an ABC-classification. After the classification it is possible to find appropriate warehouse systems for each product groups [18].
CONCLUSION

Due to the increasing product variety, customer requirements, suppliers and costs the network building of autonomous companies and the optimization of business process is of upmost importance to stay competitive. The cooperation in production and supplier networks leads to a quality improvement and risk minimization because of know how bundling. Networks are also an appropriate instrument to stay or improve competitiveness. For example, time advantages can be reached by reducing lead and processing or increased reaction times. Economies of scale and scope can be achieved by improved market entry and market penetration. Technical specialisation and synergy effects, that can cause cost reduction, are also much easier to realize in networks than for one company alone.

To reach all the advantages of network building it is top priority to coordinate all material and information flows between the different operating areas and the company’s interfaces. This leads to new challenges and responsibilities for logistics that can be countered by the development of precise network management. According to the permanent improvement of optimization systems and models the optimization potential for an efficient coordination of a company’s processes is not utilized by a long time.

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TRAVELLING COST AN ASSESSMENT CRITERION OF THE MODEL OF CITY LOGISTICS

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Abstract
A description of a complex reality in a simplified form, which can be used in research, constitutes the basic purpose of modelling. A system of city logistics interpreted as a system of elements involved in the flow of people, freight and information in urbanized areas is such a complex picture in urbanized areas. In the modelling process of the system of city logistics, mathematical modelling was used, which consists in the creation of mathematical models of the systems analysed and further in the use of the mathematical apparatus on the stage of experimenting with these models. The article includes the presentation of a model of city logistics together with one of the most important assessment criteria of the model presented of urbanized areas that are essential to users, i.e. travelling costs. This quantity reflects subjective perception of the nuisance of travelling in the urban reality. A reference was made to travelling costs, where the total generalized travel costs and the total external travel costs were determined as components.

Keywords: City logistics, model of city logistics, travel costs

1. INTRODUCTION
The issues of city logistics constitute an essential element of the present-day urban transport policy. The use of ideas, methods and techniques of logistics management on the stage of an improvement and streamlining of the flow of people, freights and information in towns has become an important element of this policy. City logistics as a town’s management conception constitutes the whole of activities and processes related to the management of the flows of people, cargo and information inside an urban logistics system [8]. The superior objective of the conception presented herein is to satisfy those needs that are the result of the activity of the users of urban areas, which are manifested in the need to travel, the effect being travels in towns [4]. In the perspective of the theories of systems, we identify the city logistics system, which is interpreted as a set of elements (users, infrastructure, rates, regulations etc.) involved in the flow of people, freights and information in urban areas [7].

The present article offers a proposal of the construction of a model of city logistics in relation to the flow of people. In the model, the guidelines were used of the conception of the formation of mobility in the urban area in the aspect of environmental protection [2]. The economic assessment criterion in the form of the travelling cost was defined in a great detail as an extension of indicator mobility assessment [3].

2. ASSUMPTIONS OF THE MODEL OF CITY LOGISTICS
The model is the tool of an analysis and assessment of the functioning of existing or designed systems of city logistics. The properties of the city logistics system, which are essential from the perspective of the research objective, are reflected in the model. The issues of city logistics modelling were presented in the studies [1, 5, 6, 7, 9, 10].

Taking into consideration the specific nature as well as the objectives realized by the city logistics system in the perspective of the transport of people, it is essential that the following properties are reflected in its model:
- the resources of the system that represent the elements of urban infrastructure of transport and the users of the urban area who travel,
needs of modelling, the following sets were defined:

- tasks performed by city logistics,
- the organization that represents the way in which trips are realized and manner in which the travel flow is distributed.

The model of city logistics an formally be written as an arranged four in the following form:

$$MLM = (ZS, SL, ZR, OR).$$

On the stage of an organization of travels in the urban area, single-modal travel was distinguished, where there is no possibility to change the transport subsystem (e.g. travelling by car). Another travel type is a double-modal travel, where it is possible to change the transport subsystem (e.g. travels in Park&Ride system). For practical purposes, all trips were numbered and recorded in the form of a set of the numbers of single-modal travel:

$$HJ^p_j = \{h_j^{p_i} = 1, 2, ..., H_j^{p_i}\}, \quad p_j \in PJ, \; PJ = \{1, ..., p, e, ..., P, E\},$$

and set of the numbers of double-modal travel:

$$HD^{pd} = \{hd^{pd} = 1, 2, ..., HD^{pd}\}, \quad pd \in PD, \; PD = \{1, ..., p, d, e, ..., P, D, E\}$$

where: $PJ$ set of the numbers of types single-modal travel, while $PD$ set of the numbers of types double-modal travel.

A travel in the urban area is a chain of relocations (connections) identified as the stages of the travel. For the needs of modelling, the following sets were defined:

- a set of all the stages that belong to single-modal travel:
  $$LHJ(h_j^{p_i}) = \{(s, s') \in LP\}, \quad h_j^{p_i} \in HJ^p_j,$$

- a set of connections in the transport network in the urban area that belong to single-modal travel:
  $$LSHJ(h_j^{p_i}) = \{(s, s') \in LT\}, \quad h_j^{p_i} \in HJ^p_j,$$

- a set of all the stages that belong to double-modal travel:
  $$LHD(hd^{pd}) = \{(s, s') \in LP\}, \quad hd^{pd} \in HD^{pd},$$

- a set of connections in the transport network in the urban area that belong to double-modal travel:
  $$LSHD(hd^{pd}) = \{(s, s') \in LT\}, \quad hd^{pd} \in HD^{pd},$$

where:

- $LP$ a set of connections of the structure of the city logistics system that occur between initial and through points,
  $$LP^r = \{(p, n^r)\}, \quad p \neq n^r, \; p \in P, \; n^r \in N^r, \quad r \in R,$$

- $R$ a set of the numbers of transport subsystems,
  $$R = \{r: \quad r = 1, 2, ..., r', ..., R\},$$

- $N^r$ a set of the numbers of the through points of $r$-th transport network,
  $$N^r = \{n^r_e\}, \quad e = 1, 2, ..., e', ..., E(r), \quad r \in R,$$

- $LT$ a set of transport network connections,
  $$LT = \{(s, s') \in PS\},$$
3. ASSESSMENT CRITERIA OF THE CITY LOGISTICS MODEL

Seeking a solution to a decision issue requires an acceptance of an appropriate criterion function. This function will constitute a decisive criterion as to which permissible decision is the optimal decision. In the study, travel costs constitute the proposed criterion. Total generalized travel costs and total external travel costs are the components of the accepted assessment criterion. Total generalized travel cost is the cost that is directly borne by passengers. Total external costs are borne by society in the scale of the town, country and continent. All the costs are the result of the realization of single-modal and double-modal travels in towns. We assume that travel costs \( KPM \) are presented as the sum of costs, i.e.:

\[
KPM = CUK + CKZ,
\]

3.1. Total generalized travel costs

On the stage of the determination of the travel costs, the notion of the generalized travel cost will be used. The accepted notion enables one to take into consideration all the factors which present a value to the passenger, including costs formulated in a financial form (e.g. the ticket cost, the cost of fuel) as well as in another form of equivalent values (e.g. waiting time, travel time). Taking into consideration the individual nature of the individual types of travel, the following travel costs were defined:

- **generalized cost of single-modal travel**:

\[
KU^{hjp} = \sum_{(s,s') \in LH_jhjp} k_u^{(s,s')} + \sum_{(s,s') \in LSH_jhjp} k_b^{(s,s')} + \sum_{y \in Y} kd^{y,hjp},
\]

- **generalized cost of double-modal travel**:

\[
KU^{hdpd} = \sum_{(s,s') \in LHD_{hdpd}} k_u^{(s,s')} + \sum_{(s,s') \in LSHD_{hdpd}} k_b^{(s,s')} + \sum_{y \in Y} kd^{y,hdpd},
\]

where:

- \( k_u^{(s,s')} \) - generalized unit cost of the relocation of the travel stage \((s,s')\), which is an element of travel \( h_j^{p} \) or \( h_{dpd} \) perceived by the \( u_o \)-th user of the urban area,

- \( k_b^{(s,s')} \) - unit cost of the relocation of the travel stage \((s,s')\), which is an element of travel \( h_j^{p} \) or \( h_{dpd} \), that constitutes a cost to the \( u_o \)-th user of urban area in the case of the realization of relocation in the \( y \)-th manner,

\( UO \) - a set of the numbers of urban area users, \( UO = \{1, \ldots, u_o, \ldots, UO\} \),

\( PS \) a set of numbers of the points of the activeness of users in the structure of the city logistics system,

\( PS = \{s: s = 1, 2, \ldots, s', \ldots, S\} \),

\( P \) a set of the numbers of the initial points, \( K \) a set of the numbers of the final points, \( N \) a set of the numbers of the through points,

\( P = \{s \equiv p: s \in S\}, \quad K = \{s \equiv k: s \in S\}, \quad N = \{s \equiv n: s \in S\} \),

\( LT \) a set of connections of the city logistics structure that occur between through and final points,

\( LK_r = \{(n^r_v, k): n^r_v \neq k, k \in K, n^r_v \in N^r, \quad r \in R, \) \]

\( LN_r = \{(n^r_v, n^r_v): e \neq e', n^r_v, n^r_{v'} \in N^r, \quad r \in R. \) \]
Element of travel

Factors. As a result, the unit generalized cost of relocation on the accepted stage of travel of the specified attributes was taken into consideration in the form of the appropriate values of equivalent nervousness, tiredness etc. can diversely be perceived by urban area users. The diversity of the perception each stage of the travel possesses specified attributes which, depending on various factors (time of the day, weather, etc.) can be perceived by urban area users. The diversity of the perception each stage of the travel possesses specified attributes which, depending on various factors (time of the day, weather, etc.) can be perceived by urban area users.

When we take into consideration the structure of the travel flow in a given urban area, the following total generalized costs of single-modal travel:

\[ C_{KU}^{hj^p_j, h^d_{pd}} = \sum_{(s,s') \in L_{hj^p_j}} \sum_{u \in U \times O \times T} \left( k_{u_{wo}}^{(s,s')} \cdot x_{1_{u_{wo,t}}}^{hj^p_j(s,s')} \right) + \sum_{(s,s') \in L_{hj^p_j}} \sum_{y \in Y} \left( k_{d^y_{wo}}^{(s,s')} \cdot x_{1_{u_{wo,t}}}^{h^d_{pd}(s,s')} \right) \]

where:
- \( YP \) - a set of numbers of the manners of relocations, \( YP = \{1, ..., y, ..., Y\} \),
- \( Y \) - a set of numbers of additional travel costs, \( Y = \{1, ..., y, ..., Y\} \),
- \( kd_{d^y_{wo}}^{Y, h^d_{pd}} \) - additional unit \( y \)-th cost connected with the realization of \( h^d_{pd} \)-th double-modal travel,
- \( k_{d^y_{wo}}^{Y, h^d_{pd}} \) - additional unit \( y \)-th cost connected with the realization of \( h^d_{pd} \)-th double-modal travel.

Each stage of the travel possesses attributes which, depending on various factors (time of the day, weather, etc.) can be perceived by urban area users. The diversity of the perception each stage of the travel possesses specified attributes which, depending on various factors (time of the day, weather, etc.) can be perceived by urban area users.

When we take into consideration the structure of the travel flow in a given urban area, the following total generalized costs of single-modal travel can be determined, i.e.:

- total generalized costs of single-modal travel:
  \[ C_{KU}^{hj^p_j} = \sum_{(s,s') \in L_{hj^p_j}} \sum_{u \in U \times O \times T} \left( k_{u_{wo}}^{(s,s')} \cdot x_{1_{u_{wo,t}}}^{hj^p_j(s,s')} \right) + \sum_{(s,s') \in L_{hj^p_j}} \sum_{y \in Y} \left( k_{d^y_{wo}}^{(s,s')} \cdot x_{1_{u_{wo,t}}}^{h^d_{pd}(s,s')} \right) \]

where:
- \( x_{1_{u_{wo,t}}}^{hj^p_j(s,s')} \) - the size of the single-modal travel flow,
- \( x_{2_{u_{wo,t}}}^{h^d_{pd}(s,s')} \) - the size of the double-modal travel flow,
- \( T \) - the set of the numbers of time intervals, \( T = \{1, ..., t, ..., T\} \),

Taking into consideration the above, the total generalized travel costs will constitute the sum of costs, i.e.:
\[ CUK = \sum_{h^p_j \in HJ} CKU^{h^p_j} + \sum_{h^d^p \in HD} CKU^{h^d^p}, \] 

(22)

### 3.2. Total external travel costs

The external travel costs mean negative environmental impacts of the travel. In research, external costs are determined for the individual manners of relocation and in particular for relocations realized by the means of transport. External costs resulting from the individual external effects, factors, i.e. costs of air pollution, costs of noise, costs of congestion etc. are identified. The individual values of costs are written in the form of the following vector:

\[ KZE = \{ kze_{st}^{e_{zk}(s,s')} \}, \quad kze_{st}^{e_{zk}(s,s')} \in \mathbb{R}^+, \quad e_{zk} \in EZK, \quad st \in ST, \quad (s,s') \in LSH(h), \quad h \in H. \] 

(23)

where:

- \( kze_{st}^{e_{zk}(s,s')} \) it is the cost of \( e_{zk} \)-th external effect that occurs in connection with the relocation of the accepted travel stage \( (s,s') \) by \( st \)-th means of transport,
- \( ST \) a set of the numbers of the means of transport,
- \( EZK \) a set of the numbers of external effects,
- \( EZK = \{ 1, ..., e_{zk}, ..., EZK \} \),
- \( H \) a set of the numbers of travel,
- \( H = \{ 1, ..., h, ..., H \} \),
- \( LSH(h) \) a set of connections in the transport network in the urban area which belong to travel \( h \),

\[ LSH(h) = \{ (s,s') : \quad (s,s') \in LSH(h^p_j) \cup LSHD(h^d^p) \}, \quad h \in H. \] 

(27)

On this basis, we interpret the external costs for the individual types of travel as:

- external costs of single-modal travel:

\[ KZ^{h^p_j} = \sum_{(s,s') \in LSH(h^p_j)} \sum_{e_{zk} \in EZK} kze_{st}^{e_{zk}(s,s')}, \quad kze_{st}^{e_{zk}(s,s')} \in KZE, \quad h^p_j \in H^p_j, \] 

(28)

- external costs of double-modal travel:

\[ KZ^{h^d^p} = \sum_{(s,s') \in LSHD(h^d^p)} \sum_{e_{zk} \in EZK} \sum_{st \in ST} kze_{st}^{e_{zk}(s,s')}, \quad kze_{st}^{e_{zk}(s,s')} \in KZE, \quad h^d^p \in HD^d^p. \] 

(29)

When we take into consideration the structure of the travel flow in a given urban area, the following total external travel costs can be determined, i.e.:

- total external costs of single-modal travel:

\[ CKZ^{h^p_j} = \sum_{(s,s') \in LSH(h^p_j)} \sum_{e_{zk} \in EZK} \sum_{st \in ST} \sum_{uo \in UO} \sum_{t \in T} \left( kze_{st}^{e_{zk}(s,s')} \cdot x_{uot}^{h^p_j(s,s')} \right), \quad h^p_j \in H^p_j, \] 

(30)

- total external costs of double-modal travel:

\[ CKZ^{h^d^p} = \sum_{(s,s') \in LSHD(h^d^p)} \sum_{e_{zk} \in EZK} \sum_{st \in ST} \sum_{uo \in UO} \sum_{t \in T} \left( kze_{st}^{e_{zk}(s,s')} \cdot x_{uot}^{h^d^p(s,s')} \right), \quad h^d^p \in HD^d^p. \] 

(31)
Taking into consideration the above, total external travel costs will constitute the sum of external costs generated by the individual types of travel in a given urban area:

\[
CKZ = \sum_{h_j^{\text{tr}} \in H} CKZ^{h_j^{\text{tr}}} + \sum_{h_d^{\text{tr}} \in H_D} CKZ^{h_d^{\text{tr}}},
\]

(32)

4. CONCLUSIONS

Optimal solutions in the area of the formation of city logistics require a comprehensive approach based on multi-criterion optimization. Taking into consideration the assumptions of the sustainable development idea, all the criteria which are essential from the perspective of various entities involved in the process of an analysis, formation and planning of city logistics can be divided into economic, environmental and social criteria. The present study focuses on the formal description of the economic partial criterion in the form of travel costs. This quantity reflects subjective perception of the nuisance of travelling in the urban reality. A reference was made to travelling costs, where the total generalized travel costs and the total external travel costs were determined as components.

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THE SPECIFICITY OF REVERSE LOGISTICS WITH AN EXAMPLE OF MOBILE TELEPHONY

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Abstract
The aim of article is to draw attention to the problem of reverse logistics of electronic products exemplified with mobile phones. This paper presents life cycle, the process of recovery and reverse logistics of electronic products exemplified with mobile phones. In the article the following hypothesis was formulated: artificial shortening of the life cycle of mobile phones increases the number of products used in the recovery process.

Keywords: Life cycle, reverse logistics, mobile phones

1. INTRODUCTION
Technological development and production of electronic devices shorten the period of their use and the formation of large quantities of post-consumer waste. The aim of this article is to draw attention to the problem of reverse logistics of electronic products exemplified with mobile phones. With such a posed purpose the following research question was formulated: what impact on the reverse logistics does artificial shortening of the life cycle of mobile phones have? In an attempt to answer such a specific research question, the following hypothesis was formulated: artificial shortening of the life cycle of mobile phones increases the number of products used in the recovery process. As justification for the subject of the paper, it is possible to point to some shortcomings in the field of theoretical analyses and empirical research in the reverse logistics of electronic products. Mobile phones are an example of electronic products, which significantly occur in the re-use market. It can be concluded that mobile phones are frequently reused than recycled. This paper presents life cycle, the process of recovery and reverse logistics of electronic products exemplified with mobile phones.

2. LIFE CYCLE OF ELECTRONIC PRODUCTS
The product life cycle consists of four phases: introduction on the market, increase of product sales, product maturity and the product end (Figure 1). The length of the particular phases of the product life cycle as well as the entire life cycle depend on its type. Electronic products are characterized by constant technical and technological changes, as well as the ability to meet the new needs of buyers.

Figure 1 Life cycle of a product
Due to the continuous improvement of electronic products, both individual phases of the product life cycle and the whole cycle become shorter. A good example of electronic products are mobile phones. Mobile telephony market is characterized by a high level of saturation and the growing number of operators and consumers. It can be said that already in the maturity phase of mobile phone a new model occurs (Figure 2). In this way the life cycle of mobile phones shorten. All companies whose activity is the manufacture of mobile phones can exemplify that, such as Apple's iPhone and Samsung Galaxy. These companies constantly add new features to the phone user.

![Figure 2 Life cycle of mobile phones](image)

The shortening of product life cycle has now become, in stable condition market structures, one of the most important elements of the strategy development of both manufacturing and commercial companies. They are based on generating profits in line with the principle of ‘high turnover at low profit margin, which is not totally consistent with the principle of fairness of manufacturers and traders’. Factors which force customers to make purchases more frequently are, among others: manufacturers conspiracy, technological similarity of products, the lack of market transparency from the viewpoint of clients, shrinking population of rich societies and finally - demand saturation [1].

Technical differentiation of available products, however, is so large that there must be properly diversified methods of shortening their life. Basically they can be divided into two groups associated with the planned acceleration of technical and moral (psychological) use. The methods of shortening product life can be divided into two groups, due to technical wear and moral wear [1].

The most common methods of accelerating technical and electronic wear of products include, among others:

- breaking connection of components,
- use of poor quality or undersized components in electronic circuits of processors,
- bonding of housings, for example in mobile phones, which is designed to prevent access to the interior and thus, in practice, impossible to repair,
- inflating the prices of spare parts or decreasing their availability,
- introduction of new products technically incompatible with the earlier models,
- fitted cycle counters (e.g. in computer printers, batteries of mobile phones and portable computers) [1].
According to specialists, in the electronic industry devices are aging even faster. Some experts noted the rapid evolution of Apple’s iPhone model. The first model of 2007 did not have what many competitors had, e.g. GPS, possibilities of making films, sending MMS, it did not support a connection to a network of third-generation (3G). Those imperfections were eliminated in the next two versions of the iPhone. The S. Jobs’ motto, the president of Apple Inc. was: ‘it would be best if every year people bought the new iPhone’ [2]. Thus, consumers wishing to purchase a new mobile phone model shorten the product life cycle. The methods that have an impact on the purchase of new equipment include, among others:

- connecting the brand with scientific, moral authorities and likeable celebrities who give their support not out of conviction but for a fee,
- apparent change of products usability which consists of a simple e.g. made from the software - Firmware - built-in device called firmware that provides the basic procedures for its operation,
- improvements to the software update by placing a flash memory or EEPROM (Electrically-Erasable Programmable Read-Only Memory),
- reducing the number of entries and deletions of memory, depending on the type and manufacturer, which ranges from 10 000 to 1 000 000 cycles, when exceeding this value memory fails,
- unlocking in newer or more expensive versions of the product some of the features that physically existed in the previous version, often in new products such technical parameters are changed that do not actually give users any new opportunities.

3. LOGISTICS PROCESSES OF ELECTRONICS RECOVERY

According to the definition by S. Krawczyk, process creates a set of activities related to time and space relationships and technology-based logic that gives it a structure of a partially ordered set and allows to distinguish direct and indirect links transfer, implemented in order to achieve the intended result, performed in accordance with specific rules, including various internal and external factors that can promote or hinder the process. Processes of logistics however are the processes to support the production of the product, requiring coordination with both the basic manufacturing process as well as between them, form a group, which are dealt with in the framework of logistics [3]. Therefore, recovery processes are those processes that support the coordination of actions after the product life.

The standard examples dealt with processes in which actions lead to a product having value for the user receiving it, if the recovery actions involve dismantling and acquiring part of the product (raw materials, components).

The publications based on the definitions of reverse logistics are oriented to demonstrating the possibility of increasing the degree of recovery of recyclable materials from waste streams [4]. In the literature the term reverse logistics is translated often wrongly as return logistics however, it is assumed that this means the logistics of recovery [5].

Reverse logistics is defined as the process of planning, implementing and controlling an effective and cost-efficient flow of secondary material within the supply chain and information associated with these commodities in the direction opposite to the direction of flow in the traditional supply chain to recover the value or proper development [6]. Reverse logistics puts an emphasis on the recovery of the value inherent in the product or packaging [7]. Logistics in the traditional sense involves moving raw materials to manufacturers and products to end customers. After delivering the product to the final customer, that is the moment when it reaches the place of destination and use, the primary logistics process ends and thus another processes begin called return processes. These processes result, among other things, from product returns, their use and service, and at the end of compulsory development after the withdrawal from use [8].
Since decommissioned electrical and electronic equipment is a material object, supporting operations for dismantling and sourcing components are known from the traditional logistics transport operations and warehousing coordinated with the entities forming so-called removal chain, thus [9]:

- place of formation of useless products, including waste;
- entities organizing the collection;
- entities engaged in segregation and landfill or recycler.

4. REVERSE LOGISTICS OF MOBILE PHONES

In recent years a mobile phone has become a common electronics device. The amount of produced and utilized phones causes that it is currently the subject of a significant impact on the environment. According to data cited by the US Federal Communications Commission, the first mobile phone was introduced to general public in 1983 by Motorola's DynaTAC. Twenty years later, it was sold worldwide more than 1.2 billion items of phones within a year [10]. In recent years it has been possible to see some stabilization of sales, which in 2013 was estimated at 1.8 billion items [11]. According to the report of Ericsson Mobility the number of active phones in 2014 amounted to about 7 billion [12].

In addition, the abrupt technology and usage changes of mobile phones should be considered, which are signalled even by calling them Smartphone or iPhone. While users appreciate features offered to them, which is the software, so much in our perceptions we look at the composition of the material, preciousness used in the production of materials and the possibility of their recovery after use of the phone.

To be aware of the economic potential of the recovery of materials from which the mobile phone is produced, it is sufficient to take into account that its composition is:

- plastics - 56%
- metals - 25%, including copper - 15%, iron - 3% aluminium - 3% nickel - 2% and other rare metals (gold, silver, platinum, palladium) - 1%
- glass and ceramics - 16%
- other materials - 3%.

Percentage indications should be complemented by quantitative data. It is estimated that - of course depending on the phone model - with one item there can be recovered about 9 grams of copper, 150 milligrams of silver, 25 milligrams of gold, as well as small amounts of platinum and palladium. It is therefore estimated that sales in 2013 of 1.8 billion items of the phone gives at least 280 tons of silver, 25 tons of gold, 10 tons of palladium and 16 000 tons of copper, of which only less than five percent was recovered [13]. The reported figures clearly suggest that the mobile phone sector deserves more perspicacious attention both from the point of view of marketing as well as operations on products withdrawn from use.

In the case of mobile phones the removal chain should take into account highly skilled sourcing of rare materials and dangerous for human health and the environment. The awareness of the presence of such materials suggest that in places where segregation is made there should be employed workers with the right skills in the field of handling hazardous materials.

Taking into account the hierarchy of worn mobile phones, it is possible to distinguish the following phases and corresponding tasks:

- re-using,
- re-producing, creating seamless logistics chains for components subjected to the process of repair or regeneration,
recycling, creation of an efficient system of sorting, collecting and receiving used goods and their components in the recycling system,
- storage, creating an effective system of sorting, collecting takeback goods and their components, and transport to landfills or recycling station [4].

The diagram of recovery processes shown in Figure 3 presents flows of the used mobile phones according to the above phases.

According to the Package of closed-circuit economy adopted on 2 December 2015 by the European Commission in re-use, re-manufacturing and repair sectors, the cost of re-generation of mobile phones would be about half that if it would be easier to break them into parts and if it would be possible to collect 95 % of used mobile phones, it could bring savings in material costs in the amount of over 1 billion euros’. The Commission shall take the initiative in a number of areas that will be aimed at the promotion of products that can be more to repair: in the context of future work relating to new or revised implementing measures on ecodesign. The application of standardization for efficient use of materials in the framework of ecodesign includes work on standards to facilitate carrying out repairs (2019.) The Commission is preparing a programme of independent research on issues related to the practice of the potential deliberate shortening of product life cycle [14]. The environmental awareness of enterprises and population is growing. However, giving mobile phones to special points is not the only solution. It is essential to re-use as them an option. According to the 3R principle (Reduce, Reuse, Recycle - in Poland it is a 3U principle (avoid buying unnecessary things, use again, dispose) - electro-waste can be reused. On the market there are many companies receiving broken, unwanted mobile phones. This reduces the scale of environmental pollution due to harmful emissions generated in the production process as well as due to the accumulation of waste.

Figure 3 Diagram of recovery processes of mobile phones

The reuse of telephones saves valuable and scarce raw materials. Specialised companies maintain collection and purchase of phones, taking not only efficient, but also wrong items. They are managed in a fully controlled and environmentally friendly recycling or recovery process. A high number of acquired phones after improvement and possible repairs is re-used, mainly in the markets of developing countries, where the barrier is access to telecommunications technologies most often caused by a too high price of new phones. Mobile phones, which are not suitable for re-use, are recycled in an environmentally safe way.
5. CONCLUSION

The benefits of reverse logistics is certainly an impact on human health and the environment, which will not be exposed to toxic substances and elements included in this type of waste as mobile phones. Plastics, glass, metals, including precious metals, some substances can be re-used. Electrowaste is the fastest arriving type of waste. Thanks to its recovery and partial re-use of resources we save valuable space that could be used for its storage. The companies included in the repair, renewal and disposal market of mobile devices recovered from the repayment of warranty and post-warranty schemes and in Europe offer a refund of after leasing or damaged mobile phones, tablets and other mobile devices, renewing and re-utilization, which results in lower costs. It should be noted that any discoveries and achievements of man in time are translated into the current economic life, transforming them significantly. Reverse logistics is the answer to such transformations [5]. Due to a shortening life cycle of mobile phones more and more used products go to recycling and thus more and more raw materials, semi-finished products are involved in the process of reverse logistics.

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TIMETABLING PROBLEM AND INTERVAL SYNCHRONIZATION IN URBAN PUBLIC TRANSPORT

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Abstract

The paper is devoted to the timetabling problem and interval synchronization in urban public communication, which is considered as an important issue in urban transport networks with long overlapping route segments. The main objective of interval synchronization is to determine the timetable of lines sharing route segments, so that the waiting time between arrivals of consecutive buses can be balanced. Although the experts agree on the objective, different approaches to the interval synchronization problem in urban public communication can be observed. In this paper approaches to this problem are reviewed from the perspective of specific goals adopted, models developed for the problem, and methods used for solving them.

Keywords: Interval synchronization, public transport, city transport, timetabling problem, transportation planning

1. INTRODUCTION

Interval synchronization of lines can be considered as a crucial issue in urban public transport (UPT) networks with long overlapping route segments. UPT systems with long overlapping route segments are becoming more often observed as metropolitan areas and agglomerations grow and include suburban residential areas into their territorial administration. Significantly huge mass of people travel every day from home to work and back, and they need to be provided with efficient, comfortable, and robust collective transport, so that they have a real alternative to private cars. Leaving private cars at home and switching to collective transport result in reducing emission, noise, and traffic congestion. Therefore, providing efficient collective transport service is listed among priorities of sustainable urban mobility paradigm [17, 18, 19, 21, 22, 25, 27, 28, 29, 30, 31, 32]. No matter what type of metropolitan or urban public transport network is adopted in modern megapolises, there are route segments - usually considerably long ones - linking ends of the network (e.g. park & ride hubs) with stops of the ring line in the downtown or with intermodal transfer hubs. When such long route segments are served by more than one line, there appears the need to avoid bus (or tram) bunching and to make the waiting time between consecutive arrivals of any line evenly-spaced [4, 7, 16, 20, 24]. That need can be considered to be the foundations of the interval synchronization problem in UPT.

The substantial literature and optimization models for interval synchronization problem in UPT seems to be scarce, e.g. [6, 8, 9, 16, 24], in contrary to transfer synchronization problem, which is investigated more frequently, e.g. [1, 2, 5, 11, 15, 17, 18, 19, 21, 22, 23]. The main objective of interval synchronization in UPT is to determine the timetable (usually departure time from the first stops) for lines sharing route segments, so that the waiting time between arrivals of consecutive buses at a shared stop can be balanced and bus bunching can be avoided. Although the experts agree on the general objective, different approaches to dealing with interval synchronization problem in urban public communication can be observed.

In this paper selected approaches to interval synchronization problem are reviewed from the perspective of specific goals adopted, models developed for the problem, and methods used for solving them. The paper is organized as follows. We begin with general description of the interval synchronization problem in UTP; we provide the review of formulations of this problem. We put the emphasis here to the importance of interval synchronization in the bigger timetabling and UTP synchronization problems which cover also other aspects
of UTP planning. Next, we provide a review of optimization models for interval synchronization problem in UTP. For works, where optimization models for interval synchronization were not presented, we reviewed conceptual models on which algorithms for timetabling generation were based. In conclusions, we collect recommended directions of the interval synchronization problem in UTP development as well as suggested methods to be used for solving this problem in the near future.

2. INTERVAL SYNCHRONIZATION IN URBAN PUBLIC TRANSPORT

Interval synchronization problem in UPT can be defined as finding departure times of all trips of all lines which share overlapping route segments, in order to make time gaps between their arrivals at stops belonging to the shared segments as even as possible. Specific character of interval synchronization can be easily observed when compared to transfer synchronization [1, 6, 16, 24]. In Figures 1 and 2 we present scratches of network segments, where interval (Figure 1) and transfer (Figure 2) synchronization is needed. In interval synchronization are interested passengers whose origin and destination belong to the long route segment served by several lines. These passengers can travel with any line serving the route segment, so they do not follow the timetable of lines. The worst synchronization here is the one resulting in bus bunching, while the best timetabling is the one which makes passengers remember only one number - time gap between consecutive arrivals. Interval synchronization becomes even more important at overlapping long route segments served by lines of small ride frequency (e.g. 3 rides per hour); in such case bus bunching results in considerably long waiting time between consecutive bunches. Therefore, the goal of interval synchronization is to obtain even (what is hardly possible) or almost even time gap (the interval) between two consecutive arrivals at the shared stop. Interval synchronization depends significantly on other assumptions - flexible / fixed headways, ride frequency, number of lines to be synchronized etc.

![Figure 1](image1.png)

**Figure 1** A long route segment where interval synchronization in UTP is needed. Source: [6]

![Figure 2](image2.png)

**Figure 2** A transfer node where transfer synchronization in UTP is needed. Source: [6]
The main visible result of interval synchronization is preventing buses from bunching. It is typical for long route segments served by more than one line that buses arrive at shared stops simultaneously or almost simultaneously. And it is not caused by traffic congestion, the timetable is just like that - because the timetable was synchronized globally for the whole network according to the superior objective was transfer synchronization at transfer hubs, and timetable at long radial segments was obtained as a consequence of that synchronization. Another result of interval synchronization is the increase of regularity and punctuality of public transport service at long route segments as well as at the entire network. Once time gap between consecutive arrivals at a given stop is even or almost even, the maximal time gap between consecutive arrivals at this stop also decreases. In consequence the distribution of passengers in vehicles serving the stop is more balanced, the number of overcrowded vehicles decreases, and, comfort of travel increases [5, 6].

Interval synchronization problem in UPT is not frequently addressed directly in work on UPT synchronization and timetabling problem - detailed reviews of synchronization and timetabling problems in UPT are to be found in e.g. [3], [6], [10], and [12]. Interval synchronization is reduced to bus bunching problem and if a model or a method developed for transfer synchronization prevents buses from bunching, the model / method seems to be considered as well enough for dealing with synchronization at long overlapping route segments [1, 16, 20]. However, these methods do not reach the main goal of interval synchronization: arrivals at shared stops are not evenly spaced in time - it may happen for numerous datasets, but it does not happen on purpose. In such models / methods the goal is to maximize the number of pairs of arrivals of different lines between which time gap is greater than a predefined value [4, 13, 14, 15, 16].

As interval synchronization aims at congestion avoidance, the main objective here is obtaining evenly-spaced intervals between arrivals of lines A and B as well as between arrivals of lines B and A. There are works where recommended interval is computed basing on lines' headways and then it is introduced to the model as a parameter [1, 24]. Obviously, this approach is correct for UPT systems with fixed headways, where headways are each other's multiplies [1, 24], and / or in systems with predefined precedence of lines serving shared overlapping route segment [24].

3. MODELS FOR INTERVAL SYNCHRONIZATION PROBLEM IN URBAN PUBLIC TRANSPORT

[1] addresses interval synchronization problem in UPT very briefly. In order to obtain evenly-spaced timetable at the route segment served by one line it is recommended to set and executed fixed headway during the planning period. Fixed headways are also recommended for a group of line serving shared route sector; headways should be equal or be each other multiplies - synchronization cycle is determined by the longest headway. For this predefined sequence of lines, intervals between lines are computed basing on relation between headways. A non-linear programming model is briefly introduced. The objective here is to minimize the average waiting time. The author neither presents it in details nor specifies the algorithm used for searching for solutions.

The inspiration for [1] was [26], where synchronization problem was formulated as the quadratic semi-assignment problem and a tabu search algorithm was proposed for solving it. The model presented in [26] was the objective was to minimize the total transfer waiting time. Nevertheless, interval synchronization was also included in this model, since it also guarantees maintaining the security distances between vehicles sharing route segments.

[24] provides metaheuristics for interval simulation problem with fixed headways - despite the author declares that the model aims at obtaining evenly spaced timetable, the objective implemented in the model in minimization of the total waiting time. Results were obtained with a Monte-Carlo simulation combined with gradient descent.

Although minimization of the total of the average waiting time is an objective in numerous models for UTP synchronization problems, it does not seem to be the best choice. As interval synchronization aims at evenly
spacing arrivals over a planning period, time gaps are more likely to exceed than to shorten. More proper objective here would be rather to maximize the total number of consecutive arrivals between which time gap are equal or almost equal.

In [6] multiple-criteria mixed-integer linear models (MCMILP) - Model V and Model R - are presented. Objectives introduced to the models guarantee maximization of the total number of pairs of arrivals between which time gap is the same (Model V) or equal to the recommended interval (Model R), at the same time the total difference between actual headways and recommended headways is minimized, the total extension of average travel time between nodes is minimized. The non-dominated solution is computed subject to headway flexibility constraints, synchronization constraints, arrival and departure time constraints, and variable non-negativity and integrality conditions. The models cover a wide range of interval synchronization problems; they can be used for obtaining single planning period single node timetables as well as for multiple planning period multiple node networks where headways change between planning periods. In both models flexible headways during each planning period are allowed. Model V can be used for finding the optimal interval for a node, which means that in a node the highest number of pairs of subsequent arrivals of different lines are separated from one another by the optimal interval. Model R allows the scheduler’s intervention in the settings of synchronization: the scheduler defines the recommended interval as a parameter, and the total difference between optimal and recommended interval is minimized. Model R is useful especially for multiple node networks, where synchronization depends also on travel time between nodes, as having recommended interval as a parameter can force preferred interval at a chosen node. Model V and Model R determine the sequence of lines and synchronize trips, which is not typical for models dedicated to interval synchronization.

4. CONCLUSIVE REMARKS

Interval synchronization of radial lines is crucial for providing passengers with reliable collective transport service in networks with long overlapping route segments. Passengers traveling along a route segment served by several lines use so-called joint ride-frequency of the set of lines, so from their perspective a fixed separation time between consecutive arrivals would be perfect.

Due to scarcity of works addressing this problem directly, research in this area of interval synchronization problems in UPT should be continued. All the available models are suitable for simplified interval synchronization problems. A survey on the impact of interval synchronization on other subproblems of urban transport planning and managing on the timetabling problem [4, 12]. Advanced research on models containing precedence constraints [6] should be continued, since it seems to be promising direction for interval synchronization problems. Another direction of development of the interval synchronization problems in UPT is to conduct research with multiple planning periods, where ride frequencies can be different in every planning period [4, 6, 13, 29]. Two issues are faced here: determining the length of a planning period and assuring smooth transition between periods, especially in systems where flexible headways are allowed.

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SEGREGATION OF PACKAGING WASTE AS AN ELEMENT OF ECO-LOGISTICS

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Abstract

Typical logistic process concerns actions which relate to product delivery to the customer. New approach to environmental protection, especially sustainable development concept forced another step, e.g. after their used, goods move from the customer to the distributor or to the manufacturer who has to organize shipping not only of the defective product, testing the product, dismantling, repairing, but also, what is important in this case, recycling or disposal of used product. It is very important especially in the case of packaging. Packaging should follow the 3R's hierarchy: reduce, reuse, recycle. Reusable packaging systems require a closed-loop logistics system. The first step of this logistic system is well organized segregation of packaging. To achieve good segregation people should be aware of problem with packaging waste. In Poland, like in other countries of European Union, waste segregation, not only packaging waste, is demanded. In the paper process of packaging waste segregation in Poland, connection with eco-logistics and reverse logistics, its organization in Poland were presented.

Keywords: Packaging waste, segregation, eco-logistics, reverse logistics, environmental awareness

1. INTRODUCTION

When shopping, together with target products, customers buy the packaging. This package is designed to protect the product during transport, facilitate its storage and provide information about the product, its content, manufacturer, or expiration dates. Unfortunately, after removing the product from the packaging, this packaging becomes waste. Most manufacturers, selecting packaging for their products, should take into account, which material was used to produce this packaging and whether they can recycle it and reuse it.

Appropriate segregation of garbage and waste is not tiring task, and most of the packaging waste, e.g. glass, paper, plastic and metal, is a valuable source of secondary raw materials, which, when properly sorted, can be recycled and reused. This allows to save natural resources, energy, and reduce the amount of waste in landfills, which consequently can reduce the negative impact on the environment. Selective collection of packaging waste also reduces fees for garbage disposal, which in turn reduces the cost of living.

To make re-use of packaging waste or its recycling possible, there is properly organized logistics system based on eco-logistics and reverse logistics needed. There is a need of properly prepared containers for different types of packaging waste, but also properly organized reception of such sorted waste [1,2].

In the paper process of packaging waste segregation in Poland, connection with eco-logistics and reverse logistics, its organization in Poland were presented.

2. PACKAGING AND WASTE PACKAGING

According to the Act on packaging management and packaging waste, the packaging is defined as "products placed on the market, made of any materials, intended for the storage, protection, transport, delivery or
presentation of any product, from raw materials to already processed goods” [3]. So understood packaging according to this Act includes [3]:

- packaging unit, for transmitting the product to the user in the place of purchase, including also consumption product, such as disposable dishes,
- multipacks containing multiple unit packages of products, regardless of whether they are transmitted to users, or are transmitted to selling points, that can be removed from the product without compromising its features,
- transport packaging, used to transport products in packaging unit or multipacks in order to prevent damage, with the exception of containers for transport by road, rail, water or air.

Product packaging aim is to encourage potential customer to buy the product. It contains information about the name of the product, its composition, producer, expiration date. It is responsible for protection of the product from the damage and helps the customer to transport this product to home. Due to the need to protect the environment, and thus the need to use recycled materials, also product packaging should be recycled and reused [4].

Definition of the packaging waste was also included in the Act on packaging management and packaging waste by packaging waste. According to this Act by packaging waste it can be understood “all packaging including reusable packaging withdrawn from the re-use, constitute waste within the meaning of the waste legislation, with the exception of waste generated in the production of packaging” [3].

3. REVERSE LOGISTICS AND GREEN LOGISTICS

Packaging should follow the 3R's hierarchy. The first R as reduce. Packaging should be reduced prior to the manufacturing stage, by designing and marketing products for the first "R". This means reducing the number of layers, materials and toxins at source. The second R as reuse. Packaging should be designed to be reusable, refillable, returnable and durable to the greatest extent possible. The third R as recycle. Packaging should be designed to be recyclable and/or made with recycled content.

Logistics of reusable packaging is becoming more and more popular. Disposable containers most often used in trade, transport, manufacture or storage of product, produce consistently high costs associated with their acquisition, disposal and forwarding. Such packaging has also a greater impact on the environment [5].

Logistics packaging waste is based on two types of logistics: eco-logistics and reverse logistics. Therefore both concepts in relation to the waste should be defined.

Eco-logistics can be defined as the realization of optimal solutions in the area of the collection, removal and direction to recycling or liquidation of various types of wastes that are characterized by a high negative impact to the environment and society [6]. Eco-logistics as an integrated system can be described as follows [7]:

- It is based on the concept of the management of the re-circulatory flow of material streams in the economy and the flows of information related to them.
- It guarantees the readiness and ability of an effective planning of segregation and processing as well as recycling of waste according to the accepted process rules and also technical and technological rules that fulfill the standardizing requirements and environmental protection rules.
- It facilitates decision making on technical and organizational levels with the aim of a minimization of the negative effects of the environmental impact that accompany the realization of the processes of supply logistics, re-engineering production, the logistics distributions and servicing in the logistic chains of supplies.

Within eco-logistics, the eco-logistics of packaging waste has a special place, because waste due to its ever-increasing quantities creates recently a growing threat to the natural environment [8].
With eco-logistics is related reverse logistics. Reverse logistics according Dowlatshahi is [9] is a process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, remanufacturing or disposal. Meaning of the reverse logistics in comparison to normal, forward logistics is presented in Figure 1. The reverse logistics is increasing and will only increase more in the future due to reusable and returnable packaging, and logistics chains need to be able to adapt to this increase [10-11].

![Figure 1 Logistics and reverse logistics [12]](image)

4. PACKAGING WASTE SEGREGATION

According to the Central Statistical Office in 2014 average resident of Poland has produced 268 kg of household waste. It was one of the lowest ratios among European countries. The countries that produce the largest quantities of waste are: Japan (one resident produces 1000 kg household waste per year) and the USA (864 kilograms per capita). In Europe, most waste in 2013 were produced in Denmark (747 kg), Cyprus (624 kg) and Germany (617 kg). Average European citizen produces annually approx. 481 kg of waste [13].

In 2013, 156.9 kg of packaging waste was generated per inhabitant in the EU-28. This quantity varied between 46.7 kg per inhabitant in Croatia and 210.4 kg per inhabitant in Germany [14].

The first step in the use of packaging waste in accordance with the eco-logistics and reverse logistics is appropriate segregation of this type of waste. Segregation in Poland concerns not only packaging waste, but overall waste. However, the situation related to the use of waste in Poland is not as good as in other European Union countries. From the total amount of municipal waste in the EU 31% are disposed on the landfill, 27% was recycled. In Poland, it was respectively 53% and 21%. In Poland less waste was also burned or biological processed.

From the 4,846,080 tons of packaging placed on the Polish market in 2014 2,694,170 tons were recycled. Therefore Poland achieved almost 56% of recycling of the packaging waste. This is a correct level in comparison to the target level of recycling of packaging waste specified in the Act of 13 June 2013 on packaging management and packaging waste [13].
Legal regulations on packaging and packaging waste in Poland result from the legislation:

- Act of 11th May 2001 on obligations of entrepreneurs in term of management of certain waste and on product fee (OJ 2007, No 90, item 607, with amendments),
- Act of 13th June 2013 on packaging management and packaging waste (OJ 2013, item 888),

The regulation defines a specific way of dealing with packaging waste, including, among others, a method of collecting of the packaging waste made of: paper, glass, plastic, aluminum, steel, multi-material.

The Act amending the Act on maintaining cleanliness and order in municipalities and other acts introduces the need to segregate the municipal waste, including packaging of products purchased by residents of the municipality [15]. Thanks to this Act, more and more people separate waste, including packaging waste. According to the act all waste should be divided into paper, plastic, metal and glass. However, it is also acceptable used in many municipalities a simplified division into dry waste (recyclable), wet waste and glass.

It is possible to mention several ways, which can have effect on the reduction of the packaging waste:

- segregation of the packaging waste,
- processing of sorted waste,
- purchasing a smaller amount of products,
- selection of least packed products,
- selection of packaging that can be easy to process,
- actions aimed to reduce their volume and weight (e.g. reducing the weight of mass of glass packaging as a result of strengthening them by coating a solution of tin tetrachloride, titanium compounds or plastics),
- limitation of introduction of plastic bags on market.

Separate collection of the waste packaging goes in stages. At the beginning of the track there are households where residents, in accordance with the laws and municipal regulations, segregate all waste dividing it into so-called fractions. This is called "sorting at source". The most common solution is the system with three-fraction selection into mixed waste, dry segregated and glass. It should be emphasized that the best results in the recovery of secondary raw materials is obtained when there is carried out selective collection system with multi-fraction selection (e.g. glass, paper, so-called light fraction, i.e. plastic, cans, cartons for liquid food, wet fraction, i.e. organic waste, etc.).

Collection of the packaging waste from a manufacturer should be done in a selective manner with a separated individual types of packaging waste. All packaging waste must be submitted to further their recovery and recycling.

Packaging waste management and its objectives are presented in Figure 2. According to Figure 2 in the packaging waste management there are involved many groups of people. These are residents, usually consumers of products, manufacturers and suppliers of packaging and products but as well as public administration and units involved in direct management of this type of waste. The objective is not only the recovery of the waste at the level set by law, but above all, reduction of the risk to the environment throughout all life cycle of the packaging waste.

Recycling of secondary raw materials helps to reduce raw materials, which in turn contributes to the protection of natural resources of the earth. It also reduces the amount of space in landfills.
5. ENVIRONMENTAL AWARENESS

The most important element related to waste management, including packaging waste, is to change the attitude of society and to improve awareness in this regard. It is up to people to decide whether segregation take place. And this concerns not only households, habits which later have results into behavior at work, and therefore segregation of waste by different types of enterprises or other organizations.

It can be observed that new concept of environment awareness appears. This concept can be defined as: the extent to which residents are interested in the topic of the environment and its protection, what are their beliefs about the degradation of the environment and that have the knowledge of possible action to support its protection. Green behavior means activities positively affecting the environment, which can be taken by every man.

People in Poland are slowly beginning to increase their environmental awareness. Many people, not only in big the cities, began to segregate household waste, including packaging waste. Many people are interested in a material of which the packaging has been done, or if the packaging is recyclable and what they have to do with it after unpacking the product. An important element of packaging waste is a disposable bag. Since some time, lots of people, going shopping, take with them reusable bags.

To develop the environmental awareness there is a need of a proper knowledge management focused on this subject. It is the task of enterprises that sell their products in packaging. Such packaging shall include information not only about the product itself or the manufacturer, but also the packaging and how to deal with it. So there is need of proper education in the field of recycling in order to develop appropriate attitudes and behavior.

A pilot actions, appeals of authority and legal orders, that orient the actions and behavior of society, can be really helpful. Many people listen to famous people and trying to proceed in the same way. Environmental awareness is promoted also as an element of fashion which is followed by many people. Changing the mentality of society is an important step towards sustainable development and environmental protection.

6. CONCLUSION

New approach to environmental protection, especially sustainable development concept forced change of the attitude to packaging waste management. Now the manufacturer not only produces goods, has to organize
shipping of the defective product, testing the product, dismantling, repairing, but also, what is important in this case, has to organize recycling or disposal of used product and its packaging.

Logistics of reusable packaging is becoming more and more popular. Disposable containers most often used in trade, transport, manufacture or storage of product, produce consistently high costs associated with their acquisition, disposal and forwarding. That's why packaging waste management is so important in case of the enterprises.

We have to remember that suitable packaging waste management will reduce its number in the environment and save resources of the natural environment. We should note that this waste management is connected not only with enterprises. Also users of packaged products should pay attention to what they buy. Because it is a customer who decides in the end what happens to the packaging and packaging waste.

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ASSESSING LOGISTICS CUSTOMER SERVICE IN BUSINESS MANAGEMENT

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Abstract

The aim of the paper is to identify the area of logistics customer service in the selected company as the one determining market success of the surveyed business entity, particularly taking into account the level of the processes of logistics service in the opinion of the customers. The applied research method was the Servqual method which, among others, enabled the assessment and specification of the level of customer expectations towards the quality of the services provided by the enterprise. The specific objectives of the research were to diagnose the expectations of the customers in relation to ideal logistics service, compare the expectations with the provided level of service and determine the areas requiring changes in the company.

Keywords: Logistics customer service, the Servqual method, management

1. INTRODUCTION

The companies on the contemporary market will not achieve success if they ignore the needs of their customers. Therefore, appropriate customer service should be the priority compared to other strategic tasks [1]. All business entities, irrespective of production profile or service activity, cannot operate if they do not find customers who wish to use products or services provided by them [2].

The primary objective of the paper is to assess the logistics customer service in the selected company. The definitional approach to the concept of logistics customer service applicable in the research was adopted after R.H. Ballou [3], M. Christopher [4], D. Kempny [5], B.J. La Londe [6], P.M. Price and N.J. Harrison [7] as the skill or ability to satisfy the requirements and expectations of customers, mainly as for the time and place of the ordered deliveries while using all the available forms of the logistics activity, including transport, warehousing, management of inventories, information and packaging. The specific objectives of the research were to diagnose customers’ expectations in relation to the ideal logistics service, compare the expectations with the provided level of service and determine the areas requiring changes in the company.

2. METHODOLOGICAL BASES

The applied research method was the Servqual method [8], consisting in measuring differences between the quality perceived by the customer and the quality the customer expects from the specific service [9]. The research tool was the questionnaire consisting of three parts. Two parts consisted of 22 statements: the first one illustrated the expectations of the customers with reference to the specific service whereas the second one included the statements concerning the assessments of the service of the specific service provider. The third part was in the form of the statements aimed at the identification of the significance of five leading attributes of services for the customers by means of distribution of 100 points among the determinants. The responses were given on the seven-point Likert scale where 1 meant that the specific factor is of little significance and 7 that the factor is really significant.

For the purposes of the research, there was prepared the set of 22 questions, classified into 5 main categories which subsequently referred to: questions 1-4 - logistics infrastructure, questions 5-9 - reliability of deliveries, questions 10-13 - rapidity of service, questions 14-17 - competence, questions 18-22 - empathy.
The research was conducted in the company whose business profile is the sale and distribution of confectionary. Currently, the range of products of the company includes more than 50 items of different manufacturers. The company belongs to the group of small enterprises: there are 11 employees and its annual turnover does not exceed EUR 10 million. The headquarters is located in the medium-size city of Częstochowa in Southern Poland, the company serves the customers in the area of Częstochowa Poviat.

The assumed size of the representative research sample amounted to 80 units. To diagnose the level of satisfaction with the service 120 customers of the company were asked to express their opinion about the enterprise in terms of the services provided by the company. The survey was carried out by a traditional technique of collecting data via personal interviews performed by the interviewer using the paper questionnaire (PAPI method) and via e-mail.

3. RESULTS OF THE RESEARCH IN THE AREA OF THE EXPERIENCE AND EXPECTATIONS OF THE CUSTOMERS

The research conducted with the Servqual method [10] was subjected to the analysis in three areas: assessment (to emerge the elements rated the highest in the company irrespective of expectations), expectations (to identify the quality criteria most important for the respondents while using the services of the specific enterprise), the difference between expectations and experiences (to determine the quality features closest to the ideal and the weakest points of the range of services).

The arithmetic means of the obtained respondents’ responses to individual questions included in parts I and II of the Servqual questionnaire along with the overall score, i.e. the difference between the average of experiences and expectations are presented in **Table 1**.

**Table 1** The observations and expectations of the customers of the company towards logistics customer service

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>The average of experiences P</th>
<th>The average of the expected value O</th>
<th>Score P - O</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Possession of modern transportation and storage equipment.</td>
<td>4.75</td>
<td>5.58</td>
<td>-0.83</td>
</tr>
<tr>
<td>2</td>
<td>Explicitly formulated declaration of logistics service given to the customer information.</td>
<td>3.35</td>
<td>6.09</td>
<td>-2.74</td>
</tr>
<tr>
<td>3</td>
<td>Own means of transportation.</td>
<td>6.60</td>
<td>6.46</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>Convenient location.</td>
<td>5.13</td>
<td>5.45</td>
<td>-0.32</td>
</tr>
<tr>
<td>5</td>
<td>Fulfillment of complete deliveries.</td>
<td>5.07</td>
<td>7.00</td>
<td>-1.93</td>
</tr>
<tr>
<td>6</td>
<td>Striving for documentation free of errors.</td>
<td>5.55</td>
<td>6.98</td>
<td>-1.43</td>
</tr>
<tr>
<td>7</td>
<td>High availability of products from stock.</td>
<td>4.59</td>
<td>5.90</td>
<td>-1.31</td>
</tr>
<tr>
<td>8</td>
<td>Provision of services within the prescribed time limit.</td>
<td>5.14</td>
<td>6.62</td>
<td>-1.48</td>
</tr>
<tr>
<td>9</td>
<td>Clearly defined standards and principles of the complaint.</td>
<td>5.43</td>
<td>7.00</td>
<td>-1.57</td>
</tr>
<tr>
<td>10</td>
<td>Informing customers of any changes in the order.</td>
<td>5.42</td>
<td>6.78</td>
<td>-1.36</td>
</tr>
<tr>
<td>11</td>
<td>Delivering products with the frequency required by customers.</td>
<td>5.26</td>
<td>6.72</td>
<td>-1.46</td>
</tr>
<tr>
<td>12</td>
<td>Informing customers of the exact date of order provision by the staff.</td>
<td>5.39</td>
<td>6.72</td>
<td>-1.33</td>
</tr>
<tr>
<td>13</td>
<td>Responding to the reported customer needs by the staff.</td>
<td>5.14</td>
<td>6.81</td>
<td>-1.67</td>
</tr>
<tr>
<td>14</td>
<td>Assuring customers of the safety of the transaction.</td>
<td>6.59</td>
<td>6.96</td>
<td>-0.37</td>
</tr>
</tbody>
</table>
Nov 28th - 30th 2016, Poland, EU

The analysis of the individual questions of the questionnaire allows for the conclusion that in 95% the expectations of the customers concerning an ideal logistics service are not met by the company. Only in the case of the question about the possession of own means of transportation, the assessment of the facts exceeded the expectations of the customers in this field. This means that 3 trucks possessed by the enterprises fully satisfy the existing demand.

4. RESULTS OF THE RESEARCH IN THE AREA OF GAPS

The most important area of the interpretation of the conducted research is to characterize the gaps occurring between the perception and expectations towards the services provided by the company since poor assessment of the enterprise does not always mean the discontentment of the customer. The largest disproportion (-3.74) occurred in the case of the question about the delivery of damaged goods to customers, which reveals the commonly recurring deliveries with defects and forces customers to make the complaint and simultaneously wait for its consideration and the provision of new products. In this way, the company is exposed to the loss of customers but also significant costs associated with goods, re-transportation. Subsequently, the second position was taken by the explicitly formulated declaration of service given to the customer information - with the score of (-2.74). A large gap (-1.88) occurred with reference to the provision of services at the time convenient for each customer. Their standard service and order fulfillment takes place at 10 to 6 pm and on Saturdays only to 2 pm. Such a time slot does not appeal to bars and restaurants since they open at about 5 pm. Moreover, waiting time for unavailable goods is about 2 days. The completeness of deliveries was also low rated (-1.93), which means that the enterprise does not conduct full specification of the ordered goods.

The following were assessed positively: convenient location (-0.32), safety of transactions with the company (-0.37), possession of modern transportation and storage equipment (-0.83), high level of knowledge and competences of the staff (-0.99). However, it does not mean that the analyzed company fully corresponds with the expectations of the customers concerning the service in these areas. The arising minor disproportions can be reduced with minor expenditures to achieve higher rating in the listed areas. All the identified differences between the expectations of the customers of the company and their experiences in the cooperation with the entity are also presented in Figure 1.
The distribution of 100 points by the respondents among five dimensions of logistics customer service with the possibility to grant any number of points in a given area allowed to establish their relevance for the customers (Table 2).

Table 2 shows that the most important area in making an assessment of the quality of logistics service from the point of view of the customers turned out to be reliability of deliveries (24.83). It is characteristic though that all the dimensions were rated at a similar level, therefore they are equally important for those questioned. The maximum difference between the identified average ratings of the respondents amounted to 10.12. There was also calculated weighted average for all the diagnosed areas, indicated in Table 3.

Table 2  The relevance of the dimensions of logistics customer service in the opinion of the customers of the wholesaler

<table>
<thead>
<tr>
<th>The dimension of logistics customer service</th>
<th>The average rating of the respondents (weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Logistics infrastructure</td>
<td>19.02</td>
</tr>
<tr>
<td>2. Reliability of deliveries</td>
<td>24.83</td>
</tr>
<tr>
<td>3. Rapidity of service</td>
<td>23.19</td>
</tr>
<tr>
<td>4. Competence</td>
<td>20.86</td>
</tr>
<tr>
<td>5. Empathy</td>
<td>14.71</td>
</tr>
<tr>
<td>Sum of weights:</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3  Total weighted average for the Servqual

<table>
<thead>
<tr>
<th>The dimension of logistics customer service</th>
<th>Overall average for the dimensions (Σ P - O)/n</th>
<th>Weighted average ( (Σ P - O)/n)* weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Logistic infrastructure</td>
<td>-0.93</td>
<td>-17.83</td>
</tr>
<tr>
<td>2. Reliability of deliveries</td>
<td>-1.54</td>
<td>-38.23</td>
</tr>
<tr>
<td>3. Rapidity of service</td>
<td>-1.45</td>
<td>-33.62</td>
</tr>
<tr>
<td>4. Competence</td>
<td>-1.64</td>
<td>-34.21</td>
</tr>
<tr>
<td>5. Empathy</td>
<td>-1.49</td>
<td>-21.91</td>
</tr>
<tr>
<td>Sum of weights:</td>
<td></td>
<td>-145.8</td>
</tr>
<tr>
<td>Total weighted average:</td>
<td></td>
<td>-29.16</td>
</tr>
</tbody>
</table>
The data in Table 3 indicate that for all the diagnosed areas the weighted average showed negative values. This reveals the occurrence of discrepancies between the expectations of the customers and the actual satisfaction of their needs by the entity. The calculations indicate that the largest gap between the desired quality of service and the obtained one occurs in the case of the dimension of competence (-1.64), followed by the dimensions of: reliability (-1.54), empathy (-1.49), rapidity of service (-1.45), logistics infrastructure (-0.93).

The product of weights assigned to individual areas of logistics customer service and the average value for the statements in specific dimensions is the weighted average indicating the discrepancy between the actual situation and the customers’ expectations. The smaller the value for an individual area the greater the improvement actions are required. In the view of the above, most modifications must be carried out in the dimension of reliability, which recorded the lowest rating (-38.23), i.e. by 9.07 below the total average. The most favorable situation refers to logistics infrastructure of the company (weighted average -17.83), which requires little transformation and even it may be sufficient to provide a specific declaration of logistics service and transfer it to business partners.

5. CONCLUSION

The conducted research indicates that the achievement of a high level of logistics customer service is an extremely difficult task due to the multidimensionality of the issue requiring coordination, the integration of logistics and marketing and also due to difficult to achieve compatibility between the assessment of the desires of customers, the intentions of the enterprise, the actual implementation of the service policy, its reception by the customers and their actual desires [11]. Generally, it is concluded that the less restrictive the freedom and alternatives of the selection of different conditions of the transaction the higher the level of service from the perspective of the customers [12].

The analysis of the logistics customer service in the surveyed company revealed many irregularities which certainly determine its low position on the local market and annually the falling number of customers in spite of many advantages in the form of a wide range of products, modern technical equipment, experienced staff and the letters of recommendation from suppliers. The formulated service policy does not take into account the actual needs of the customers since it was developed without specific research in this field. The research conducted with the Servqual method among the customers of the company confirmed the above observation. The respondents, while describing their experiences, evaluated this factor the lowest. A significant gap appeared in the field of providing the customers with damaged goods, which reflects frequent defects in supplies and the need to initiate the complaint process. This factor particularly contributes to discontentment and dissatisfaction with business contacts with the company. The research indicated that the elements associated with the logistics infrastructure of the company directly associated with service do not play a significant role. Therefore, technical equipment does not count for the customers but what does is: accuracy, completeness, comfort, safety, an interest in solving the arising problems.

REFERENCES


SCHEDULING OF THE PRODUCTION PROCESS IN DENTAL TECHNOLOGY BASED ON THE GANTT CHART

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²Czestochowa University of Technology, Czestochowa Poland, EU

Abstract

The paper presents the graphically production planning in dental offices and technical laboratories. In the paper, the two typical scheduling tools, flow char and Gantt chart have been used. Charts allows to schedule tasks at the prosthetic restoration manufacturing process, thereby coordinating the work of the two cooperating departments: a dentist and technical laboratory. The importance of prosthetic restoration execution scheduling has been pointed and the stages which may arise delay of execution have been determined.

Keywords: Process scheduling, Gantt chart, prosthetic restoration, dental office

1. INTRODUCTION

The efficiency and effectiveness of each organization determines the ability to manage a number of processes and tasks, this refers to the various types of production and applies to all industry production [1-8]. That is why a group of new or modified projects require, above all, the use of methods that facilitate the management and enabling the completion of their implementation within the prescribed period. In management of not very large and not very time-consuming projects, especially in the stages of planning structure, often classic Gantt charts are used. The Gantt chart allows to proper plan and monitor of the project implementation. [9]. Production planning, supervision of order tasks, and minimize the time the operation is particularly difficult in the case of orders in the dental laboratory. Each prosthetic detail (dentures, bridge, veneer) or dental braces are treated as individual product (one-off project), the implementation of which is dependent on a number of special processes. The standard defines the so-called, special processes, as that of which the progress results can not be verified by subsequent non-destructive inspections and tests, or these which mistakes may be proven only during the use of the product by the customer. Due to the limited possibilities for their verification, supervision of such processes is subjected to specific requirements. According to data from the literature [10-13] in the process of individual production (dental restoration production) is required to have specialist knowledge, which guarantees precise requirements determination, and more ensure an appropriate level of quality. Production unitary is marked by a specific set of requirements for implementation. It should also Reed the processes, operations and equipment qualifications. During the producing process of prosthetic restoration or braces all parameters are negotiated individually with the client (patient), and dimensional parameters depend on the individual anatomy of the patient's mouth. This is connected with an individual approach to individual order. An additional factor is the fact that the individual production is controlled through direct dialogue between the contractor and the client [14-16].

This work is devoted to propose the use of planning tools in manufacturing orders in prosthetic laboratories. The paper presents Gantt chart and the the planning stages in dental laboratory. Analysis of timely execution of orders related to the exemplary set of activities is presented in case of the partial prosthetic restoration manufacturing technique. The aim is to identify the critical points in the implementation of the order and milestones in the project plan.
2. PROJECT SCHEDULING

The need for collaborative action planning is considered theoretically by most of the people, however, in practice, is also often overlooked (which is wrong). Planning is usually based on the coordination of more participants work, taking into account a large number of unknown, unpredictable factors, which are impossible to determine in the beginning. Project according to definition is an unique, innovative and creative activity, as opposed to routine activities. However, absolutely it not due to the fact that the action plan is unnecessary. In other words, the importance of the project plan can be presented on the basis of stages ie.: rational description of the task and methods, presentation of the tools for achieving the goal (measurement, correction), the review of project expectations. In technical terms, in the dental laboratory the elements of planning (according to contracts) are: method of team and subcontractors coordination, basis for measuring of project progress, controlling tools. As a basic triangle of the project are: (1) project executive time, reflected in the schedule of the project, (2) project budget based on the cost of resources: people, equipment and materials required to perform the tasks, (3) the tasks of the project and work required to implementation.

Project management is the process of planning, organizing and managing tasks and resources in order to achieve the objective within the constraints of time, resources or cost. After defining the objectives of the project and its main phases, should be ready to create a plan:

- introduce and organize a list of tasks to be performed with the duration of each task and the dependencies between tasks,
- plan to add resources: people, equipment and supplies, as well as the relevant costs,
- allocate these resources to the tasks,
- using this information, creating a project schedule.

2.1. Scheme of the partial dental prosthesis execution

In this work the plan of the partial dental prosthesis implementation has been described. Flow chart of a process is described in Figure 1. Dental prosthesis being artificial, and also an integral part of the stomatognathic system can not to interfere with the activities of its individual components. The process begins with a patient visit in the dentist's office. There takes place the examination of the patient, followed by an analysis of the prosthetic base, when the plan of the treatment course is stated, the diagnostic impressions of the patient's mouth is taken. The patient's mouth impression should include the exact site of the future prosthesis to ensure its maximum maintenance, support and stabilization during speech and chewing. The impression downloaded properly is the first milestone in the process. Performed impressions are transferred to the dental laboratory and their are the role models for gypsum casting. For gypsum models obtained from the diagnostic impressions, the wax shaft is applied and again the detail are transferred to the dentist to take the impression of the patient’ occlusion. On the wax model of teeth short-circuit, dentist in addition to establishes a central short-circuit of teeth and also selects the shape, size and color of artificial teeth, on the model applied guide lines that help during the artificial teeth setting (detail returns to the technician). The wax model with inserted artificial teeth shaped by a dental technician as the future prosthesis are transferred back to the dentist.

During the patient’ visit the control of the test prostheses is taken. After application of the necessary adjustment, the model again returns to the technique where is canned (wax model of the prosthesis placed in the lower part of the can), and the wax is replaced by the acrylic material. This stage of implementation consists the several steps: gypsum hardening, cans opening and plastic wax removing, gypsum molds cleaning with a water vapor stream, drying of gypsum mold, gypsum mold coating with several layers of the insulator, drilling of the holes in the surface of the tooth plate. Prepared in this manner molds are filled with acrylic material. The can is placed in the prosthetic press and is left for over 20 min. For complete polymerization can with acrylic
material is placed in a water bath (water temperature is gradually raised to 70 °C, and left for 7 to 16 hours, finally the temperature is raised to 100 °C for next 2 to 3 h). After heat treatment the prosthesis is removed carefully from the can and mechanically machining (to remove any excess of acrylic material), eventually prosthesis is polished to a high gloss. The prepared restoration is passed to the dentist, and if it is well suited process is considered to be terminated, in case of improper fitting, the restoration returns to the technician to correction.

**Figure 1** Flow chart for production process of a dental prosthesis

2.2. Gantt chart for the process for partial denture

In Figure 2 the Gantt chart is presented as schedule of the production process of partial prosthetic restoration, according to the course in Figure 1. In Figure 2 it can be seen that all the operations follow one after the other and it is not possible to carry out concurrent processes. Among the most critical points, should be indicate the
transport stage of the diagnostic impression from the dentist's office to the dental laboratory. Life times of such impression is about 12 hours. Proper impression representation of the patient’s mouth is closely related to the type of material used to this purpose. In the process, four milestones have been determined. The appearance of each of them is associated with the necessity of proper adjustment of the prosthesis elements during a meeting with the patient. The greatest dangerous is that if milestones are not exceeded the process operations have to return to operation from the initial stage.

Another information resulting from the Gantt chart are the places marked with “X” - sources of delays. This delay is closely connected with the deadlines of meeting - dentist with the patient. It should be noted that in the illustrated diagram were determined only the planned project implementation times. Chart does not include days off work.

3. CONCLUSION
On the basis of the analysis, it has been found that it is possible to create the graphic plan of prosthetic restorations production process using a Gantt chart. Chart allows to schedule tasks at the time which is especially important because in most cases during the manufacturing process, there are involved two entities: a dentist and technical laboratory - the work of these two units is not concurrent, and their action is consecutive. Another advantage is the possibility of avoiding a delay in the execution of the order by timely patient schedule meetings with the dentist. Due to the graphic presentation it is possible to present the milestones that have a significant impact on product quality and timeliness of its implementation.

REFERENCES


PROJECT TEAMS IN SUPPLY CHAINS IN POLAND - THE RESULTS OF EMPIRICAL RESEARCH

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²Wroclaw University of Economics, Faculty of Economics, Management and Tourism, Wroclaw, Poland, EU

Abstract

The aim of the article is to present the characteristics of project team operation in supply chains. The authors concentrated on issues such as the composition of project teams, their size, the way of team management, the tools used for managing the team, as well as on the object of their operation and the extent of reaching the objectives within a supply chain. The paper concentrates particularly on project teams having non-organizational character (whose members are the employees of at least two enterprises within a supply chain). The results of a survey conducted in 20 supply chains located in Poland are presented in the paper.

Keywords: Project teams, supply chain, supply chain integration

1. INTRODUCTION

The success of supply chains depends predominantly on the ability to integrate and coordinate actions of the network participants in particular concerning the flow of goods, information and financial means from the places where the raw materials are obtained to the place of consumption, which (as it is emphasized in the reference literature) contributes to the creation a competitive edge of a supply chain participants and their customers. The cooperation of particular links of a supply chain is mainly based on many standardized processes, but also more and more often on projects. The projects, in contrast to the term applied to the processes in management, are of unique character, limited duration and are gradually made more and more precise. In practice, the undertakings which are projects are realized by project teams (task-oriented). Such a team is a group of people put together to perform tasks which lead to the aim, that is the completion of the project. The people most commonly work under the supervision of the project manager - the team might thus have a well-developed hierarchical structure. The character of project teams is marked with exceeding the functional limits, and in some cases (as for example in the case of a supply chain) even organizational ones. However, the relevant literature lacks the descriptions of the characteristics and operation of project teams both in theoretical and in empirical dimension. Yet, in the operational practice of supply chains, the creation of project teams in a common organizational solution. The authors believe that it implies a need to examine the characteristics and objectives of project teams in those specific network structures. The cognitive concern thus expressed resulted in the formulation of the objective of the paper which is the presentation of the characteristics of project teams functioning within supply chains. The attempt to obtain the aim is expressed in the analysis of the relevant literature and the presentation of the results of empirical research conducted in 20 entities of supply chains, conducting business in Poland.

2. PROJECT TEAMS IN A SUPPLY CHAIN - THEORETICAL CONSIDERATIONS

The issue of the integration of particular links in a supply chain is widely discussed in relevant literature and theoretical studies are abundant of structured lists of integration tools, developed on the basis of varied criteria of classification. Usually, their common feature is joint operation of varied links in a supply chain, understood as degree of extending the borders of the organization and integrate the partner within the borders [1]. To develop a comprehensive conceptualization of supply chain integration, we included practices strengthening
the linkages between companies occupying different positions in the supply chain (i.e., vertical linkages) and practices that foster horizontal linkages amongst the various functional areas within the firm [2]. Thus, it should be noted that a tool which enables the supply chain entities to merge and cooperate is the creation and operation of (internal) project teams, whose scope of operation concerns at least two enterprises within a supply chain [3].

The empirical studies reveal that the internal integration of an organization (for example, merging the function of production with logistics and marketing) constitute the first step to a full integration within a supply chain [4]. The relevant literature emphasizes that the most effective tool of internal integration is the creation of cross-functional teams [5,6,7], which are aimed at developing bonds between people representing different organizational units with theoretically contradictory interests. Cross-functional teams are usually used to achieve the integration needed across internal functions to ensure that quality or innovation aims are realized [8,9]. Occasionally, the representatives of suppliers or customers become members of the team, then the cross-organizational team becomes a tool of external integration, thus team work may support the development of both vertical and horizontal linkages in supply chains.

The overview of literature enables to make a distinction between two levels of supply chain integration by project teams [3]:

- Level 1 (low) - the variant of internal integration - the project teams are mainly established within the enterprises of the leader of the supply chain.

- Level 2 (high) - the variant of external integration - the enterprise of the leader of the supply chain initiates the creation of inter-organizational project teams including the members from partner organizations.

At Level 1, a project team consisting of the members of the leader’s organization may fulfill tasks on behalf of the same enterprise, as well as on behalf of the activities preformed within the supply chain. Level 2, on the other hand, which assumes establishing cross-organizational project teams within a supply chain, represents a higher stage of integration. Consequently, apart from the integration of particular functional areas, a transfer and diffusion of knowledge is provided to such places within a supply chain, where particular project tasks are performed. Additionally, this option is likely to allow a more accurate selection of the team members in terms of their knowledge and competence - as it is possible to choose specialists from many not from one organization. More importantly, particular organizations (links) of the supply chain will accept more easily (in comparison with the Level 1) the decisions / solutions developed within the project team, if their representative was a member of the team (due to the fact of the representation of their interests).

3. RESEARCH METHODOLOGY AND GENERAL CHARACTERISTICS OF THE SURVEYED COMPANIES

The empirical research was conducted on the basis of a survey consisting of two parts. The study was focused on the identification of project teams structure in supply chains in order to identify the type of integration they serve. The first part of the survey concerned the general aspects of the operation of project teams in the analyzed companies. The second was about the activity of a project team consisting of employees from different organizations within a supply chain, in which the analyzed company operates. The surveys were sent to 20 selected companies by email or given directly to the members of project teams.

The subject of the research was a purposive sample of enterprises - a supply chain links - selected under the condition that there are project teams in their structures. The analysis of the obtained results was performed with the use of Excel spreadsheet.

A half of the companies were big enterprises, namely employing 250 employees or more. One fourth of the examined group consisted of middle-sized companies. The remaining units are classified as small-sized or
micro enterprises. In terms of the dominating profile of business activity the distribution is fairly proportional, namely 9 manufacturing companies, 7 service companies and 6 trade companies. It means that the research included the representatives of different links of a supply chain. The authors would like to emphasize that the researched companies represent different branches, including for example: automotive, construction, IT, FMCG, furniture, medical, education and training services, and e-commerce.

Due to the share of foreign capital in studied enterprises 11 out of 20 units are companies without any foreign capital. In 8 cases, they are entities with dominating foreign capital (that is over 50% of shares). Only in one entity the share of foreign capital is minor. The companies with the share of German capital are most common among the researched companies (3 entities), then with Japanese capital (2 entities) and one from Great Britain, USA and joint French and American capital.

4. RESEARCH RESULTS

4.1. General aspects of project teams operation

As it was mentioned, the first part of the survey concerned mainly general aspects of the functioning of project teams in studied entities. Cross-functional project teams exist in all 20 supply chains, thus in each of the analyzed cases we deal with the variant of internal integration (Level 1 of integration - low).

The selected results for this part of the research are presented below. They concern for example the frequency of establishing cross-functional project teams, the type of activities performed by them, the criteria of selecting the managers of project teams and main problems and advantages resulting from the realization of tasks relying on such teams.

![Pie chart](image)

**Figure 1** The percentage of responses in terms of the type of the undertaking realized by project teams (total number of responses = 43).

In terms of the frequency of establishing such project teams, among the researched entities, such teams are a permanent element of the operations of the company in a huge majority of entities (12 entities). In the case of 2 entities the teams are established at least a few times a year, and in 6 entities occasionally, that is once a year or a few years. There results show that the implementation of undertaking on the basis of project teams is a quite popular practice in business. The respondents selected 43 options within 6 suggested groups (it was possible to choose more than one answer) with reference to the type of undertakings realized in project teams. Most commonly they regarded the implementation activities such as launching a new product on the
market, the implementation of quality management system or IT system and tasks aimed at solving one particular problem such as the elimination of a product defect (in both cases each got 23.3% of all selected options). Next, the tasks performed as a part of regular activity of the company was selected, such as individual requests of customers, untypical / unique orders (18.6% of all selected options) and developmental projects, such as the development of the company’s strategy or designing a new product (16.3% of all selected options). The remaining areas of project teams activity obtained a lower percentage. Detailed results were presented in the Figure 1.

In terms of selecting the manager of the created project team 101 responses were selected among 13 defined answers. Having specialist knowledge and skills (16.8 % of all selected options) and experience (15.8%) were chosen most commonly. Next, communicative skills (10.9 %) and ability to work in a team (9.9%) were pointed out. The lowest number of responses received the criterion of negotiation skills (2%). Detailed results are presented in Table 1.

**Table 1** The percentage of responses with regard to the criteria of selection of project team managers (total number of responses = 101)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Knowledge and specialist skills</th>
<th>General knowledge</th>
<th>Experience</th>
<th>Independence</th>
<th>The knowledge of planning and organizational methods</th>
<th>Creativity and compliance</th>
<th>Flexibility</th>
<th>Determination</th>
<th>Reliability</th>
<th>Communicative skills</th>
<th>Negotiation skills</th>
<th>Ability to work in a team</th>
<th>Current position</th>
<th>In total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of responses*</td>
<td>17</td>
<td>7</td>
<td>16</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>11</td>
<td>2</td>
<td>10</td>
<td>9</td>
<td>101</td>
</tr>
<tr>
<td>Share in general number of responses</td>
<td>16.8%</td>
<td>6.9%</td>
<td>15.8%</td>
<td>5.9%</td>
<td>3.0%</td>
<td>5.0%</td>
<td>4.0%</td>
<td>4.0%</td>
<td>6.9%</td>
<td>10.9%</td>
<td>2.0%</td>
<td>9.9%</td>
<td>8.9%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* It was possible to choose more than one answer.

4.2. Project teams consisting of employees from different organizations within a supply chain - the external integration variant

The second part of the questionnaire concerned the activities of project team consisting of the employees from different organizations within a supply chain, in which a studied company operates. It appears that only in 5 out of 20 researched entities cross - organizational project teams are established, including the members - employees of suppliers and / or recipients. It means that in the researched entities, despite the fact that the implementation on the basis of project teams is a quite common practice, they are most often limited to the employees of a given company (all 20 enterprises) and the representatives of other links of a supply chain do not participate therein. Thus, only in ¼ of the studied supply chains level 2 - high level of integration was identified, corresponding to the external integration.

In the cases where a project team allows the participation of employees of different organizations within a supply chain, such teams most often consist of at least 4 persons and operate over 6 to 12 months. In 4 out of 5 cases the team is of interdisciplinary nature, including members representing the suppliers or recipients of various specialization, namely the participants represent different areas, such as marketing, IT, finance and accounting from a few enterprises of a supply chain. Only in one case such a team had a functional nature, so it included members from the suppliers or recipients having the same specialization.
The answers provided by this group of entities reveal also that the members of such a team:

- perform tasks connected with the work / participation in the project team apart from other tasks in their original unit (5 responses) and also within another task team (3 responses). There was no response, claiming that the employee performs tasks exclusively on behalf of the task team,

- leave the team once they have performed their tasks, and their place is occupied by other participants, who implement the following stages of the project (4 indications),

- communicate within a team via email, teleconferences and direct meetings of the whole team (5 indications each), hardly ever through internet communicators and internal documents (1 indication),

- use mainly the techniques and tools to schedule the work, including the Gantt chart (5 indications) and the methods CMP and PERT (2 indications each), while planning and organizing the team’s work.

31 responses were selected among 14 defined answers in terms of the main criteria of selecting members for the discussed teams. Having specialist knowledge and skills as well as experience (16.1 % of all the responses) were most commonly indicated, similarly as it was in the case of the selection of the manager of the project team. Next, creativity, communicative skills and the ability to work in a team were selected (each 12.9 % of all the responses). Such criteria as: general knowledge, determination and current position, were not selected at all. The results were presented below in a table.

Table 2 The percentage of indications with regard to the criteria of selecting project team members from different organizations within a supply chain. (total number of indications = 31)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Knowledge and specialist skills</th>
<th>General knowledge</th>
<th>Experience</th>
<th>Independence</th>
<th>The knowledge of planning and organizational methods</th>
<th>Creativity and compliance</th>
<th>Amicability</th>
<th>Flexibility</th>
<th>Determination</th>
<th>Reliability</th>
<th>Communicative skills</th>
<th>Negotiation skills</th>
<th>Ability to work in a team</th>
<th>Current position</th>
<th>In total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of responses*</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Share in general number of responses</td>
<td>16.1%</td>
<td>0.0%</td>
<td>16.1%</td>
<td>3.2%</td>
<td>3.2%</td>
<td>12.9%</td>
<td>6.5%</td>
<td>6.5%</td>
<td>0.0%</td>
<td>6.5%</td>
<td>12.9%</td>
<td>3.2%</td>
<td>12.9%</td>
<td>0.0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* It was possible to choose more than one answer.

It needs to be emphasized that in the case of each of the analyzed entities in this group, the results of the team’s work are transferred and implemented by the suppliers / recipients. In three cases the transfer consisted of handing over the project documentation, in two - trainings at the supplier / recipient company. Additionally, in one entity the transfer was realized in the form of donating a high-value fixed asset for the purposes of the prototypical work conducted in the project.

The main problems identified by the respondents in terms of the creation and operation of the described project teams included (there was a possibility to mark more than one answer): difficulty in balancing everyday duties and project team tasks (5 indications), problems with integration and coordination of work of team members (4 indications) and difficulties in communication between the team members and different views and opinions represented by particular members (3 indications each). It might be concluded that those problems are mainly the consequence of inter-organizational nature of such teams.
5. CONCLUSION

The conducted research showed that in all 20 analyzed cases cross-functional project teams were identified fostering the internal integration of a supply chain. However, merely in ¼ of cases the external integration variant exists - in 5 empirically studied supply chains cross organizational project teams are created. Despite the fact that the effects of team work in each of the analyzed cases affect the operation of enterprises in a network, only in the 5 cases mentioned hereinafore particular enterprises participating in the project have the influence on the direction and shape of the effects rendered by the teams. The presence of the representatives of suppliers and recipients in the project team, as its active participants, increase the predilection to accept the produced solution by their parent company. As a result, in those supply chains we have the possibility to deepen the connection between particular links of the supply chain, a better bilateral flow of information and knowledge and the synergy effect connected with the presentation of different perspectives (suppliers, recipients and producer), which in turn contributes to a mass production of a component meeting the expectations of the final customer.

REFERENCES


BUSINESS MODELS OF FLAG ENTERPRISES IN DISTRIBUTION NETWORKS

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Abstract

The aim of the paper is to indicate those elements of business model, which differentiate flag enterprises in the distribution networks of steel mill products. Literature research aimed at distinguishing elements defining business model was conducted to obtain the objective. Additionally, three standard business models of enterprises cooperating in the supply networks were described. Then, the cooperation models in a network were referred to flagship companies in the distribution networks highlighting both the attributes, allowing to distinguish a flag distributor among the organizations cooperating within a network and those attributes, which differentiate flagship companies. The research was conducted between 2011-2016 in the sector of steel products distribution. 20 flagship companies were distinguished, in 18 organizations a thorough research was performed.

Keywords: Business model, flag enterprise, distribution network, postponed production

1. INTRODUCTION

Distribution network is particularly important part of the supply chain, where material decoupling point is the production for stock or assembly on order. In two remaining types of supply chain about the decoupling point: production according to the order and designing a product according to an order, the distribution part of the supply chain is considerably smaller and fulfills mainly an informative function. In the network structure of the distribution it is possible to indicate a central link, which is a dominating hub (dominated network, for example administrated or corporative) or fulfills a coordinating function due to collecting and sharing the knowledge with the actors in the network.

Such an organisation is described as flag enterprise of distribution network. The role of such organisations is particularly important for the supply chains of standard products as well as products differentiated according to the order of a customer, where the order is realised pursuant to the strategy of postponed production. Business models of flag enterprises of distribution networks are a multidimensional and heterogeneous construct. The business model is defined from different perspectives. They are described in the first part of the paper, which also includes the elements comprising the business model, with reference to the business models of enterprises in distribution networks. In the following part of the article the elements of business model of flag enterprise within a distribution network of steel mill products. The aim of the paper is to emphasise those elements of business model, which differentiate the flag enterprises of distribution network of steel products.

2. THE BUSINESS MODEL ELEMENTS DISTINGUISHING THE CENTRAL ORGANIZATION IN A DISTRIBUTION NETWORK

The discussion about the business models of flag enterprises should commence with the indication of the interpretation of a business model. There are numerous concept defining a business model in a literature. They depend on the adopted perspective and differ with the set of elements distinguished in a model. The selected definitions of a business model are listed in Table 1.
### Table 1 Business model - selected interpretations

<table>
<thead>
<tr>
<th>Name and surname of the author</th>
<th>Definition of the business model</th>
<th>Elements defining the business model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venkatraman, Henderson (1998, p.33-38)</td>
<td>The business model is a coordinated plan of action, the aim of which is developing strategy which satisfies customer expectations.</td>
<td>enterprise’s architecture, resources, value for the customer</td>
</tr>
<tr>
<td>Tapscott(2001, s.5)</td>
<td>The business model refers to the enterprise's architecture and in particular to the manner in which the enterprise uses resources in order to create a distinguishable value for the customer</td>
<td>the proposal of the value for purchasers developed with key stakeholders and comprising operations which create and offer this value</td>
</tr>
<tr>
<td>Linder, Cantrell(2001, p.13)</td>
<td>The business model is the idea of carrying out a profitable activity in changing environment</td>
<td>the set of products and services delivered on the market in a particular manner by a given organisation, appropriately placed on the market, which provides strong relations with current and future customers</td>
</tr>
<tr>
<td>Petrovic et al. (2001, pp.1-2)</td>
<td>The business model describes logics of the business system aiming at creating the value resulting from processes taking place in the enterprise. Hence, the business model constitutes the implementation of business strategy at conceptual and structural level as well as the basis to implement business processes</td>
<td>the description of value offered by the enterprise to a group or groups of purchasers, the description of the enterprise's architecture and the network of partners who co-create, offer and deliver the value and relational capital providing profitable and stable revenue streams</td>
</tr>
<tr>
<td>Morriss(2003, pp.17)</td>
<td>The business model describes manners of creating and delivering values and it may evolve along with changes of needs and preferences of purchasers</td>
<td>the value understood as overall advantages expected by purchasers logics of the enterprise's operation, i.e. various forms of the enterprise’s activity aiming at creation of this value and its delivery to customers</td>
</tr>
<tr>
<td>Afuah(2004, pp.2-17)</td>
<td>The business model is a set of actions taken in a particular manner and in appropriate time in given conditions of market environment to create and deliver the highest value to purchasers and provide the enterprise position enabling to capture such a value</td>
<td>The business model should not be only descriptive (product, customer, manners of delivering value, resources of the organisation), but also it should take into consideration a kind of financial model. With such an assumption the business model presents not only the idea and elements of a given undertaking but also detailed financial justification of the activity</td>
</tr>
<tr>
<td>Osterwalder et al. (2005, p.30)</td>
<td>The business model is a conceptual tool containing a set of elements and relations between them, which enables to express business logics of a given enterprise</td>
<td>The business model should consist of two parts - narrative and calculative ones which should form an answer to questions: &quot;Who is a customer? What is a value for him? In what way such a value may be delivered rationalising costs and in what way does the action engage resources of the enterprise?&quot;</td>
</tr>
<tr>
<td>Keena, Quresh(2006, p.2)</td>
<td>The core of the business model is the value for the customer and logics of the enterprise's operation which is connected with its creation</td>
<td>the stream of value, the stream of revenue, a logistic stream.</td>
</tr>
<tr>
<td>Rasmussen(2007, pp.1-2)</td>
<td>The business model should consist of two parts - narrative and calculative ones which should form an answer to questions: &quot;Who is a customer? What is a value for him? In what way such a value may be delivered rationalising costs and in what way does the action engage resources of the enterprise?&quot;</td>
<td>The business model is a configuration of three streams of flows which are key to business: the stream of value, the stream of revenue, a logistic stream.</td>
</tr>
<tr>
<td>Mahadevan (2009, p.9)</td>
<td>The business model is a configuration of three streams of flows which are key to business: the stream of value, the stream of revenue, a logistic stream.</td>
<td>The business model is characterised through spheres distinguishing its essence: actions and resources connected with them, created and captured values. Spheres of actions and resources play here the role subordinated to the creation of the value for the customer as well as the ability of its capturing and maintaining. The primacy of creating the value results from perceiving it as the most important goal of the enterprise, the achievement of which gives it competitive advantage. Profitability is the most important financial dimension, the level of which is influenced by actions carried out by the company and resources which it owns.</td>
</tr>
<tr>
<td>Brzóska (2009, p.7)</td>
<td>The business model is a scheme of a manner in which the enterprise configures the set of strategic products concerning: markets, customers, proposal of value, organisational structure, competence, processes, culture, measures in order to create the value and next its capture.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own elaboration
A lot of presented approaches define the business model through its attributes. Summing up the above interpretations of the business model, one may assume that it includes the description of the value offered by the enterprise to a group or groups of customers, along with determining basic resources, processes (actions) as well as external relations of this enterprise which create value and providing the enterprise with competitiveness in a given field as well as enabling to increase its value. The most quoted elements of the business model include: the position of the enterprise in the chain of value, the value for the customer, the sources of income, resources / competencies, relations with partners, offered products[13,14].

The shape of the business model is mainly dependent on the sector, because it is a manner in which the organisation - in the conditions of environment identified and diagnosed by it - runs its activity. Taking into account the presented theoretical background of the organisation and the research problem indicated in the introduction, the analysis was narrowed to the distribution of steel products. In this sector business models of organisations cooperating in supply chain which adopt the role of designing and coordination of the network as well as the organisation of material flows were considered. Such organisations are described as flag enterprises of distribution network or flag suppliers [15]. Adopting the perspective of the business model analysis at the level of flag enterprises of the distribution network points out on a particular level of detail in conducted research.

The theoretical construct of the flag enterprise of the distribution network of steel products consists of elements considered as the constant value:

- place in the value stream: distribution - the sale of products with a various processing level and customising to the consumer's needs,
- products: steel products,
- relations with partners (number and structure): numerous and complex - it is a network organisation.

Elements diversifying the business model of flag enterprises of the distribution network of steel products allowing to build competitive advantage between flag suppliers of steel products, which are considered in research presented in the article, are the following: value for the customer (types of carried out processes), key competences and key resources, the types of formed relations. The article does not take into consideration all elements of the business model. A hypothesis was formulated that the elements diversifying business models of flag enterprises of the distribution network of steel products include as well: the sources of income, costs, the segments of recipients. The hypothesis will be verified in the future research.

Figure 1 summarises the concept of the analysis concerning the model of the flag enterprise of the distribution network of steel products presented in the article.
3. THE CONSTRUCT OF THE FLAG ENTERPRISE OF THE DISTRIBUTION NETWORK OF STEEL PRODUCTS

Flag enterprises of the distribution network of steel products are characterised by attributes of both the integrator of the network and the conductor [15]. Managerial roles of enterprises distinguishing by models of the conductor, operator and integrator described in the literature are depicted in Table 2.

**Table 2** Characteristics of roles of the operator, integrator and conductor in the network

<table>
<thead>
<tr>
<th></th>
<th>Operator</th>
<th>Integrator</th>
<th>Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creation of network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection of partners</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ensuring cohesion of the network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delegation of tasks to partners</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in accordance with competencies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creation of identity and organisational culture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setting transactions with customers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and partners of the network</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: [15]

Regardless of stronger roles of the central enterprise (in the direction of the integrator or conductor), owning such features is necessary to qualify an organisation as flag enterprise, due to the fact that identified roles decide about the position of an organisation in the network, the possibility of creation of the network and its management.

Flag distributors differ in the scope of processes carried out in the value stream. Classical tasks resulting from the role of the commercial enterprise include stock management, the choice of purchase sources, the management of relations between recipients and suppliers, market research, purchase and sale of products [13,14]. These are key competences of organisations specialising in the supply so they compose the business model of the supplier. Frequently, these tasks are extended with transportation processes and, what is significant for the sector of the distribution of steel products, with carrying out tasks concerning postponed production. The strategy of postponed production may be implemented on different stages of the product manufacturing. Yang et al. (2004) presenting the role of deferral strategy in reducing negative effects of fluctuations in demand takes into consideration the following variants: the deferral of the product development, the deferral of the purchase of materials, parts, components, the deferral of production, a logistic deferral.

AlGeddawy and Elmaraghy (2010) distinguished three levels of postponed diversification of the product: the strategic level in which the positioning of the product diversification point is optimised, tactical (physical) level which includes sequencing of the process and designing of assembly line system and the operational level.

Carrying out tasks of postponed production is the attribute distinguishing flag enterprises in the supply chain of steel products. The range of carried out services rendered within the framework of deferral is the feature of the business model of the flag enterprise which significantly diversifies these entities in the sector of the distribution of steel products.
4. THE ANALYSIS OF SELECTED ATTRIBUTES DIVERSIFYING BUSINESS MODELS OF FLAG ENTERPRISES OF THE DISTRIBUTION NETWORK OF STEEL PRODUCTS

The research depicted in the article focuses on two elements of the business model which diversify flag enterprises of the distribution network of steel products: key resources and formed relations (reasons and types). Table 3 presents three aspects taken into consideration in the research: the strength of the flag enterprise of the distribution network of steel products, elements involved in relation competencies and elements considered in the resource policy of the flag enterprise.

Table 3 Element of the business models

<table>
<thead>
<tr>
<th>Strength of flag enterprise</th>
<th>Relational competence</th>
<th>Resource of flag enterprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value and the quantity of sold products</td>
<td>Number of different types of co-operators included into the cooperation</td>
<td>Rarity</td>
</tr>
<tr>
<td>Width of the assortment</td>
<td>Motives for establishing the cooperation</td>
<td>Flexibility</td>
</tr>
<tr>
<td>Number of supported segments</td>
<td>Types of the relation</td>
<td>Substitutability / complementarity of resource of the co-operator</td>
</tr>
</tbody>
</table>

Source: own elaboration

The research was conducted on the sample of 60 distribution enterprises associated in the Polish Union of Steel Distributors. In this group 20 organisations fulfilled the assumptions of flag enterprises of the distribution network. Firstly, the correlations of each of the attributes and the network built by the flag enterprise with the indicator of its strength were examined. Resources were described by such attributes as rarity, flexibility, substitutability / complementarity of resources in which the enterprise invests, while relations were determined by: the number of various co-operators, the reasons of establishing collaboration, the types of formed relations and substitutability / complementarity of the co-operator's resources. The attribute describing resources of the flag enterprise such as the rarity indicator achieved a high correlation. Flag enterprises have rare resources allowing them to be distinguishable in the environment and capture values unavailable for other organisations. However, all enterprises indicated a significant share in the base of resources which are also owned by other suppliers of steel products. The rarity indicator was estimated in the range of <0 - 1>, where 0 meant lack of rare resources and 1 - exclusively rare resources. The obtained results of flag enterprises of the distribution network of steel products were very similar and fell within the range of <0.4 - 0.6>. Another correlation at the significance level \( p=0.11 \) with the Spearman's rank of 0.48 was revealed by the variable describing relations formed by flag enterprises: the number of various types of co-operators. The number of various types of organisations included by flag enterprises of the distribution network of steel products was between \( (0.8 - 1) \), where 1 meant relations with all types of organisations. The types of organisations were determined as: a supplier, a classical wholesaler, the subcontractor carrying out tasks of postponed production, a retailer, a final customer, a transport undertaking, a supply centre, a logistics centre. The results concerning both factors indicate a large compliance of such an strategic approach among flag enterprises of the distribution network, which allow to include these attributes into elements characterising the business model of the flag enterprise and not into the features differentiating these organisations (they are differentiated by types of rare resources and the fact of having a rare resource). Other variables which did not achieved an adequate level of significance have the following impact on the strength of the flag enterprise: the flexibility of machines owned by the flag enterprise increases its strength, the increase in informal relations slightly reduces the strength of the flag enterprise, the average substitutability of machines obtained as a result of cooperation (both under the cooperation agreement and informal relations) increases the strength of the flag enterprise. The flexibility indicator of machines is connected with the economies of scale and the character of the flag enterprise. The flag enterprise chooses resources in accordance with the possibility of achieving high economies of scale. This
results in the exclusion of highly specialised (dedicated) resources beyond the flag enterprise’s own resources and, in accordance of outsourcing, obtaining them from other organisations. The detailed correlation analysis shows that the more complementary resources are obtained by means of cooperation, the more frequently the flag distributor decides to cooperate formally (cooperative agreements replace informal cooperation). Thus, the research presented both attributes distinguishing the business model of the flag enterprise of the distribution network of steel products and attributes differentiating particular flag distributors (Figure 2).

![Figure 2 Attributes of flag enterprises of distribution network of steel products](image)

Source: Own elaboration

The listed attributes indicate the ways of competing between flag enterprises in the supply chain of steel products. At the same time the obtained research results are the voice in the discussion between theoreticians and practitioners of management specialising in business models. This is due to the fact that one can distinguish those elements which characterise actors cooperating in networks of given industries and create theoretical construct of the business model of such organisations. On the other hand, it is possible to identify such elements which diversify organisations with a particular business model and allow to build the competitive position and implement different strategies.

### 5. CONCLUSIONS

The conducted research allowed to distinguish both elements defining the business model of the flag enterprise and elements differentiating particular flag distributors of steel products.

In the research the index of the strength of the flag enterprise was used. The developed index allowed to analyse business models of flag enterprises, including in particular the scope of resource and relation elements. The shift of the product diversifying point from the level of production enterprises on the level of distribution enterprises called service centres and steelyards becomes particularly important. The supply chain designed in such a way requires from flag enterprises of the distribution network to coordinate both logistical, commercial and marketing tasks as well as those connected with postponed production (postponed differentiation). The implementation of tasks of postponed production extends the resource base with rare resources and those with various levels of flexibility and complementary. However, analysing the distribution of steel products in Poland in the course of 20 years, one may put a hypothesis that relation competences have been of key importance in building positions of particular organisations in the network. The topic of business models is still inexhaustible and the research presented in the article showed further areas which should be taken into account in the next research stages.
REFERENCES
DRIVER’S PERCEPTION AND REACTION TIME AS AN IMPORTANT ISSUE FOR URBAN TRAFFIC MODELLING

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Abstract
The driver behaviours are one of the crucial determinant for the transportation system functioning, especially within the city. They are shaped mainly by driver’s individual perception of reality. Many examples from literature shows, that the perception is strongly associated with a human perception. The process of analysis and understanding of factors affecting driver perception can help with planning more effective and safer transportation facilities, i.e. road infrastructure. The driver reaction time is a parameter which describes a perception and directly affects the road safety. Thus the ability and required accuracy of its measurement is an important element in traffic modeling. In this work the results of microscopic traffic simulation for selected Cracow artery have been presented, considering the fluctuations of the mentioned above parameter. The aim of the studies was to analyze the impact of driver’s reaction time parameter changes on traffic simulation effectiveness. As a result, the importance of potential measurement error of driver reaction time has been presented. Furthermore the effects of conducted research shows the significance level of impact reaction parameter measurement error on the urban traffic simulation model, which is very often a basis for future planning of transportation system elements. The calculations have been performed for selected traffic parameters in the context of statistic compatibility of the model by the use of Aimsun software.

Keywords: Driver’s reaction time, perception, measurement accuracy of driver reaction, traffic micro simulation

1. INTRODUCTION
The driver’s reaction for any traffic incident or object on a road requires some time for recognition, understanding the situation, decision making about reaction and finally reaction taking. Put simply, the perception-reaction process involves detection, identification, decision, and reaction. These four terms are defined as follows:

- Detection of information, based on visibility, which is the visual awareness that an object is present on the roadway. At night, it depends entirely on a contrast sensitivity;
- Identification is the process of gathering information about the object until enough information is gathered for the driver to make an appropriate decision of the object recognition, whether it cause a danger, and whether its existence calls for some responsive action;
- Decision, or evaluation, is the next step and it involves the driver’s decision about taking appropriate action to avoid the object
- Reaction occurs then orders are issued by the driver’s brain to the appropriate muscle groups in order to initiate the responsive action for traffic incident [9].

Analysis of road safety takes into account a number of factors that affects the way of driver’s movement in the selected area or point of the road. These factors are part of the road traffic system, which consists of four main elements: human, other road users, vehicles and roads, traffic and its organization (Figure 1). The correct interaction of these elements provides an effective and safe realization of movement by the traveler.
To the technical category in the road traffic system, the road, traffic and its organization as well as vehicles can be attributed. A road in directly and indirectly manner affects the formation of a number of road accidents. Such features of the road network, like lack of hierarchy and the associated with it availability control, as well as a limited range of different types of movement segregation create the conditions for dangerous behavior of traffic participants [2]. To the non technical category a driver and other road users can be included.

Participation in the road traffic system is a set of complex actions and driver's behavior as a result of forming relations with other elements of the system. Dexterity in the handling of the vehicle combines three areas:

- physical state determined in medical card,
- mental state determined in psycho-physical medical card,
- knowledge, skills and attitude of the driver [4]

Dexterity in the handling of the vehicle by the road user directly affects its behavior in road traffic. The results of this kind of behavior are many adverse effects on the environment, where the most important include traffic accidents, collisions, formation of traffic congestion and excessive pollution. Driving behavior often depends on driver's perception on the way, which is how he perceives, interprets and reacts to events resulting from driving. Thus, the rate of driver reaction is the result of his time reaction to the situation occurred.

2. THE PERCEPTION OF THE ROAD TRANSPORT SYSTEM

There are many definitions of perception, in spite of this, it can be noticed that they are all consistent with each other. Universal Polish dictionary defines perception as a cognitive process based on perception, unawareness of objects, phenomena and processes occurring as a result of certain stimuli to the senses [16]. According to dictionary of foreign words perception, i.e., observation is a conscious sensory response on the external stimulus; a method of reaction of obtaining impressions [8].
It should be noted that perception is not only in the reception or registration of certain sensations and their processing through the senses in accordance with the way of thinking of each person. This means that for the same impressions, it is possible to make different conclusions and different ways to interpret them. The person processes the information received, mainly on the basis of the previously accumulated experience in the same or similar situations, schemes or behaviors. What and how people perceive (especially in ambiguous situations), also depends on their knowledge, current emotional state, attitudes, opinions and beliefs [13].

In scientific literature there is a notion of reaction time (Perception-Response Time), which is defined as the period of time that begins with the emergence of the phenomenon or appearance of an object in driver’s field of vision and ends when he respond to it (brakes or turn the steering wheel) [7]. In this regard, several studies aimed at the identification and determination of influence of external environment on the behavior of the driver in the road transport system has been performed. This kind of research is conducted to improve the safety of the driver and other road users.

Żakowska [18] indicates the concept of perception of security, which relates to safety behavior during displacement of the driver in traffic. She speaks about the issues related to objective and subjective feeling of the driver to the road on which he moves.

Due to the fact that the perception refers to receiving a certain stimuli from the environment and response to it, in transportation engineering a numerous studies from that area have been carried out. Usually they address the problem of driver response to a traffic accident. Therefore, it can be assumed that the concept of "the perception of the driver" would be appropriate term that describes the behavior of the driver on the road and his reaction due to the occurrence of unexpected events.

Researchers have conducted various studies on perception and reaction time of drivers. Its different for peoples in different age. The perception and reaction time for young drivers (18 - 30 years) is 1.65 sec and 1.95 sec for old drivers (56+ years) [15].

According to a NHTSA Technical Report, the perception and reaction time of drivers to apply the brake is 1.52 sec, based on the 95th percentile of drivers’ brake reaction time [11]. The mean perception and reaction time as 1.5 sec Lerner studied out of 116 observations where drivers applied the brake in response to a surprise rolling of a trash barrel on a chain into the road [9]. The perception and reaction time was carried out from experiments using simulator. The time of 1.35 sec for pressing the brake pedal in response to the brake light was achieved [17].

3. DRIVER’S REACTION TIME

The driver's reaction time is a parameter, directly affecting the safety of road traffic. This parameter can be defined as the period of time counted from the moment the event occurs until the driver measures aimed at avoiding the adverse consequences of its occurrence. In scientific literature it can be find lots of methods to study the reaction time of drivers. In particular, it was determined through the method to a simple stimulus [6], by direct observation of traffic [12] or using a special equipment such as driving simulator [5]. However, regardless of the chosen method, each of them is characterized by its measurement error. The value of this error can significantly affect both further analysis and conclusions.

One of the examples that can change the drivers reaction time may be microscopic traffic simulation. The current world trend in the traffic simulation indicates very high popularity of this kind of methods. Analysis of microscopic simulation is performed mainly to verify and assess the possible transport solutions. The basic idea of a microscopic model is statistical consistent re-creation of real traffic. It is necessary to study a lot of characteristic factors of the simulated object. It may be the intensity of traffic flows, the generic structure of vehicles, response time, the representative path in a road network, traffic lights, etc. Thus, data quality can have a key value on results and duration of the calibration process of the model. The work investigated how
changing the reaction time affects the individual micro-simulation model parameters. This change can be equated with the so-called systematic measurement error, which is often trivialized due to the feature of repeatability in each of the studies. In the end, the results obtained always have a linear offset.

4. SIMULATION RESULTS - CASE STUDY OF CRACOW

To perform the analysis of these considerations, the program Aimsun 8 was used. It contain a functionality, which allow to simulate traffic on three levels of detail modeling: micro-, meso - and macroscopic. The one of the basic information in microscopic traffic simulation which has a significant impact on the progress and result of simulation are the parameters describing the drivers behavior. In the current version of Aimsun, there are three main types of parameters related with driver time response [1]:

1. Reaction time in traffic - is the response time, what is needed for the driver to adjust their speed to the preceding vehicle,
2. Reaction time at a standstill - the reaction time at the start of the preceding vehicle, which a driver need to start acceleration from a standstill,
3. Reaction time to traffic lights - is the reaction time to green light appearance at the intersection, when a driver is about to start moving.

In the conducted research a micro-simulation model for one of the main arteries of Krakow, the (so-called Trzech Wieszczy Avenue) was created. The actual values of these reaction times were determined based on the work of Ostrowski [12] and own researches of authors. These values served as the nominal variant, which has been changed in the range from -0.5 to +1.0 seconds in increments of 0.25. In addition, for the validation purposes of the model, a real traffic measurement from the 30 selected points of the road network have been applied. In this research the 8 traffic parameters and 1 statistical compatibility parameter were selected. These parameters are [1]:

- GEH statistic: is statistic test used in traffic engineering and traffic modelling to compare two sets of traffic volumes: real and simulated. If GEH statistic is less than 5 for over 85% of volumes in traffic models, the model has the statistical compatibility with real traffic. If GEH statistic is in range of 5 to 10, the traffic volumes should be investigated.
- Flow: average number of vehicles per hour that have passed through the network during the simulation period. The vehicles are counted when leaving the network via an exit section
- Travel Time: average time a vehicle needs to travel one kilometer inside the network. This is the mean of the entire single travel times (exit time - entrance time) for every vehicle that has crossed the network, converted into time per kilometer.
- Delay Time: average delay time per vehicle per kilometer. This is the difference between the expected travel time (the time it would take to traverse the system under ideal conditions) and the travel time. It is calculated as the average of all vehicles and then converted into time per kilometer.
- Stop Time: average time at standstill per vehicle per kilometer.
- Number of Stops: average number of stops per vehicle per kilometer.
- Mean Queue: average length of the queue in that section, expressed as the number of vehicles per lane. It is calculated as a time average.
- Vehicles Waiting to Enter - Number of vehicles waiting to enter the network
- Speed - average speed of vehicles per kilometers per hour.

The results of the tests are shown in Table 1.
Table 1 The impact of driver's reaction time variability on traffic simulation effectiveness

<table>
<thead>
<tr>
<th>Measured parameters</th>
<th>Added changes to nominal reaction time [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.50</td>
</tr>
<tr>
<td>Delay Time [sec / km]</td>
<td>220.2</td>
</tr>
<tr>
<td>Flow [veh / h]</td>
<td>8 482.0</td>
</tr>
<tr>
<td>Mean Queue [veh]</td>
<td>764.9</td>
</tr>
<tr>
<td>Number of Stops [- / veh / km]</td>
<td>0.1</td>
</tr>
<tr>
<td>Speed [km / h]</td>
<td>19.5</td>
</tr>
<tr>
<td>Stop Time [sec / km]</td>
<td>183.5</td>
</tr>
<tr>
<td>Travel Time [sec / km]</td>
<td>275.8</td>
</tr>
<tr>
<td>Vehicles Waiting to Enter [veh]</td>
<td>378.0</td>
</tr>
<tr>
<td>GEH statistic</td>
<td>Percentages of detectors below GEH value</td>
</tr>
<tr>
<td>GEH&lt;5</td>
<td>76.67%</td>
</tr>
<tr>
<td>GEH&lt;10</td>
<td>96.67%</td>
</tr>
</tbody>
</table>

The conducted analysis reveals some important facts which can be considered at three levels:

1) Traffic modelling at the micro level:
   a) the driver’s reaction time is an important element for traffic modelling. Its accuracy of evaluation affect the simulation results making that the statistical compatibility may not be provided for the real network.
   b) underestimating the response time parameter does not change significantly simulated traffic parameters. however. such a model has low statistical compatibility.
   c) overestimation of the response time parameter significantly worsens the simulation results as well as the value of statistical compatibility parameter GEH.
   d) whereas that any tool dedicated to microscopic simulation is characterized by a number of input parameters. improper values of driver’s reaction time can extend the calibration process model - a planner can wrongly attempt to modify other parameters of the model.

2) Measurement of driver’s reaction times:
   a) the usage of measurement methods. in which it is possible to occur a systematic error (e.g. manual direct measurement). it may significantly affect the quality of further analysis.

3) Driving behaviour in the transport system:
   a) delayed psychomotor reaction of given driving population significantly worsens the capacity of the road network. e.g. 0.5 seconds greater driver’s reaction time reduces the flow by 4.46% and increases the average queue of vehicles by 12.45%; and in turn. a longer reaction time of about 1 second worsens the flow by 11.78% and an average queue by 29.11%.
   b) the drivers population with a longer response time to external stimuli worsens traffic flow - in extreme cases. the number of stops increased by 50% and speed decreased by 18.76%.
   c) the driver behaviour can adversely affect the exhaust emissions from vehicles by increasing the number of stops and time of stops in the queue at the intersection (increase to 50.79%).

5. CONCLUSION

The users behaviour in the transportation system is a crucial factor in terms of the efficiency and capacity of the road network. Therefore. it seems be needed that the knowledge in this field should be extensive. reliable and multifaceted. The presented study takes an attempt to evaluate how significant is the influence of the
drivers reaction time on three aspects: traffic modelling at the micro level, measuring of drivers reaction time and traffic parameters determination for the different values of reaction parameter. The obtained results confirm the previously defined thesis and indicate the future direction of research. It may refer to the comparison of different measurement methods and associated with it measurement errors of other parameters, which describe the driver behaviour and perception in the urban transport system.

REFERENCES

Abstract

The paper presents elements of formal model of warehouse process based on selection of technologically plausible material flow itineraries according to time of realization and space, labour and equipment resources constrains. Model includes structure of supplies and shipments from warehouse facility and types of materials. It can be applied to assessment of efficiency or reliability of warehouse processes depending on the formulated criteria function.

Keywords: Warehouse process, modelling, process itineraries

1. INTRODUCTION

Warehouses are key elements of logistics networks. Without regard to the location and type warehouses perform logistics processes buffering, moving and transforming materials. Warehouse process is a sequence of transformations effected on material flows to change incoming materials into materials dispatched to the clients. Typical warehouse processes consists of standard, repeatable logistics operations ([4], [7], [9]).

Warehouse processes are modelled to investigate design variants of warehouse facilities and to manage warehousing operations [10]. Underlying pace of developing modern warehouse management systems is to include „what if?” analyse tool supporting decision making which needs adjusted formal models representing core feature of warehousing operations. Warehouse processes and their models are widely discussed in literature. Dominant standpoints for that are efficiency, reliability and responsiveness, especially when it comes to supply chain configuration ([1], [3]). For over 50 years this problems are discussed on different levels (ie. [2], [5], [6], [8], [11]) and different mathematic models were introduced.

The paper presents assumptions and general formulations for formal model of warehousing process with itineraries of material flow as convenient organization method. The itinerary is defined as realization of particular implementation of material flow through the warehouse facility. Determination of itinerary depends on availability of technical and human resources and availability of free space and ordered materials at a certain time.

2. THE MODEL OF WAREHOUSE PROCESS ITINERARIES

2.1. Assumptions

Representing material flows in mathematical model requires simplifications on the one hand, and must contain all substantial features of modelled flows on the other hand [9], [11]. The model is constituted by basic elements representing functional and physical structure of the warehouse, human and technical resources, material flows, organization and information system. As it was discussed in [4] model of any warehouse can be noted as ordered six:

\[ MCD = \langle S, R, Q, P, O, I \rangle \] (1)
where:
S - *structure* mapping functional and physical conditions of warehouse facility, based on hierarchical division of warehouse into subsequent tiers of functional areas grouping locations (addresses),
R - *resources* representing human and technical resources (means of internal transport and equipment),
Q - *material flows* defining volumes and structure of material flows and range of transformations related to shipment orders and supplies,
P - *logistics process* mapping sequence of material flow transformations,
I - *information system* representing mechanisms triggering, controlling and confirming material flows,
O - *organization* defining ways of transforming material flows in current situation.

The model of warehouse processes bases on foregoing model of warehouse facility:

1) Warehouse is divided into functional areas performing consecutive phases of warehouse process.
2) Warehouse process is split into phases of *supplies* (purchased materials are moved from loading docks to storage areas) and *shipments* (ordered materials are moved from storage areas to loading docks to be shipped). Material flows in both phases are non-correlated in a short time (like day) but are performed by shared resources in the same functional areas.
3) The basic flow unit is *purchase-line* for supplies and *order-line* for shipments. Line is a part of a sales order or purchase order that specifies the detailed information about requested (single) item. Plausible variants of line realization are called *itineraries*.
4) Each itinerary has defined probability of occurrence, wherein some itineraries are more plausible (primary processes) than other (auxiliary and emergency processes).
5) Probability of itinerary selection can be increased by equipment modernization, re-organization and improving storage capacity.
6) Itinerary is composed of sections of determined duration. Duration time can be set as random variable dependent on availability of resources, materials and space in current system state.
7) Aggregated duration time of itinerary is used to set efficiency and reliability parameters of warehouse.

2.2. Functional areas and material flow transformations

Warehouse functional areas correspond to places where parts of warehouse process are performed. Functional areas most commonly use specialized technologies of material flow handling or transforming which results from process requirements. Functional areas group physical locations (addresses) which are places where units of material are directly put or retrieved from. Locations in functional area can be divided into sub-sets of locations engaged in particular stages of warehouse process. In that way set of functional areas \( FA = \{1, 2, \ldots, fa, \ldots, FA\} \) is decomposed (*Figure 1*) into set of nodes \( SF = \{1, 2, \ldots, sf, \ldots, SF\} \).

Nodes extracted from warehouse functional areas are categorized by four sets \( A \cup B \cup C \cup V = SF \) where:

- **A** - set of sources of material flows entering warehouse (supplies) \( a, a \in A \),
- **C** - set of mouths of material flows exiting warehouse (shipments) \( c, c \in C \),
- **B** - set of nodes representing storage areas (long-term storage) which are both; internal mouths and sources of material flows \( b, b \in B \),
- **V** - set of intermediate nodes \( v, v \in V \) (*Figure 1*).

To represent material flow structure the following sets are defined:

- set of material groups \( GM = \{1, 2, \ldots, gm, \ldots, GM\} \) representing types of goods or / and package forms,
- set of time moments \( T = \{1, 2, \ldots, t, \ldots, T\} \),
- set of types of transport equipment and machines \( U = \{0, 1, 2, \ldots, u, \ldots, U\} \),
- set of labour categories \( H = \{0, 1, 2, \ldots, h, \ldots, H\} \).
Each unit of material of \( gm \)-th group entering the facility is subjected to sequence of transformations whose ultimate goal is to ship it to customer in accordance with order. Transformations are interpreted as transitions between pairs of structural nodes. For simplicity all transformations are divided into two groups: 1 / movement within functional area and between them, 2 / processing (conversion), including: simple production, breaking and consolidation, control and identification (delay) and buffering (awaiting and short term storage). Type of transformation is formally noted as \( i(sf, sf') = 1 \), if material is moved between nodes \( sf \) and \( sf' \), \( i(sf, sf') = 2 \) if material is converted or buffered and \( i(sf, sf') = 0 \) if no transformation occurs between nodes (Figure 2). Only one connection between two nodes \( sf \) and \( sf' \) is possible. In case of larger number of transformations between nodes the deeper decomposition of warehouse structure is necessary. Buffering capacity of functional area is represented by maximal number of transformations \( i(sf, sf') = 1 \) to be performed at the time between nodes representing that area.

![Figure 1 Basic warehouse process decomposition](image)

\( \text{Figure 1 Basic warehouse process decomposition} \)

Transformations can be divided into two groups according to the phase of warehouse process. The first group of transformations \( I_{in} \) fills storage areas (supplies) while second group \( I_{out} \) empties them (shipments). Accordingly, set of all transformations concuring to warehouse process is described as \( I = I_{in} \cup I_{out} = \{ (sf, sf') : i(sf, sf') \in \{1, 2\}, sf \neq sf', sf, sf' \in SF \} \).

Transformations of material flows \( i(sf, sf') \in I \) are interpreted as transitions between nodes \( sf, sf' \in SF \). Nodes arise as a result of decomposition of functional areas \( fa, fa' \in FA \). Thus, it was assumed that the structure of logistics process in warehouse can be represented by graph \( G : G = (SF, I) \) where \( SF \) is a set of nodes and \( I \) is a set of edges.

![Figure 2 Transformations in warehouse process](image)

\( \text{Figure 2 Transformations in warehouse process} \)
Daily volumes of successive transformations depend on supplies and shipments structure. Supplies and shipments are given as random variable of known distribution \( \{Q_{in}(gm,t), p(Q_{in}(gm,t)) \} \) and \( \{Q_{out}(gm,t), p(Q_{out}(gm,t)) \} \). Distributions are determined on the basis of historical data. It was assumed that supplies and shipments from the warehouse are independent in a short time (usually day). In the long term the structure of supplies and shipments are correlated due to the planning mechanisms.

As previously described material flow volumes are expressed by number of purchase-lines \( pl, pl \in PL \) (supplies) and order-lines \( ol, ol \in OL \) (shipments) submitted to the system. Realization of purchase and order lines may be done in different ways - depending on the availability of resources and the structure of supplies and shipments. Possible variants of line realization are noted as itineraries.

2.3. Warehouse process - itineraries

Ordered set of process itineraries corresponding to possible passes of materials through the warehouse constitute a warehouse process. Itineraries are interpreted as acceptable paths in graph \( G \). The path depends on unoccupied resources that can be assigned to the realization of each line in consecutive instants. Path in graph \( G \) is established separately for each purchase and order-line. Process itinerary is an element of logistics process determining sequence of handling operations, conversions and delays caused by buffering performed on materials specified by purchase or order line. Therefore, itinerary defines the technologies and resources applied to its realization ([9], [11]).

Each itinerary is described by sequence of nodes of which the first is the start of relation and the last one is the end of relation. Passing relation of supplied materials is defined as ordered pair of nodes \((a, b)\) where \( a \in A \), \( b \in B \) and passing relation of shipped materials is defined as ordered pair of nodes \((b, c)\) where \( b \in B \) and \( c \in C \). Filling and emptying processes described above can differ for different groups of materials, so any two nodes \( a \) and \( b \) or \( b \) and \( c \) can be connected by many process itineraries. The single itinerary connecting source \( a \) with storage area \( b \) is numbered as \( e_{in} \) and noted as follows:

\[
pp_{in}(a,b,e_{in}) = \{(a = sf_{1}, sf_{2}, \ldots, (sf_{n}, sf_{n+1}, \ldots, (sf_{n}, sf_{n+1}, b)\}
\]

Set \( E_{in}(a,b) \) gathers process itineraries for relation \((a, b)\). By analogy single itinerary connecting storage area \( b \) with exit \( c \) is numbers as \( e_{out} \) and noted as

\[
pp_{out}(b,c,e_{out}) = \{(b, sf_{1}), \ldots, (sf_{n}, sf_{n+1}, \ldots, (sf_{n}, sf_{n+1}, c)\}
\]

while \( E_{out}(b,c) \) is a set of itineraries for relation \((b, c)\).

Daily volumes of supplies and shipments dictate content and number of purchase and order-lines. Single line can be realized in different ways, but total number of possible itineraries is known. The probability of particular itinerary selection depends on technical and organizational factors, but itineraries representing primary (desirable) process are more likely than other. Basic factors influencing itinerary selection are: free space in buffering and storage areas (for supplies), and availability of ordered materials (for shipments).

If ordered item is not available in functional area or will not be available within specified time, probability of selection of itinerary including that area is 0. Each purchase or order-line has appointed tree of decision situations embracing all possible itineraries of realization. The exemplary tree of itineraries for single shipment line is presented in Figure 3. Material flow processes can be disturbed by errors and mistakes, in most cases of human origin. Detection of any error can be done at specific stages of the process. Error detection triggers corrective operations, which are elements of different itineraries.

2.4. Model parameters

In addition to previously-defined sets, each type of route and each material group must be described by additional parameters (selected):

\( n(u) \) - number of available vehicles / machines of \( u \)-th type,
\( n(h) \) - number of available workers of \( h \)-th labour category.
2.5. Decision variables

The model can use following decision variables (selected):

\( l_1(u, gm, pp_{in} (a, b, e_{in})) \) \(-\) number of vehicles / machines of \( u\)-th type necessary to service unit of \( gm\)-th material under filling itinerary \( e_{in}\),

\( l_2(u, gm, pp_{out} (b, c, e_{out})) \) \(-\) number of vehicles / machines of \( u\)-th type necessary to service unit of \( gm\)-th material under emptying itinerary \( e_{out}\),

\( l_3(h, gm, pp_{in} (a, b, e_{in})) \) \(-\) number of workers of \( h\)-th labor category necessary to service unit of \( gm\)-th material under filling itinerary \( e_{in}\),

\( l_4(h, gm, pp_{out} (b, c, e_{out})) \) \(-\) number of workers of \( h\)-th labor category necessary to service unit of \( gm\)-th material under emptying itinerary \( e_{out}\),

\( t_1(gm, pp_{in} (a, b, e_{in})) \) \(-\) time of performing process itinerary \( e_{in}\),

\( t_2(gm, pp_{out} (b, c, e_{out})) \) \(-\) time of performing process itinerary \( e_{out}\).

Process itinerary duration is set by times \( t((sf, sf'), u, h, gm, gm')\) of particular transformations constituting that itinerary. The time depends on assigned resources, group of material and transformation type.

2.6. Technological constrains and criteria function

The model can use following constrains (selected):

1) Limited resources (available number of people and equipment in moment \( t\)).

2) Itinerary selection (each purchase and order-line must be assigned to itinerary).
3) Maximal itinerary queuing time (from line registration to realization begin).
4) Maximal storage capacity of functional area and availability of ordered materials.
5) Required ratio of successful itineraries to all itineraries in supply handling and shipments.
6) Maximal itinerary realization time for purchase and order-line.
7) Balanced flows between \( A \) and \( B \) and between \( B \) and \( C \) (all started itineraries must be finished).
8) Non-negative flow volumes.

The basic requirement for a process is maximal number of handled shipments and supplies:

\[
\sum_{gm, ol} \left( \sum_{pl, pl', pp_{in}(a, b, e_{in}) \in E_{in}} \sum_{ac, k, b, c} x1(pl, gm, pp_{in}(a, b, e_{in})) + \sum_{ol, ol', pp_{out}(b, c, e_{out}) \in E_{out}} \sum_{bc, c} x2(ol, gm, pp_{out}(b, c, e_{out})) \right) \rightarrow \max
\]  

(2)

3. CONCLUSION

Presented elements of formal model of warehouse process can be freely developed in order to meet specific requirements of particular processes and modelling goals. Process itinerary is a basic mechanism of simulation which is efficient tool of process analyses. Proposed parameters, variables, constrains and criteria function are examples of possible application using only part of potential included in the model.

ACKNOWLEDGEMENTS

The scientific work carried out in the frame of PBS 3 project "System for modeling and 3D visualization of storage facilities" (SIMMAG3D) financed by the National Center for Research and Development.

REFERENCES

INDICATORS PROPOSAL FOR PERFORMANCE PROCESS BASED ON PULL SYSTEM IN CONTEXT OF QMS PRINCIPLES

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Abstract

Production processes (PP) consist of continuous and discrete types of technology operation, transport, manipulation and storing processes regards the flow of material and also the equipment and machines. Other specifics are: long production cycles, great inertia, tree structure of production processes (from roots up to the leaves), high level of investments etc. These characteristics resulted in some specifics of production logistics. This article deals with these specifics and explains it using the conditions of production processes. For process approach it is important that outputs and their Quality & Quantity match the inputs. The principle of Q & Q is about the responsibility of a systems approach.

Keywords: Process approach, quality, customer requirements, customer services, process

1. INTRODUCTION

The aim of QMS is to provide clear instructions and generally applicable behavior for the organization in terms of quality implementation. This system must constantly adapt to the changing demands of customers, or purchaser, or competing consumers of company products. The current quality management systems operate on so-called strength principle, which means that customers 'pull' businesses towards their requirements. The principle of "prosumer" (producer - consumer) pressure from future users is more proffered.

2. PROCESS APPROACH

One of the conditions for successful implementation of quality management system is thorough detection and identification of all processes affecting conformity to the customers' requirements to make them compatible and provide for business development. Processes are divided according to their nature into:

1) Main: custom management, proposal management and development, security of supply, ensure the conformity of the product (production, handling, packaging, shipping).
2) Control: documentation management, planning, management review, internal audits, corrective and preventive action.
3) Support: inspection, testing, measurement and metrology, service, maintenance and repair of nonconforming products, employees' training.

The organization has to document the quality management system, to maintain and to continually improve its effectiveness in accordance with the requirements of EN ISO 9001:2015 - Quality Management Systems. Requirements. It is the responsibility of an organization to determine the sequence and interaction of processes. All of the above described processes need to be monitored, measured and analyzed (Figure 1) [1].

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The basic document for the EMS standard is the EN ISO 14001:2015 Environmental Management Systems. Requirements with guidance for use [2]. The current joint evaluation of "integrated" management system for quality and environment (sometimes called POEMS) contributed to the expansion of application area by combining standards 9001 and 14001. If we consider standard Cartesian axis system, the x axis or the depth represents quality, the y-axis or the width represents environment and the z-axis or the height represents the benefits of joint action [3]. The strategy of socially responsible business, based on the principle of sustainable development, which provides for current needs, but also considers the needs of future generations, is also called a strategy of double benefit. Problems of relation between man and the individual environmental components are the logical consequence of the uneven development of the human population and its access to usage and influence upon nature and competitiveness of the business entity improves [4].

3. CUSTOM LOGISTICS AND CUSTOMER SERVICE

Problems of relation between man and the individual environmental components are the logical consequence of the uneven development of the human population and its access to usage and influence upon nature and competitiveness of the business entity improves [4]. In order for the custom logistics to fulfill all the tasks that are required, it must integrate all business activities related to planning and providing for manufacturing process, to meet customer requirements at reasonable cost conditions [5]. Customer service is a process in which the participants in the supply chain significantly benefit from added value in a cost-effective manner. This process takes place between the buyer, seller and the third party. The result of this process is a value added product or service that is subject to change. Customer service as part of the overall business philosophy can be seen from three aspects, namely:

1) activity or function that needs to be managed,
2) actual performance set to specific parameters,
3) individual activities and measurement of their performance.

Components of customer service can be divided into three groups: pre-sales, sales, after-sales. This classification follows the definition used in marketing that is based on the understanding of market transactions carried out before, during and after the sale. Basic indicators of custom logistics and customer service are handled in Table 1.

Table 1 Indicators custom logistics and customer service, source: own processing

<table>
<thead>
<tr>
<th>Structural framework and indicators</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) The sales volume of individual products in units (pcs, kg, l, m³), [MAX]</td>
<td></td>
</tr>
<tr>
<td>2) The volume of sales of products in the financial units (EURO), [MAX]</td>
<td></td>
</tr>
<tr>
<td>3) Number of orders for the period (number), [MAX]</td>
<td></td>
</tr>
<tr>
<td>4) The total sales volume for the entire range of financial units (EURO), [MAX]</td>
<td></td>
</tr>
<tr>
<td>5) The structure of sales variable = sales volume of the item in EURO / total sales in euro x 100 (%) [MAX]</td>
<td></td>
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<tr>
<td>6) Average customer turnover = total sales in EURO / number of customers (EURO / customer), [MAX]</td>
<td></td>
</tr>
<tr>
<td>7) The average order size = item / order number (pcs / order) or sales volume in EURO / number of orders (EURO / order), [MAX]</td>
<td></td>
</tr>
<tr>
<td>8) Number of expeditions during the reporting period (number), [MAX]</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Productivity indicators</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) The average length of the delivery period = Σ delivery times for the period / number of deliveries for the period (day / van), [MIN]</td>
<td></td>
</tr>
<tr>
<td>2) Productivity expeditionary operations = number of shipments for the period / length of the period (consignment / year), [MAX]</td>
<td></td>
</tr>
<tr>
<td>3) The average speed of response to customer special requirements = Σ times consumed on special equipment requirements / number of special requirements for the reporting period (time / special requirement), [MAX]</td>
<td></td>
</tr>
<tr>
<td>4) The average speed of warranty repairs = Σ time used for the equipment warranty repairs / number of warranty claims for the period (time / repair) [MAX]</td>
<td></td>
</tr>
<tr>
<td>5) The average traffic speed = time used for transport for the reporting period / number of shipments for the reporting period (time / shipment), [MAX]</td>
<td></td>
</tr>
<tr>
<td>6) Average complaints handling duration = Σ complaints handling time used for the handling of complaints / number of complaints during the reporting period (time / complaint), [MAX]</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Quality indicators</th>
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</tr>
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<tbody>
<tr>
<td>1) The consistency of delivery time = (number of deliveries, maintaining the length of delivery time / total number of deliveries during the reporting period) x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>2) The level of service during the delivery period = (number of orders per year - number of transports per year / number of orders per year x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>3) Annual service level = number of stocks transports per year (number), [MAX]</td>
<td></td>
</tr>
<tr>
<td>4) Average delivery time = Σ additional delivery time required to perform additional supplies / number of additional supplies (day), [MIN]</td>
<td></td>
</tr>
<tr>
<td>5) Ratio of accepted items = number of items / total number of delivered items x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>6) Value of accepted items = value of received items / total value of delivered items x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>7) The share of supplies received = number of supplies / total number of completed deliveries x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>8) Value share of received supplies = value of supplies received / realized total value of supplies x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>9) Percentual fulfillment of item = number of items delivered on time / total quantity of ordered items x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>10) Supply emergency of item = number immediately made demands / total number of requests x 100 (%), [MAX]</td>
<td></td>
</tr>
<tr>
<td>11) Availability of spare parts = number of spare parts delivered from stock / total number of delivered spare parts x 100 (%), [MAX]</td>
<td></td>
</tr>
</tbody>
</table>
4. IMPORTANCE OF THE GROUP INDICATORS

4.1. Structural, framework and productivity indicators

They report on the scope and structure of expeditionary operations within a company. They reflect the speed of response to customer orders, requests for other services provided by the supply service and response duration to changing customer requirements.

4.2. Quality indicators and logistics costs

They quantify the level of service provided. They are the most important group of indicators, because they have the highest weight in assessing the supply of customer service. Costs that arise in contract logistics and are related to the time demands on order fulfillment. Another, no less important costs are the records of orders and order processing costs. Other costs are costs for technical and technological assessment, costs for economic and capacity assessment and other costs. These include, for example, the cost of confirmation of the purchase contract and legal costs.

I. Costs for orders processing

The cost of order registration ($C_{RO}$)

$$C_{RO} = P_S + P_H + P_{ICT} + W_W$$

where:

$P_S$ - software price, $P_H$ - hardware price, $P_{ICT}$ - price for ICT, $W_W$ = workers wage.

The cost of order processing ($C_{OP}$)

$$C_{OP} = C_{PE} + C_{ICT} + C_{PO} + W_W$$

where:

$C_{PE}$ - cost of pc equipment, $C_{ICT}$ - cost of ICT, $C_{PO}$ - cost of orders preparation, $W_W$ - workers wage.

II. The cost of technical and technological assessment ($C_{TTA}$)

$$C_{TTA} = (P_C + C_A) \cdot N_A + C_{MDDTP} + W_W$$

where:

$P_C$ - price certificate, $C_A$ - audit costs, $N_A$ - number of assessments, $C_{MDDTP}$ - the cost of maintaining and developing databases of technological processes, $W_W$ = workers wage.

III. The costs of economic assessment ($C_{EA}$)

$$C_{EA} = C_{SW} + C_{CE} + C_D + W_W$$

where:

$C_{SW}$ - software costs, $C_{CE}$ - cost of computer equipment, $C_D$ - cost of documents, $W_W$ - workers wage.

IV. The capacity assessment cost ($C_{CA}$)

$$C_{CA} = C_{Fl} + C_C + C_{PS} + W_W$$
where:

\( C_{FI} \) - cost of information flow from storage, \( C_{C} \) - communication costs in the logistics chain, \( C_{PS} \) - costs of production scheduling, \( W_W \) = workers wage.

V. Other costs associated with the orders logistics

Costs for confirmation of the purchase contract (\( C_{CPC} \))

\[
C_{CPC} = C_D + F_V + F_N 
\]

where:

\( C_D \) - cost of documents, \( F_V \) - fees for verification, \( F_N \) - fees for notary.

Cost of legal services (\( C_{LS} \))

\[
C_{LS} = (F_{VD} \cdot N_D) + F_N 
\]

where:

\( F_{VD} \) - fee for verification of documents, \( N_D \) - number of documents, \( F_N \) = notary fee.

The main problem of the costs that may arise, is an insufficient level of customer service. Thus unwanted costs may incur caused by the loss of unused opportunities even the loss of a customers. The costs spent later on a new customer acquisition are approximately five times higher than the costs that are necessary to maintain the customer's satisfaction. The cost of customer service can be divided into four major groups. The costs of the first group are formed prior to the sale of goods or services. This includes for example the cost of providing information to customers, the cost of presentations and exhibitions. The second group consists of costs incurred during the sale. Here are shipping costs, costs for presentation or installation costs of ICT. The third group includes all costs incurred after the sale of goods or services, such as the cost of claims, and the costs of customer service. The fourth group consists of customer service audit costs. All these groups are further subdivided. Common costs for all four groups are labour costs, energy costs, depreciation, insurance, repairs, etc. [6].

VI. Costs before sale

The cost of providing information to customers (\( C_{PIC} \))

\[
C_{PIC} = (W_W \cdot N_E) + P_S 
\]

where:

\( W_W \) - workers wage, \( N_E \) - number of employees, \( P_S \) - price of services.

Cost of presentations and exhibitions (\( C_{PE} \))

\[
C_{PE} = C_P + C_E 
\]

\( C_P \) - cost of presentation, \( C_E \) - cost of the exhibition.

5. CONCLUSION

Today's business strategy is focused on the so-called 3Cs - Customer, Competitors, Company, while providing high corporate culture, that is - Commitment, Competent, Consistent. QEMS integration based on the process
and the customer approach, as one of its main pillars, requires the monitoring and evaluation of all eligible costs for providing support processes, which are customer service and customer logistics. Success factors and business growth not only benefit the customers, their loyalty/satisfaction, customer experience, customer perception by staff, speed up of processes, but also employee productivity and their satisfaction / loyalty.

ACKNOWLEDGEMENTS

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REFERENCES

LOGISTIC IN PRODUCTION SYSTEM

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Abstract

Paper presents an analysis of the logistics system. The analysis covered the production system manufacture of cement. Logistics system, which was analyzed consists of the delivery, the preparation and distribution of cement. Analysis of stream flow values has been made and identify areas of improvement of the system.

Keywords: Logistics, production system, improvement, reliability of supplies

1. INTRODUCTION

The paper presents organization and implementation of sales in the production system. Supporting decision-making and information logistics department was presented on the example of the functioning of the cement plant. An important element of the presented work is to improve the system of internal logistics and information flow. The aim of the study is to analyze the structure of logistics management elements in relation to the manufacturing process Cement Plant. Also of interest is the use of corporate knowledge in improving standards of systems used to manage the production and distribution.

2. COMPANY’S LOGISTICS SYSTEM

The company's organizational unit, which deals with logistic activities there are designated activities and tasks of this unit. Manager of the logistics department is responsible for activities concerning the [1]:

- the movement and transport of goods (materials, raw materials and articles),
- warehousing and storage,
- industrial packaging, control the level of stocks,
- execution of orders,
- demand forecasting,
- production planning,
- purchases,
- customer service at the appropriate level,
- location of factories and warehouses,
- the processing of returns,
- supply of spare parts and after-sales service,
- storing and disposal of waste products.

Logistics department located within the sales department structure includes its actions transport, supply, distribution, storage of finished products and materials. The combination of logistics department with sales division, functions in the company, which has its own distribution network. The purpose of this division is in this case primarily to provide logistic distribution, but also to supply essential materials.
The organization of the logistics position as the operational coordinator, is used when the various logistical tasks were assigned to departments and agencies, and the need to supervise their. In this case, the coordinator is located in production or trade. Its tasks include the analysis requiring decision-making in the field of cooperation of several organizational units [1, 2].

The process model of the company is related to the implementation and the dynamic development of the logistics concept. In the modern transformation of structures, processes, which are implemented in enterprises, particularly a very important role is played by the processes of integrated logistics. The model company processes customer-oriented it is the execution of orders is a key, fundamental and primary process. However, all other processes in this type of model is presented as another independent processes (Figure 1).

In addition to the key processes of orders and creation of services, creating services they were separated as the supporting processes. This concept is the basis of disposal and execution of key of business process, while ensuring the development of production capacities and new possibilities benefits to customers. Generally, you can not expect a uniform definition of the processes, but you can differentiate and divide the processes according to the specific characteristics (criteria) and define different types of process models. Therefore, the product development process is taken into account in each of the models of business process as a separate process [2, 3]. The logistics process of creating and offering services can be presented as a model of input-process-effects (Figure 2).
Expenditures required for the processes are formed by two groups of agents. The first is expenditure on the objects logistics (materials, goods and information), which are dynamic variables, and their use is determined by the availability of space and time. The production process itself is considered from the point of view of the nature of logistics service in two phases: pre-production and final production [3].

2.1. Analysis of supply chain processes

The essence of the mapping process is to analyze the functioning of the system. This process may include a single process or set of processes and their inter-linkages. The mapping involves the development of graphic diagrams organizational or activities that make up the business process. It is useful in the audit, where it is important to understand the sequence of individual actions and identify primarily those that do not increase value-added [3, 4].

Process maps are used to make changes in the functioning of the economic system by the way:
- implementation of quality management systems
- implementation of process management,
- implement the Lean Manufacturing,
- modeling the organizational structure,
- organization of the company during the restructuring,
- shortening the runtime of processes,
- reduce the costs of carrying out the processes
- implementation of integrated systems,
- transition to a business based on the Internet,
- creation of integrated supply chains.
The second stage is in the accurate identification and grouping the processes and includes:

- division of processes for implementing (main) and support (auxiliary),
- emphasize the key processes from the point of view attain its business objectives,
- reflection processes within individual departments.

The mapping of processes is often used, the following procedure:

- identifying the main participants in the process using a technique called mapping relationship,
- creating a detailed map of the process, presenting all the components of the process [5].

The mapping relationships in the supply chain diagram shows the basic units involved in the logistics processes in the supply chain, and the relationships and cross movement of goods and their associated information. Mapping of relationships allows for a better understanding of the functioning the supply chain by all participants and to reduce the barriers to functional and hierarchical. In addition, the mapping also allows you to improve cooperation between the various links in the relationship sender - the recipient, as well as determining the holders, who are to participate in the further improvement of the analyzed of processes.

A more detailed map is used during the implementation of new products into production or when the cause of the problem are searched in a process in which there are many operations (comb ining materials handling, etc.). Sometimes when you create process maps can be identified lots of places where it is wasted time (and therefore money) or there is a risk that inconsistent products can be delivered to the next of the process (or customer). Distinction of these elements allows their subsequent elimination.

2.2. Reference models in the supply chain

To describe and comprehensive analysis of the supply chain the most commonly used Supply-chain operations reference SCOR (Supply Chain Operation Reference-Model), which is published by the organization SCC (Supply-Chain Council).

This approach takes into account the growing complexity of the business environment and the challenges associated with a holistic approach to supply chain management. This model is based on five main processes, SCM (Supply Chain Management): planning, procurement, manufacturing, delivery and returns and distinguishes four levels of detail. The model does not include items such as: administration, sales, technology development, design, after-sales service [6].

Competitive with this model is the SCM Model proposed by the Association of Global Supply Chain GSCF (Global Supply Chain Forum). This model is based on the eight main processes SCM (Supply Chain Management):

- I. Customer Relationship Management,
- II. Customer Service Management,
- III. Demand Management,
- IV. Order Fulfillment,
- V. Manufacturing Flow Management,
- VI. Supplier Realationship Management,
- VII. Product Development and Commercialization,
- VIII. Returns Management.

3. MAPPING PROCESS IN RESEARCH COMPANIES

Cement Plant is located in central Poland, and its main owner is a foreign company. The cement plant has two lines for the production of clinker for dry method. The plant uses its own deposits of limestone from which it is transported on a production line by road transport. Element allowing the material to produce is a branch of
laboratory. Units of laboratory involved in the control and admission materials, raw materials and semi-finished products in various stages of the process. The manufacturing process is conducted in a continuous movement. Scheme production of cement by the dry method is shown in Figure 3.

Figure 3 Diagram of cement production by dry method implemented in the studied cement plant (legend: 1 - crusher clay, 2 - Stone crusher limestone, 3 - averaging clay, 4 - averaging limestone, 5 - the drying-grinding mill, 6 - homogenization, 7 - tank flour raw material 8 - rotary furnace, 9 - the fuel tank, 10 - tank clinker, 11 - tank plaster, 12 - clinker mill, 13 - cement silos)

Based on the established process, shall be determined targets for further processing components. Objectives of the processes are defined in accordance with the aims of the organization and the expectations and requirements of customers (internal and external) in the process. The goals are defined a particular year and supplemented by current assessment of progress in the implementation tasks in the process according to the needs in the register "evaluation process". The developed card and the designated changes in purposes of the organization are approved by top management.

The strategy of logistics distribution in factories is based on reliable and timely delivery of products to the company's customers. These transport is implemented either from the production plant as a the external storage. Cement plant sells either bulk cement which cement workowanego. It is sent by car transport and rail. Deliveries of cement are realized their own transport organized by the customer (delivery exwork) and transport organized by the Cement Production Plant (car fleet and rail).

4. SUMMARY

Operational risk refers to the many logistics subsystems logistics. It affects the entire supply chain and is mainly due to the imperfections of the current management focused on the supply, manufacture or market goods. Consolidates the various risks associated with the logistics, it is worth get taken a look a group of companies carrying out joint actions. These actions are necessary to meet the demand for certain products in the whole chain movement of goods - from obtaining supplies of raw materials to the final consumer. Such actions may be: the development, production, sales, service, supply, distribution, management, actions to support [7, 8, 9].

The risk is considered both in terms of all phases of the product life cycle (starting from the idea, its production, and ending with the appeal) as well as the processes that create them (occurring in each phase of the product life). The various phases of realization of the product can be implemented across the organization or the physical network that starts at the supplier and ending with the final customer. The basis of the offer logistics of the company's products is the delivery of a cement plant directly to the customer in the "free-recipient".
which is implemented by means of road and rail transport. The main advantage of the sales franco is the total liability of the supplier for the product purchased by the customer, i.e. The recipient does not bear any risk related to the transport. To provide customers with the highest standard of service, Cement plant uses modern means of transport, using the services of professional external transport companies.

The basic condition for the effective functioning of logistic processes are efficient flow of information streams, their range, structure and punctuality. Therefore, the Cement plant used programs to support the process of sales and logistics, with the use of IT.

Understanding the process as logically ordered sequence of processes (operations) occurring within a specified period of time in organizational change fully in line with this concept. Literature identifies three main stages of organizational change: defrosting, which motivates people to change and prepares the organization, a change in the activities carried out in all functional areas of the organization and freeze - which comes to integrating and stabilizing transformation.

REFERENCES
SELECTED ASPECTS OF DESIGNING THE INFRASTRUCTURE NETWORK OF REFUELING AND CHARGING POINTS IN URBAN AREAS FOR VEHICLES WITH ALTERNATIVE SOURCES OF POWER

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Abstract

Utilization of alternative fuels in transport is promoted in many EU documents and regulations. A document which has an impact on the development of infrastructure for alternative fuels is the Directive 2014/94/EU of the European Parliament and of the Council, which establishes a common framework for measures relating to infrastructure development of alternative fuels in the EU. The research problem, which is described in this paper, concerns the designing of the infrastructure network for alternative fuels in urban areas. Proposed research method and its versatility allows for use it to designing the infrastructure network both EV vehicles charging points and refuelling points for NGV vehicles in urban areas. The results obtained in the simulation experiments suggest the possibility of their use in development of national policy framework for actions in support development of the market of alternative fuels in Poland.

Keywords: Alternative sources to power vehicles, alternative fuels market, network of refuelling and charging, PHEV/BEV vehicles, NGV vehicles

1. INTRODUCTION

The processes of globalization consisting in economic terms on the free movement of goods and services determine the growth in demand for transport of both cargo and passengers. The continuing high level of transport in road transport in the European Union (EU) and in Poland involve any negative consequences for society. On the one hand, this causes dependence on imported energy and fuels, on the other hand, becomes more and more burden on the environment [3], [4].

Negative trends leading to increased demand for engine fuels and an increase in total atmospheric emissions of pollutants from road transport have led to the adoption by the European Commission (EC) development strategy for the European transport sector up to 2050 in the form of White Paper „Roadmap to a single European transport area: towards a competitive and resource efficient transport system”.

The principal objectives of the strategy are to reduce Europe’s dependence on imported crude oil, a reduction of 60% of greenhouse gas emissions from the transport sector up to 2050 and the creation of a single European transport area. Implementation of the strategy will force more competition and the creation of an integrated transport network, enabling the combination of different forms of transport. It is assumed that this phenomenon will lead to profound changes in the field of transport technologies in the passenger and freight transport in the range of cities between cities and on long distances. In addition, fundamental changes have occurred in urban transport, which will relate to using vehicles with new construction and technological solutions and alternative power sources. The strategy adopted by the European Commission assumes that up to year 2030 will be withdrawn 50% of vehicles with a traditional combustion engine, and up to 2050 they will be phased out completely [1].
Achieving these objectives requires a number of actions aimed on using a greater range of vehicles powered by alternative power sources and infrastructure development of alternative fuels. A common framework for measures relating to infrastructure development of alternative fuels in the EU sets directive 2014/94/UE [2].

2. REQUIREMENTS OF DIRECTIVE 2014/94/EU IN THE FIELD OF ROAD TRANSPORT

Directive 2014/94/UE establishes a common framework for measures relating to infrastructure of alternative fuels development in the EU [2], by setting minimal requirements for the development of infrastructure for alternative fuels both in terms of charging points for electric vehicles as well as points of natural gas as LNG and CNG. These requirements include mainly infrastructure of road transport and waterborne transport.

The Directive also specified principles for a coherent information on vehicles that can be refuelled by alternative fuels introduced on the market or charged in the charging points. The requirement is applicable to all motor vehicles placed on the market after 18th of November 2016.

Another requirement of the Directive is appropriate marking of distributors and providing the information about the prices of alternative fuels in a way enabling comparing them with regard to unit prices. The Directive obliges Member States to create a system of information which would enable access to information concerning the geographical location of refuelling points and charging points in real time.

In terms of providing of natural gas for transport purposes, Member States must ensure that building of a sufficient number of publicly accessible LNG refuelling points allowing heavy goods vehicles powered by LNG ability to move across the EU. This requirement applies to at least existing core network of the TEN-T. Another requirement is to provide by the Member States the appropriate number of publicly available CNG refuelling points to ensure the movement of vehicles powered by CNG in urban / suburban areas and other densely populated areas. Such as for LNG, and also in cases of CNG Member States must ensure an adequate number of publicly available CNG refuelling points, at least in the existing core network of the TEN-T.

In terms of electricity which is needed to power the EV, the Member States should ensure building of a sufficient number of publicly accessible charging points, which would create the opportunity to move to electric vehicles, at least in urban areas (suburban) and other densely populated areas. The Directive does not specify the number of charging points, or the rules of their deployment. The directive indicates only that the number of charging points should be determined taking into account the estimated number of electric vehicles by the end of 2020.

Under the Directive, Member States should create conditions to ensure operators of publicly accessible charging points free buying of electricity from any supplier in the EU. These requirements relate to the electricity market and the rules introduced by European Parliament and Council Directive 2009/72/WE.

3. DESIGNING THE NETWORK OF CHARGING AND REFUELING POINTS INFRASTRUCTURE IN URBAN AGGLOMERATIONS

3.1. Parameterization of input data

Designing the network of charging and refuelling points infrastructure in urban areas is carried out according to a specific algorithm. Presented in this article authors approach to this problem requires parameterization of input data and determination the order of the implemented measures.

We assume that the set of alternative fuel vehicles classes (EV, CNG, LNG) has the form: \( P = \{ p: p = \bar{1}, \bar{P} \} \), moreover a set of types of alternative fuel vehicles (cars, trucks and tractors, and buses) has the form \( R = \{ r: r = \bar{1}, \bar{R} \} \). Agglomerations which were analysed form a set in the form: \( A = \{ a: a = \bar{1}, \bar{A} \} \). Table 1 shows the parameterization of data necessary for the algorithm and the rules for their calculation.
Table 1 Parameterization of data and rules for their calculation

<table>
<thead>
<tr>
<th>The interpretation of the parameter</th>
<th>The meaning of the parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participation rate of vehicles in agglomeration $a$ in the total number of vehicles in the country in the base year;</td>
<td>$a(a) = \frac{N(a)}{N}$, $\forall a \in A$ where: $N(a)$ is the number of registered vehicles for agglomeration $a$ in base year; $N$ is the number of vehicles in the country in the base year;</td>
</tr>
<tr>
<td>Number of vehicles class $p$ in agglomeration $a$ in period $t$ (year), for which there is analysis;</td>
<td>$\bar{N}(a,t) = \bar{N}(t) \cdot a(a)$, $\forall a \in A$ where: $\bar{N}(t)$ is the number of vehicles in period $t$ in country determined on the basis of forecast;</td>
</tr>
<tr>
<td>Participation rate of vehicles class $p$ in the total number of vehicles in country in period $t$;</td>
<td>$\beta(p,t) = \frac{\bar{N}(p,t)}{\bar{N}(t)}$, $\forall p \in P$ where: $\bar{N}(p,t)$ is the number of vehicles class $p$ in period $t$ in country determined on the basis of forecast;</td>
</tr>
<tr>
<td>Number of vehicles class $p$ in agglomeration $a$ in period $t$;</td>
<td>$\bar{N}(p,a,t) = \bar{N}(a,t) \cdot \beta(p,t)$, $\forall a \in A \land \forall p \in P$</td>
</tr>
<tr>
<td>Participation rate of vehicles class $p$ kind $r$ in country in the base year;</td>
<td>$wu1(p,r) = \frac{lp(p,r)}{lp(p)}$, $\forall p \in P \land \forall r \in R$ where: $lp(p,r)$ is the number of vehicles class $p$ kind $r$ in country in the base year, while $lp(p)$ is the number of vehicles class $p$ in country in the base year;</td>
</tr>
<tr>
<td>Participation rate of vehicles class $p$ kind $r$ in period $t$;</td>
<td>$wu2(p,r,t) = \frac{lp(p,r,t)}{lp(p,t)}$, $\forall p \in P \land \forall r \in R$ where: $lp(p,r,t)$ is number of vehicles class $p$ kind $r$ in period $t$ in the country, while $lp(p,t)$ is number of vehicles class $p$ in period $t$ in the country;</td>
</tr>
<tr>
<td>Number of vehicles class $p$ kind $r$ in agglomeration $a$ in period $t$;</td>
<td>$\bar{N}(p,r,a,t) = \bar{N}(p,a,t) \cdot wu2(p,r,t)$, $\forall p \in P \land \forall r \in R \land \forall a \in A$</td>
</tr>
<tr>
<td>Daily mileage of vehicles class $p$ kind $r$ in agglomeration $a$ in period $t$;</td>
<td>$PD(p,r,a,t) = \frac{\bar{N}(p,r,a,t) \cdot PR(p,r,a,t)}{365} \cdot w\pi(p,r)$, $\forall p \in P \land \forall r \in R \land \forall a \in A$ where: $PR(p,r,a,t)$ is an annual mileage of the vehicle class $p$ kind $r$ in agglomeration $a$ in period $t$, while $w\pi(p,r)$ is the coefficient of daily mileage inequality of vehicle class $p$ kind $r$ : $w\pi(p,r) = (1.2; 1.5)$;</td>
</tr>
<tr>
<td>The number of required recharging / refuelling in the day for a vehicle of class $p$ in agglomeration $a$ in period $t$;</td>
<td>$LL(p,a,t) = \sum_{r \in R} PD(p,r,a,t) \cdot ZP(p,a,t)$, $\forall p \in P \land \forall a \in A$ where: $ZP(p,a,t)$ is a medium range for a vehicle of class $p$ in agglomeration $a$ in period $t$;</td>
</tr>
<tr>
<td>Number of charging / refuelling points for a vehicle of class $p$ in agglomeration $a$ in period $t$;</td>
<td>$LPL(p,a,t) = \frac{LL(p,a,t)}{WP(p,a,t) \cdot wk(p,a,t)}$, $\forall p \in P \land \forall a \in A$ where: $WP(p,a,t)$ is a performance of charging / refuelling point for a vehicle of class $p$ in agglomeration $a$ in period $t$, while $wk(p,a,t)$ is a correction coefficient of performance of charging / refuelling point for a vehicle of class $p$ in agglomeration $a$ in period $t$;</td>
</tr>
</tbody>
</table>
Determining the required number of charging / refuelling points in order to ensure the continuity of transport flows in the studied agglomerations resulting from the availability of points, requires the analysis of the following assumptions:

- number of charging / refuelling points in agglomeration due to the required availability of these points should be considered in the context of the administrative division. So if:
  \[ LPL(p, a, t) \geq LRA(a, t) \] then \[ LPL(p, a, t) = LPL(p, a, t), \quad \forall p \in P \land \forall a \in A \] (1)
  \[ LPL(p, a, t) \leq LRA(a, t) \] then \[ LPL(p, a, t) = LRA(a, t), \quad \forall p \in P \land \forall a \in A \] (2)
  wherein \( LRA(a, t) \) is the number of administrative divisions in agglomeration \( a \) in period \( t \).

### 3.2. The algorithm for determining the number of charging and refuelling points

Development of the EV and NGV market in Poland depends largely on the condition of the charging and refuelling points infrastructure, both in urban areas and also along public roads. It is reasonable to develop a methodology for designing of the network of charging / refuelling points infrastructure, both in terms of its shaping in urban areas and also along the TEN-T core network, which results from the Directive of the European Parliament and Council 2014/94/EU on the development of infrastructure for alternative fuels. In the article the authors restricted themselves to present a methodology for designing of the network of charging / refuelling points infrastructure in urban areas.

Designing of the network of charging / refuelling points infrastructure in urban agglomerations in the form of flowchart is presented in Figure 1.

### 4. CASE STUDY FOR SELECTED URBAN AGGLOMERATION

The analysis includes the Warsaw agglomeration and concerns the development of the network of charging / refuelling points infrastructure in 2020. Conducting complete analysis requires obtaining a number of statistical data and carry out forecasting in terms of the development both the vehicles market in total in the country and also for each class of alternative fuel vehicles. Therefore, in order to obtained results, the number of charging and refuelling points in specific agglomerations will be reliable, we must have a verified statistical data and forecasts with the highest credibility.

In analyses of the Warsaw agglomeration we assumed that the base year is 2014, the year in which in Warsaw was 1 248 661 vehicles (there were cars, trucks, tractor trucks and buses). It was also assumed that the analyses will be conducted for EVs. We considered fast charging points (AD), in which may occur loader with a capacity of about 50 kW for charging DC and 22 kW for charging AC. Charger of this type allow for charging of batteries from 30 to 80% of their capacity in vehicles both BEV and PHEV. It was assumed further that the average charging time of the vehicle is about 30 min. Fully charge of the battery of the vehicle should take place at night, in points of slow charging (AC).

Analysing the problem of the number of charging points for EVs in Warsaw and using the algorithm presented in chapter 3 it was estimated that in 2020, when the number of EV vehicles will be equal to 2732 it will be necessary to build 38 fast charging points (Figure 2). Therefore, considering the number of districts in Warsaw, which is equal to 18, it will be fulfilled dependence (1). Under this assumption, in 16 districts it should be build two fast charging points, while in 2 districts three points.

Assuming that vehicles should be additionally recharged at night, and that 50% of EV is not used at this time, it must be assumed that in Warsaw also should be 1.366 charging points free.

Another parameter influencing the number of fast charging points (AD) for EV is the charging time of the vehicle. The parameter value is varied and depends on the class of charging stations, e.g. for the charging station GARO DC QC 20 with the power 20 kW charging time is up to 60 min., while for the charging station
Figure 1 Flowchart of algorithm

START

Defining the collections: P, R, A

Are collections properly defined?

No

Yes

Determination of parameters: N and N(a)

Is parameter N(a) defined for each agglomeration?

No

Yes

Determination of parameter: α(a)

Is parameter defined for each agglomeration?

No

Yes

Determination of parameter: N(a, t)

Is parameter defined for each agglomeration and analysed period?

No

Yes

Determination of parameter: β(p, r)

Is parameter defined for each class of vehicle in analysed period?

No

Yes

Determination of parameter: N(p, a, t)

Checking of condition: (1) and (2)

STOP
The number of charging points is influenced by other parameters such as the number of EVs and their structure, the average annual mileage and their average reach. Proposed approach allows for carrying out simulation experiments, in which are taken into account different values of presented parameters.

5. CONCLUSIONS

The number of EV charging points is dependent on both the development of the vehicle market and technical-operational parameters of charging stations. Values obtained under analysis for the year 2020 require constant monitoring they should be subject of revision connected with obtaining of more data for the respective periods. The proposed approach is a universal approach, it allows for carrying out simulation experiments for different values of input parameters. This approach can be used both for designing of the network of EV charging points infrastructure and network of NGV refuelling points for vehicles infrastructure. Conducting analyses using the proposed approach allow the decision-makers to make rational decisions, both in terms of the instruments of support for EV and NGV users and entities investing in the development of charging and refuelling points infrastructure in urban areas.

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Abstract
The article is devoted to customer service in the supply chain. Dynamic changing market conditions and trends in supply chains force the improvement of customer service. The first part presents the definition of customer service and supply chain. The article presents selected standards of customer service on the example of the automotive industry. The essence of customer service manufacturer of automotive components is the need to fulfill the requirements of car manufacturers. The main factors of customer service in this company are such elements as; time, reliability, communication, convenience. The aim of this article is to present the elements of customer service for example automotive components manufacturer. In the analyzed elements of the supply chain, customer service is understood as the ability to meet customer needs, particularly as to time and place ordered supplies. The results of this article may be useful to anyone who wishes to use the service of the company and looking for its evaluation.

Keywords: Customer, customer service, supply chain, competition, logistics customer service

Introduction: The article is devoted to customer service in the supply chain. Dynamic changing market conditions and trends in supply chains force the improvement of customer service. The article presents selected standards of customer service on the example of the automotive industry. The essence of customer service manufacturer of automotive components is the need to fulfill the requirements of car manufacturers.

Materials and methods: The paper is based on the available recent scientific-theoretical research and publication. The author analyzed 1 enterprise in automotive industry. The author used case study to show the most important standards of customer service in this company.

Conclusion: The case study clearly show that customer service standards are very important for automotive producer. Selected standards about customer service brings some benefits.

1. INTRODUCTION
The evolution of views on customer service indicates, how far-reaching were the development processes of enterprises in the direction of providing customers with the highest value. Development of business in changing environmental conditions causes the constant improvement of service standards for more demanding customer. Customer service is carried out in all the cells, levels of the supply chain, each of the participants creates value for the customer. The concept of effective customer service in the supply chain is focused on two basis: on the demand side and the supply side with the demand should ensure and focus on the client, which represent the orientation of marketing and supply side represents the interests of logistics channel related to the replenishment of inventories and production.

The consequence of such assumptions, customer service helps increase the opportunistic behavior of the chain and also allows to maintain good relations between the partners, meaning that the nature of competition can change in a partnership and cooperation [1]. Partnerships chain of participants are consistent with the idea of customer service, which result is to create and deliver value to the customer. The article presents the standards of customer service on the example of companies in the automotive industry.
2. CUSTOMER SERVICE STANDARDS IN THE SUPPLY CHAIN

Cooperation and partnership of participants in the chain will lead to a situation that customers get the need product. At this stage consideration to pay attention to the concept of integration of logistics and supply chain. According to the idea of logistics and marketing, which in turn is engaged in manufacturing and its auxiliary processes, and marketing cares about customer satisfaction. The elements of customer service are both logistics and marketing activities, where cooperation in the chain translates into customer satisfaction. Logistics and marketing determining factors for the customer in the supply chain are [2]:

- Availability of supply the products
- Order processing factors
- The adequacy and reliability of supply
- Limitations associated with the size of the order
- The convenience of ordering
- The speed and flexibility of supply
- Information related to the state orders
- Contacts with the seller / supplier
- Billing procedures and their accuracy
- The status of the products at the time of collection
- Condition of the products upon receipt
- Complaints procedure
- Compatibility loading systems
- Tips in the absence of product in stock
- Confirmation of orders
- Competence seller
- Monitoring the level of inventories at the customer
- Interest in the customer’s needs and monitor their needs
- Quality of packaging and wrapping
- Logistics consulting

Providing customers with the benefits and values through cooperation and joint implementation of elements of customer service seems to be the way to the success of the supply chain. It can be said that once the chains make up the value for the customer, supply chains compete among themselves, and not the company that if the chain to efficiently support customers, you will benefit from this all, both the client and partners of the supply chain.

Competing among the supply chains very important is a high level of customer service, which affects the increase in sales, an increase in performance and a better competitive position. Customer service in today's market economy is seen not only as a basis for building a competitive advantage, but also as an element of improving cooperation in the distribution channel [3].

Reaching the high level of customer service through the implementation of appropriate standards requires the inclusion of all chain participants to work together on the basis of detailed information of the selling points, sent to the accepted computer standards. And thanks to information (one of the basic types of streams in the supply chain, in addition to products and cash), possible is to effectively analyze the market, planning of production
processes, preparation of promotional activities, more efficient use of distribution channels through the raise service levels while reducing inventory and costs [4].

The elements of customer service (so as time, reliability, communication, convenience) are considered to create a reasonable and effective customer service program while the measures of customer service will respond to questions as customer service has been implemented in the supply chain, enterprise or branch of the market. Measures of customer service are constructed in different ways, depending on the segment where the level of service it will be measured. The evaluation of customer service measurements in the supply chain evaluation are formulated from the point of view of the customer and are as follows [5]:

- Orders received punctual (on time)
- Orders processed completely
- Orders received without any damage
- Order carefully executed
- Order the exact invoiced

The system measures the level of customer service should have the following issues [6]:

- the primary task of the meter is recording events in the distribution chain, on the basis of which to assess the level of customer service,
- the registration functions should rapidly transform the functions of assessment costs (important is the art of assessing measures from the point of view of costs, which will allow an objective interpretation of the results)
- a set of indicators should provide the necessary information to develop a strategy in the field of distribution,
- system measures should be closely connected with the adopted cycle of order fulfillment.

Why customer service is so important in supply chain; customer is driving force of the supply chain, customer needs are diverse, customers require the timely execution of orders flexibility. These standards must be respected by all supply chain. The challenge of customer service in supply chain are trends of development.

Assumptions in regards to the customer service in the supply chain, allow precise evaluation both from the point of view of costs generated and also performance.

3. THE STANDARDS OF CUSTOMER SERVICE ON THE EXAMPLE OF THE AUTOMOTIVE PRODUCER - A CASE STUDY

The company is one of the world's leading manufacturers of automotive components. For the company customer service standards are very important. The case study show the customer service standards in selected parts of the supply chain in automotive industry. Provided that the requirements of customers are high level of coordination of orders, material supply and production optimization.

Supply chain manufacturer of automotive components is oriented towards achieving a high level of efficiency according to the Kaizen. Objectives and areas of continuous improvement resulting from "lean culture" are about to more efficient layout of the surface, maximum utilization and optimize material flows. At the level of product design the company receives from its customers procurement programs for a period of 5-6 years. The main key role in the supply chain that manufacturer create the automakers. Factors of customer service of manufacturer components are shown on the table [7] (Table 1, Factors of customer service on the example of automotive components manufacturer).
Table 1 Factors of customer service on the example of automotive components manufacturer

<table>
<thead>
<tr>
<th>Factores</th>
<th>Description</th>
<th>Implementation on the example of Automotive producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>- Time of transfer orders&lt;br&gt;- Development time orders&lt;br&gt;- Time order preparation&lt;br&gt;- Delivery time&lt;br&gt;- Waiting time for the ordered products</td>
<td>- Time is a strategic component of competition by the producer&lt;br&gt;- Wasting of time generates high costs, which is why the company attaches great importance to timeliness, which is 99.9% and the rational use of time</td>
</tr>
<tr>
<td>Reliability</td>
<td>- Security of supply&lt;br&gt;- Compliance with the order of delivery</td>
<td>- Through 5S and Kaizen, the company guarantees a high level of reliability of supply&lt;br&gt;- High penalties from customers for failure to meet the deadline or errors in the contract, in addition to mobilizing the company to ensure 100% supply reliability</td>
</tr>
<tr>
<td>Communication</td>
<td>- The efficiency of information flow between the supply chain&lt;br&gt;- The availability of information</td>
<td>- SAP system with suppliers and customers&lt;br&gt;- Emphasis on the constant flow of information and their availability in real time</td>
</tr>
<tr>
<td>Convenience</td>
<td>- Flexibility&lt;br&gt;- The ability to modify the rules of operation under the influence of external factors&lt;br&gt;- Flexible delivery</td>
<td>- The customers have the ability to change the daily orders of 10 - 15% of their value in relation to the resulting sales forecast&lt;br&gt;- Adapting to the needs of the customers</td>
</tr>
</tbody>
</table>

4. CONCLUSION

In the process of managing the customer service particularly very important are standards of its service, which goes far beyond the purchase transactions. The unique role of the information system in meeting the standards due to the guiding principles of supply chain management, which requires the need to shorten and speed up all processes at each stage of the supply chain, while maintaining the required quality of customer service. The case study clearly show that customer service standards are very important for automotive producer. Selected standards about customer service brings some benefits. For the automotive producer standards of customer service means:

- customer orientation in terms of quality, cost, service and technology
- cooperation in the supply chain to share best practices
- internal and external relationships are based on honesty, security, data exchange and integration.
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RELIABILITY OF LABEL FOR PROTOTYPES

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Abstract
This paper presents results of tests done in one of the prototype centre of automotive company. The researchers focused on reliability of labelling made of label printer. At the beginning of the article it has been hypothesized that there is a need of protecting of label printed in prototype shop because of damage possibility during transportation between operating stands. Authors try to justify the hypothesis using the results of case study. The summary of these studies were used to increase satisfaction of plant management and customer. Recommendations prepared based on the analysis are focused on improving of the visibility of letters on the label.

Keywords: Prototype, labelling, visibility

1. INTRODUCTION
Most of companies optimize their activities and modernizes paths of project development. During prototyping process there is no special requirements for labelling or marking. Supplier has a lot of possibilities and can chose the type of component marking. Today’s trends shows that reliability of the prototypes is needed and it is good if durability is confirmed by ageing tests. Described situation is forced by short timing dedicated to design the new solution. This trend is typical for automotive market. Reliability tests of prototypes have become the standard in product development path. That’s why cheap and fast marking method needs to be validated [1, 2].

2. LABELLING FOR PROTOTYPES
Authors tested two types of labels. Paper label currently used for prototypes for internal information only and thermal printed labels made of plastic material which used to be send to customers. Both labels are self-adhesive and manufactured from commercially available materials and can be glued to different plastic components. Today produced labels used for tests are environmentally friendly [3]. Both types of labels were tested under the same conditions using climatic chambers and specified mediums. Researchers postulate that using paper label in selected conditions it can be observed that the information on paper are visible after ageing process and for prototyping it is enough to use this kind of labelling. From company point of view the prototype component has one main role: have to withstand operating conditions during assembling process plus withstand some basic functional tests. This approach has changed when engineering department began a durability tests on proto parts. Currently in automotive market the main type of marking of plastic components is a hard marking because is durable and easy to read even after hard tests simulating road conditions. General information included on hard marking are: a type of material and logo of supplier. But there is a group of information which is changing after every production run like date of prototype building or a component revision number. Hard marking is dedicated to share an information which are constant but in case of markings which are changing the laser marking or labelling is an easier way. Laser marking can be programmed on machine or label can be printed with different text or barcode. On prototype stage of the project printed text is used more often than barcode. This second solution requires dedicated equipment to read and encode the symbols. Prototype Centre does not have any process which can decodes barcode and that is why a big impact on that
decision have costs and a complexity of printed solution. The management sees cost saving and orders extensive testing of this solution [4]. The goal is to find the compromise between easy marking preparation and read versus costs of the marking. That means no additional equipment to encode and easy solution for printing is needed. In parallel marking for prototypes has to withstand some ageing tests or high temperature production process which are described in the article [5, 6]. At the beginning the researchers analysed which technologies do not generate additional costs on start of project implementation. Management requires a solution which is flexible and give a possibility to easy change marked text. Hard marking is rejected because of complicated way for text changes during process. For example the production date can be changed on hard marking when designer will use stamps (clocks) which can be updated to new settings. But this solution require intervention in meld tool. The similar topic was taken by engineers and scientists working on automotive market. One of the well-known by automotive engineers type of the marking is vibration assisted face milling (VAFM) enabling the placement any kind of information on the product surface. The technology is using a piezoelectric milling tool. The milling process is really quick but require dedicated equipment. The process can be used on many type of housing materials for example plastics, steel, aluminium alloy and titanium alloy [7]. But described solution requires special machine what generates additional costs. Competitive way of fast marking giving the same possibilities is laser marking. This type of marking offers the most opportunities for plastic components. Laser marking can be used for some other materials but requires special equipment what generate high costs. This type of marking can be used by plastic manufacturers and companies which are building products with plastic body. Laser marking is giving a possibility to illustrate company logo with high quality [8, 9]. Advantage of both of these methods is ability to make changes in the marking via computer program without changing the settings on the machine. For example operator can pick up the revision of the product if any kind of design change is implemented on final product. Second important point is production date which can be changed automatically. This kind of automatic changes is impossible when hard marking is used. This type of marking requires exchange of the stamp in meld tool what is time consuming. Yet another type of the marking is label printing which is easy to implement and the costs of implementing are 60% lower than other. Additional advantage is a possibility of using colour paper to highlight product of special care. Typically the printers use one colour for printing and it is why colorized paper is liked by operators on the production line, logistic department, model shop or on plant [10]. It is no matter what type of labelling will be used - all information must be readable. That is not important whether this is prototype or production part in case of specific material which have to be disposed carefully. This kind of information is very important for people handling the component [1, 11]. For production phase the labelling has to be automatically read and that is why laser sensing or optical technology may be used. On production line bar code is very helpful because gives a possibility of quick check of the component and verify in the system [12]. In case of prototype area the automatic system cannot be used. That is the reason why the authors are going to test two types of printed labels (no barcode) and check whether the labels are readable after durability tests. The production path and possible failures of label during production are also taken into account. The best solution will be recommended to prototyping centre for marking.

3. DURABILITY TEST PLAN FOR LABEL

Researchers prepared test matrix which included two main paths. First was linked to production path and second included parts of durability path for product. In production path two main types of test were described: mechanical and thermal tests (Table 1). This kind of tests were linked with conditioning in high temperature during potting process. The polyurethane resin required holding a few hours in specified by Material Specification Data Sheet temperature and the label which was glued on prototype component had to withstand this conditions too.
Table 1 Test matrix

<table>
<thead>
<tr>
<th>Group of test</th>
<th>Test name</th>
<th>Label part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests simulates possible production process impact</td>
<td>Temperature storage (a)</td>
<td>UST/16/1101 - UST/16/1106</td>
</tr>
<tr>
<td></td>
<td>Mechanical attrition (b)</td>
<td>UST/16/1101 - UST/16/1106</td>
</tr>
<tr>
<td>Main durability tests</td>
<td>Temperature alternation test (a)</td>
<td>UST/16/1107 - UST/16/1112</td>
</tr>
<tr>
<td></td>
<td>Stone impact (b)</td>
<td>UST/16/1107 - UST/16/1112</td>
</tr>
<tr>
<td></td>
<td>Fluid impact</td>
<td>UST/16/1113 - UST/16/1148</td>
</tr>
<tr>
<td></td>
<td>Salt spray test</td>
<td>UST/16/1149 - UST/16/1155</td>
</tr>
</tbody>
</table>

The test sequence was scheduled according to automotive specification one of the general automotive company in Europe. Based on that temperature test (a) had to be prepared before mechanical impact test (b). In presented above table the sequence is visible for both test groups. Fluid impact and salt spray test are single test and are not linked to any other. That means in this case any other pretesting was not required by customers. The singular test or test sequence was made on 6 pieces of labels as described in column 3 of Table 1. Set of labels for testing included two types of row material: three paper labels and three thermal printed labels. The media used for tests were common for a few customers and the test results are universal. All fluids were taken from test handbooks from customers and specification is common for all of them. Media used for tests are fuel, AdBlue®, engine oil, water, coolant, glass cleaner. The results are going to be assessed for example by percent of label destruction (letters), change of the paper colour, contrast of letters to background, and label adhesion to component. The label was covered by letters on almost whole surface which gave a possibility to count the number of unreadable letters after durability testing (Figure 1).

![Design of the label](Figure 1)

Letters used on label were the minimum font size (font size 9) specified by customer. Authors were going to test the worst case. That allowed to put nine lines of text on the label during experiment [13, 14, 15].

4. TESTING

Described in article labelling type was glued on plastic prototypes made of polyamide with glass fibre (33% of glass fibre) as the only one material used for product line. Before placing of the label on the peace of plastic component the surface was manually cleaned and checked against dust and inequalities. Primer was not used for surface degreasing during experiment because it is not standard approach in prototype centre. During prototype building no cleaning fluids were used. From project point of view it was controlled that the label has to be glued on surface where was no parting lines after injecting process or no depression points after stamps. Location was specially selected by engineer and recommended to label gluing. To cover above described conditions a plastic prototype parts were used for testing. At first the tests simulating possible production process impact were run in order to test matrix. The prototypes during production in model-shop centre were
stored in climatic chamber by 4 hours at 80 °C for conditioning of a potting resin. At the beginning of prototyping process the label was glued on the main body to sign the part and control a process flow step by step. In this case label had to withstand the same conditions as component and had to be readable after finalizing of the build. After temperature storage the mechanical destruction could happen on production line for example during machining or welding process. Temperature impact was unknown and may have made mechanical destruction easier to happen. The test was done on three paper labels and three thermal printed labels and the results were similar for both. Thermal ageing in constant temperature did not destroy the letters and a row material as visible on Figure 2. Only the contrast on label was a little different than on virgin part but this result did not discriminate paper raw material to use in prototype centre. Each letter (294 out of 294) on every label (6 out of 6) was readable and hole labels were accepted after testing. Retention force of aged label was also accepted. The measurement system was specially designed and consisted of holder dedicated to label keeping and measurement electrical device [16]. This solution can be recommended for prototype centre as a proper type of prototype signature. Even if the labels withstand production conditions the durability test which the customer is going to prepare may fail the paper and make the letters unreadable. After sending of the parts to the customer the producer lose control on parts and has to commit to status of the parts (functionality and durability). Before shipping a supplier can check the quality and exchange the label in case of any issue. Further the component is strongly operated by customer and marking has to be visible after basic durability test. That is the reason why the authors run second part of test matrix to confirm labelling reliability. In first step the temperature alternation test was done with temperature profile from -40 °C to +100 °C. Temperature migration takes 5 hours and holding time in max and min temperatures is 1 hour. Profile takes 12 hours in total and 30 cycles were done. In second step stone impact test was performed after temperature alternation test with an interval of one day between tests. Stone impact test was done according to the most restrictive customer specification which were intentionally selected. When the set of tests was finished the labels were assessed via criteria described at the beginning of the article. Temperature alternation test was done before stone impact test and the results were positive after this set of tests as presents Figure 3. Both type of labels were readable and, change of contrast was not detectable by human eye (application of any other digital method was not necessary).

![Figure 2](image1.png)  
**Figure 2** Labels after simulation of production conditions test (left: paper, right: thermal printed)

![Figure 3](image2.png)  
**Figure 3** Labels after durability test (temperature alternation and stone impact)

Low temperatures did not have any impact on labels and the visibility of letters was correct. Retention force decreased maximum 18% versus virgin labels what was acceptable. Stone impact test results were not positive on standard paper label: 289 out of 294 letters were fully visible but it was not enough to be text readable. The failure which may happen when two adjacent letters (one after another) were scuffed what could provide to a situation the production date or part number were unreadable ant that cannot be accepted by operators (engineers and people working on production line of prototype). Short part number and production date were
main information on label which have to be visible during whole live time of component. Thermal printed label does not share any defect of letters which makes them unreadable. Last two test were chemical impact tests and it should have been prepared on separated samples. Both types of label (three part of each) were under 1 hour exposure of medium. Six different mediums were used and the test was performed in room temperature (Figure 4 and Figure 5). All liquids were painted on label twice with one minute interval. Standard brush was used for this operation.

This kind of fluid application on whole label simulates inundation of the label. Retention force test is not applicable in case of paper label because material is damaged. Only thermal printed labels can be checked and the results are changed maximum 11% versus virgin samples. Last one test: Salt spray test was a specific ageing process which allow to check leak and reliability of connections like O-Ring or potting adhesive. Salt spray test is dedicated to the group of products which are exposed on snow or rain. Labelling has to withstand this kind of impact too. The test was done in salt spray chamber according to automotive specification. The results showed that paper label cannot be used for this kind of application versus thermal printed labels which are excellent under salt conditions. The letters after cleaning of the label are fully visible and all information are readable. Marking on paper is polluted and during cleaning whole text was destroyed. The results of the test are shown on Figure 6 [14, 17, 18, 19].

5. CONCLUSIONS

Both types of labelling can be applied to the dedicated application if ageing tests are not applied. Other way the only what needs to be checked are conditions which have to be covered by raw material of label. Conducted tests shows that paper label cannot be under chemical impact at all. Moreover mechanical impact can makes them unreadable. But it does not mean the applications where paper label can be used does not exists. Researchers propose to use the paper labelling for electronic applications where chemical testing is not used and the possibility of stone impact does not exists. That approach generate 62% cost saving. In one of automotive company located in Krakow 4170 prototypes were built during 2015 year. 1807 of them were electronic devices located under car dashboard or inside the passenger compartment. This allow to use paper
label which is four times cheaper than thermal printed label. Other prototype components are located in engine compartment or under vehicle where marking has to be resistant against specific fluids, stone impact and salt may be built with use thermal printed label. This kind of cost saving in one division of company is an added value and every one department may introduce this kind of approach makes the product more green and scale effect will bring cost saving on higher level [3, 4, 19, 20, 21].

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THE MEANING OF THE SUPPLY CHAIN VIRTUALIZATION FOR THE FUNCTIONING OF LOGISTICS COMPANIES

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Abstract:
The subject of this paper is describing what the virtualization of supply chains means for the functioning of logistics companies. Attention shall be paid to what virtualization is and how it is used with respect to logistics, but also, what are the advantages of its application in supply chains.

Keywords: Logistics, virtualization, supply chain, virtual organization, ERP, virtual supply chain

1. INTRODUCTION - DISCUSSING THE MOST SIGNIFICANT TERMS

1.1 Supply chains
The basic notion associated with the discussed topic is the supply chain. Generally, the term „supply chain management” has first been used in the 80s of the XX century, so the concept referring to it can be regarded as relatively new. This chain is defined in many ways. For e.g. M. Christopher claimed that it is a network of organizations engaged through associations with suppliers and clients, in various processes and actions which create a particular value in the form of products and services supplied to end consumers [8].
While P. K. Banchi wrote that the supply chain consists of networks of facilities and contractors that supply raw material and components, subsequently process them into semi-products and sub-assemblies, further use them for the production of end products and finally render their consumption possible to the end consumers [8].

In both definitions provided above it has been indicated that the supply chain is a sort of network that consists of all entities engaged in creating products and services for clients, and particularly suppliers, manufacturers and distributors.

It is necessary to further add that M. Brzozowska stressed that initially, the term „supply chain” was understood as a simple combination of companies that cooperate and exchange goods for the purpose of satisfying their clients’ needs. Gradually however, this definition has become extended by the opinion that supply chains are integrally associated not only with material flow, but also information flow which is necessary to offer particular clients products or services complying with their requirements. The flow of such information concerns for e.g. providing suppliers with information on the amounts of raw material necessary to carry out the production and its delivery time by producers [3].

1.2 Virtualization and virtual organization
The term „virtualization” originate from the word virtus, virtutis, which means fluency, courage, bravery or fitness, as also virtualis, which means effective. In ancient times this word was strongly associated with philosophy and referred to exercising authority and power even if the individual wasn’t physically present in a...
particular place. Currently however, virtualization is tightly connected with IT and particularly cyberspace which is a digital reality and which is created by means of the Internet [10].

Generally, virtualization consists in generating reality by means of computers and the Internet and the coexistence of this reality with what is real. This way, virtualization can mean the ability to act and achieve particular target, but it refers to the unreal. It consists of any information and the organization of its flow, as also the knowledge base [10].

Virtualization can also be treated as a kind of delocalization of business activity, so a transfer of those elements of the company’s functioning which have till now occurred in the real world and which have had a physical dimension, to the Digital world in the form of data stored and processed in IT systems. This way, virtualization makes it possible for companies to present their products or deliver services in any time and place, which is achieved by means of multimedia systems [1].

Virtualization is also associated with the functioning of virtual organizations and for this reason this term also needs to be explained. According to J. Kisielnicki, this organization constitutes a model of the functioning of a company, which includes the voluntary connection of resources remaining to the disposal of the cooperating companies. It is supposed to lead to the performance of a common venture which should bring particular companies benefits larger than if the venture was to be performed traditionally [6]. This definition thus discusses the synergy effect which leads to the fact that companies integrally cooperating achieve significantly larger benefits than if they were to act individually. It is undoubtedly one of the most significant features of virtual organizations.

It is important to add that the subject literature of ten defines virtual organization also as:

- Virtual corporation,
- Modular corporation,
- Virtual company,
- Chain organization [2].

1.3. Virtual supply chains

One of the most important definitions of virtual supply chains has been proposed by Mary Beth Watson-Manheim. She claimed that the chain is a network which includes single companies concentrated on performing one target (venture). This definition thus combines notions concerning supply chains and virtual organization [4].

According to another definition, the virtual supply chain is considered to be a global supply chain that functions within a dynamic network of companies engaged in many various relations, and the functioning of this chain is based on the existence of three mutually associated elements, which are:

- Information and Communications Technologies,
- The competence of the main participants of the performed venture,
- The competence of the participants who deal with carrying out specialist tasks with respect to this venture [5].

2. THE IDEA OF THE SUPPLY CHAIN VIRTUALIZATION

2.1. The idea of the supply chain virtualization

Virtual supply chains have started to occur and develop mainly in the 80s and 90s of the XX century. It resulted from a number of various factors, which according to D. Biniasz and I. Pisz have undergone an intense
technological development, globalization processes and the strives of particular business entities for the increase of efficiency [2].

In case of the first factor, it was connected with an intense IT and technology development which concerned software to a large extent, including systems designer to support management, IT and telecommunication networks, mainly the Internet. Thanks to the systems, such as ERP (Enterprise Resource Planning, so planning the company’s resources) it was made possible to integrate processes occurring within the functioning of companies, which may be achieved thanks to information resources placed in the form of data in particular data bases being part of integrated IT systems. Data integration helps to integrate organization functions and liability which is necessary to use this data, and integration may also take place between two or more companies thanks to other IT systems, such as SCM (Supply Chain Management), SEM (Strategic Enterprise Management) or CRM (Customer Relationship Management) [2].

The development of the supply chain virtualization also resulted from globalization processes, which means processes that led to new networks of associations and dependences occurring between particular markets and companies. Globalization was also supported by the growth of worldwide integration tendencies by means of creating various transnational and trans state connections, relations or political and economic organizations, such as the European Union, collapse of the Soviet block at the beginning of the 90s of the XX century, which on the other hand led to the cancellation of the division of the world into the West and the Communist, as also the cancellation of the borders in global IT networks, which occurred thanks to the Internet [2].

The third factor for the development of the virtual supply chains was the intensified Struve of particular companies for the achievement of efficiency and thus for securing their competition advantage, acquiring new clients, reducing costs and increasing profits. For this purpose, particular entities have started to concentrate on operations connected with eliminating significant costs incurred with its business activity or on the development of key competence and ceasing to compete between employees to the benefit of increasing work efficiency [2].

2.2. Characteristics of virtual supply chains

D. Kisperska-Moroń has included the following to the most significant features of virtual supply chains:

- **Temporariness** - connected with the fact that the chains are created in order to perform a particular venture and upon its completion the structure of the Niven chain undergoes decomposition, so virtual chains break up when the cause of their association disappears; what’s important, even during performing a venture, particular participants may take part in other virtual supply chains or create entirely new ones,

- **Concentration on the client** - the creation of virtual supply chains is supposed to constitute a direct answer to the clients’ requirements and needs, and the client, being the entity of the virtual organization in this case, may also participate in the operations performed within these chains,

- **Geographical dispersion** - the virtual supply chain may include participants - entities that are located significantly far away, even on different continents; it occurs thanks to the fact that IT systems and the Internet, used on a large scale, provide an effective communication between the participants of the chains,

- **Intense application of specialist IT technologies**,

- **The existence of a chain organization structure** - it’s connected with the fact that usually there are no hierarchical dependencies within the virtual supply chains, and only one participant of these chains plays the role of the coordinator of the operations undertaken within a given venture,
using the key competence of the chain participants - a company having competences and resources useful for the performance of a venture, such as knowledge, skills, technology or staff, to a large extent decides about their engagement in the said venture and each stage of the virtual supply chain is executed by the participant who has the biggest knowledge and skills in the scope of carrying out tasks connected with this stage,

- voluntary participation of particular cooperants in virtual supply chains [7].

2.3. Tools and forms of virtual supply chains

Virtual supply chains in order to function consist of a number of various tools. These include, first of all, IT systems, so the systems mentioned earlier in this paper ERP, SCM, SEM i CRM. Their place in the virtual supply chain is illustrated by Figure 1.

The SCM system SCM contributes to building and strengthening proper relations with suppliers, the ERP and SEM systems integrate operations undertaken by particular participants of the supply chains, whereas the CRM system is responsible for the adequate level of customer service.

It has been mentioned that one of the participants within the virtual supply chains accepts the role of the coordinator. The coordinator’s basic tasks include:

- Constant control over operations undertaken within particular elements of the chain,
- Maintaining constant contact with clients,
- Acquisition of new counterparties for the performance of the venture,
- Constant extension of the logistic network,
- Adding demands for particular products or services [11].

The coordinator’s duties can be fulfilled by the virtual logistics center. His place in the virtual supply chain is illustrated by Figure 2.
The virtual supply chain tools include, apart from IT systems, various Internet portals, catalogues and electronic repositories, data warehouses, transaction systems, Communications systems, information systems and specialist systems and software, such as digital maps, banking systems or applications for the planning of supply chains [10].

- Virtual supply chains may function within various form types. Generally, they include:
  - Virtual education systems, such as Virtual Training Calendar,
  - Virtual design organizations (PartNet oraz ARPA Distributed Design of Electronic Systems),
  - Distribution centres (San Diego Source),
  - Virtual trading organizations (Global Trade Point Network oraz TradeNet World Service),
  - Regional centres of economic development (Small Business Administration or Virtual Competence Center for Environmental Issues),
  - Virtual manufacturing organizations (European ALFA Project - Global Virtual Enterprise) [2].

3. THE ROLE OF VIRTUALIZATION IN THE DEVELOPMENT OF LOGISTICS COMPANIES

3.1. Strong and weak points of the virtual supply chains

It is to be indicated that the supply chain virtualization results in a number of various implications for companies providing logistic processes, and you can distinguish both positive and negative aspects concerning its implementation. Below an example of the SWOT analysis has been illustrated for a hypothetic virtual organization, which contains the most significant aspects.
Table 1 The SWOT analysis for a hypothetic virtual organization

<table>
<thead>
<tr>
<th>STRONG POINTS</th>
<th>WEAK POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- high performance flexibility</td>
<td>- the necessity to possess large funds for the purchase of data bases</td>
</tr>
<tr>
<td>- fast order execution</td>
<td>- the necessity to generate trust between the chain participants</td>
</tr>
<tr>
<td>- minimization of transaction costs</td>
<td>- the necessity to incorporate incompetent or unreliable organizations</td>
</tr>
<tr>
<td>- reduction of investments</td>
<td>- difficulties in liability collection from the organization participants</td>
</tr>
<tr>
<td>- common operational strategy of different organizations</td>
<td>- Lack of formal supervision over transaction execution</td>
</tr>
<tr>
<td>- bringing into the organization best competence of cooperants</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POSSIBILITIES</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fast reaction to changes in the environment, including the reaction to the creation of market niches</td>
<td>- low efficiency of technologic equipment in networks</td>
</tr>
<tr>
<td>- execution of orders despite legal or organizational obstacles</td>
<td>- Lack of legal regulations with respect to the functioning of virtual organizations</td>
</tr>
<tr>
<td>- applying modern management techniques</td>
<td>- Lack of customer interest in the services offered by the organization</td>
</tr>
<tr>
<td>- possibility to start cooperation between organizations that could cooperate in other conditions</td>
<td>- resistance of many companies to implement changes in the methods of executing transactions</td>
</tr>
<tr>
<td>- New customer groups</td>
<td></td>
</tr>
<tr>
<td>- Lack of prejudice between the chain participants</td>
<td></td>
</tr>
<tr>
<td>- an unlimited information flow</td>
<td></td>
</tr>
</tbody>
</table>

As it results from the above table, with respect to the functioning of virtual organizations we can distinguish slightly more weak points and more advantages rather than threats. This causes that organizations constitute an undoubtedly significant factor which can influence the development of many companies, including logistics, as well as that it is justified to consider their meaning for increasing the efficiency of particular companies or for the improvement of their competitive situation is very large.

3.2. Advantages and disadvantages of virtual supply chains

Virtual supply chains have a number of both advantages and disadvantages. The former mainly include:

- Possibilities of particular cooperants’ abuses or violations,
- Problems with the identification of employees,
- Possibility of the virtual supply chain transforming into a number of separate contracts concluded by selected partners,
- Loss of the control over partners, connected with authority decentralization within the chain,
- Market immaturity, including the Polish market, to use the solutions offered by virtual organizations,
- Differences in management styles of the particular participants of the chain,
- Differences in referring to the adopted norm and value systems,
- Lack of confidence [2].

Virtual supply chains have a few disadvantages. A large part of them is associated with foreign partners and the possibility of their non-compliance with the provisions of the contracts, their individual initiatives to start
cooperation exclusively with selected participants of the chain, their abuses and frauds or their actions to the
detriment of the remaining participants of the virtual organization.

Despite the above, it is worth indicating that currently, in the time of a technology boom, including IT and
information, the virtual supply chains create almost enormous opportunities for a number of logistics
companies and it is most certain that these companies should take advantage of these opportunities. The
previous subchapter already discussed many of them. For e.g. the opportunity to access new customer groups:
starting cooperation with entities, in the case of which no cooperation could be possible without the
opportunities created by the IT systems and the Internet; in the scope of unlimited information flow, delivery of
orders without the existence of particular legal or organizational obstacles.

Moreover, virtual supply chains are becoming extremely useful for the present companies due to many
advantages. Generally, there are at least several dozen of advantages and for this reason this paper shall only
mention the most significant ones:

- Significant shortening of deadlines for the execution of orders and tasks,
- Division of profits between all participants of the virtual organization,
- Increased process efficiency,
- Division of costs between all participants of the virtual organization,
- Optimization of the production value chain,
- Productivity growth which is the result of the maximum use of the chain participants’ competence,
- Increase of the chain fluency and flexibility,
- Increase of motivation and engagement of the employees,
- Fast information flow in case of long distances,
- Effective acquisition of new markets,
- Possibility of off-site work, such as telemarketing,
- No agencies,
- Division of market between all partners,
- Extension of possibilities of performing work in the scope of R&D, that is Research and Development [2].

As you can see, there are a lot of advantages resulting from using virtual supply chains, what’s important there
are more advantages than disadvantages. The above mentioned advantages should also include those that
are connected with the fact that creating virtual supply chains leads to additional components, that is virtual
customers for logistic services, as also implementation of a new term which is the added value. It is a selective
logistic information referring to various aspects connected with the supply chain. This value is executed within
virtual supply chains mainly through:

- reduction of time and logistic costs which is achieved thanks to the effective organization of supply
  processes and which leads to the optimization of the entire supply chain,
- increased possibilities in the scope of collecting and monitoring any kind of need for logistic activity,
- effective monitoring the condition of the supply chain, including for e.g. the condition of the warehouses
  or logistic infrastructure,
- proper maintenance of logistic systems for electronic documents,
- introducing processed logistic knowledge to the service [11].
- The significant meaning of virtual supply chains for logistics companies is also illustrated by the fact that
  they contribute to the implementation of many positive changes with respect to the employees. These
  chains:
- almost force constant investments in human resources which on the other hand contributes to the
  improvement of efficiency and quality of their work, as also to the increased engagement in the customer
  service process,
• cause employees to more willingly engage in company management and make the most significant decisions concerning its functioning, including decisions of strategic nature,
• make it possible to base on key competence of the employees thanks to which it is possible to use their knowledge, skills, ideas or information on virtual tools to the maximum,
• make integrated management based on cooperation and harmony between the interior environment and the exterior virtual organization real [2].

4. CONCLUSION

Concluding the paper, it is important to stress that virtualization is a relatively new phenomenon as it started to develop only in the 80s and 90s of the XX century. Despite the above, you may observe increased interest of many economic entities in virtualization, including logistics companies. The reason for this is mainly that virtual supply chains, despite their many disadvantages, also have a lot of advantages and their application may contribute to the achievement of many benefits by the mentioned companies.

Among the advantages, there is first of all the possibility of starting cooperation with companies having registered offices almost all over the world, reduction of risk and costs incurred in connection with running a business, increase of flexibility, fluency and functioning efficiency, the possibility of improving the execution of particular process and tasks, increase of employees’ engagement in management processes or fast information flow. Moreover, due to the fact that each of the partners contributes to the virtual organization its best competence and fulfills its duties in the scope of the particular stage of the virtual supply chain with respect to the most useful competence, the synergy effect is achieved which on the other hand increases the effectiveness of the operations conducted by the participants of the chain. Participation in virtual organizations increases the scope of activity and the number of potential customers which simultaneously makes it possible to offer products and services to a larger number of clients. It is important to stress that using virtual supply chains by logistics companies is very much reasonable and necessary.

REFERENCES

Abstract

This article is focused on the issue of internal packaging logistics in a manufacturing company. The object of the study is internal packaging management and intensification of the use of storage space. This article aims to analyze the current state of warehouses occupancy and used packaging and design solutions to increase utilization of internal packaging and more efficient use of warehouse space. On the basis of this analysis a set of recommendations was compiled, including the use of new internal packaging sizes, rules for the use of individual packaging sizes and implementation plan, including the necessary organizational and technical measures. The use of applied methodology in the manufacturing enterprises in general is also discussed.

Keywords: Internal logistics, packaging, reusable containers, warehouse, utilization

1. INTRODUCTION

Two conceptions could be distinguished speaking about internal logistics which is not as clearly established in literature as the logistics itself. The first concept is dealing with issues linked only to non-production items, for example, depending on what business you are in, the concept might include legal correspondence and contracts, travel tickets, samples for laboratory tests and other samples, supply of IT and other technical or non-technical equipment, marketing materials and other products which are used internally. On the other hand internal logistics could be perceived as the concept working with that part of logistics chain which is bounded by supply and distribution logistics. In this concept, also used in this paper, we deal mostly with the inbound flow of material, semi products, packaging and logistics of manufacturing processes.

1.1. Internal packaging

Packaging affects almost all of the cost items in supply chains. Packaging costs mainly refer to the packaging material costs and labor costs [1]. However, many aspects of logistics cost items are impacted by packaging too. For example, damages, cargo handling, control, and warehousing costs are dependent on quality and performance of packages, and on information carried by the packages. Risks are much determined by the packages being used and packaging design alters the physical density which would affect the freight rates, warehousing and handling cost directly. Costs can be saved usually by improving the efficiency and effectiveness of the packaging design [2]. Packaging and packages tends to fulfill various functions, such as [3]:

- Packages in transport and in cargo handling,
- Packaging the manufactured items, as one part of production logistics,
- Package as a means to implement standards to make materials handling and storing easier,
- Package as information carrier that it can act as a facilitator of logistics control functions,
- Package can help to trace items in supply chains,
- Package as a channel of marketing communication and promotion.

Packaging used in the company should be volume and weight efficient. It seems obvious but it is still overlooked by many parties. If the volume and weight relation is not designed well, there is poor utilization. The strength of standardized packaging is that it makes it easier to develop efficient logistics systems because...
it places similar demands on transport and material-handling equipment. However, standardization may also lead to less adaptability with regard to change [4].

The use of plastic containers in the production processes where multiple flows of materials consolidate to a single flow at the time the final product is completed and the internal packaging used to transport parts and semi products to the internal customers creates a closed-loop system [5]. The cost associated with a reusable container system are cost of the containers themselves, cost of adapting handling devices to these special containers, and -in addition to the cost of transporting full containers- the cost of transporting empty containers back to their origin or to a central point where they are sorted, cleaned, inventoried and dispatched to the place of their next use [6]. Several studies are available and procedures were developed to determine fleet size to balance investment and containers shortage as well as simulation methods [7]. More reverse logistics issues were reviewed for example by team of De Brito [8].

1.2. Current status of internal packaging logistics in the company

Currently the company for in-house transport and storage of processed wires, which are the main semi product, use three sizes of KLT, see Table 1. Processed, cut wires, assembly or other semi products are transported to interim storage to be later transported to one of more than 300 workplaces in the company. Portfolio of stored semi product includes hundreds of various types and sizes. Not all of them are produced in one period. Some of them are produced only occasionally, some of them are produced permanently, according to customers’ long term demands and requirements. In the context of internal packaging and linked logistics following basic issues could be defined:

1) KLT are not registered and efficiently managed.
2) Purchase of new KLT is not efficiently managed and is subject to acute shortage.
3) The quantity and size of purchased KLT are determined subjectively, based on experience and current acute need.
4) The rules of use of different sizes of KLT are not set.
5) Utilization of KLT is considered to be low.

Table 1 Structure of Internal Packaging KLT Portfolio

<table>
<thead>
<tr>
<th>Structure of Internal Packaging KLT Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLT</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Big</td>
</tr>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Small</td>
</tr>
<tr>
<td>Total Quantity (Pcs)</td>
</tr>
</tbody>
</table>

2. Methodics and Data

Input data for the analysis was obtained by measuring the utilization of internal packaging within warehouses of semi products. During measurement KLT type (high, low, low) and one of 5 levels filling KLT (<10%, 10-25%, 25-50%, 50-75%, 75-100%) of the individual KLT was recorded. From a total of approximately 9009 KLT present in company during the measurements occupancy was measured at 2,624 of KLT (29%) stored in the warehouses of semi products. For the structure of sampled KLTs see Table 2. The aim of this study was to analyze the utilization of individual types of packaging and propose solutions to manage internal packaging that would allow an increase in the utilization of internal packaging KLT least to the level of 70% and a saving of storage capacity.
3. RESULTS

The performed measurements proved the assumption of relatively low utilization of internal packaging. The largest size of KLT (600x400x250 mm) was found to be most efficiently utilized packaging type. Interesting but not surprising founding was that the occupancy and thus utilization of used boxes decreases with its size. That means that the least utilized type of the internal packaging was the smallest KLT (400x300x120mm). The overall results of the measurement, frequencies within various levels of occupancy and average utilization of used packaging types are shown in Table 3. Unbalanced utilization of individual packaging sizes is mainly due to the nature of the products that are stored in them. Although the storage of each product rule are not laid down, workers, on the basis of experience, use for products with a bulky plastic cable-duct largest size KLT, for relatively long but not so volume consuming the medium box and for relatively small and few in number product the smallest box. Such products to fit large KLT usually mean only a fraction of production orders. In practice this means that even about 65% of large KLT is utilized to at least 50% the large amount of other boxes remain to be stored unfulfilled. The situation is the most alarming in the context of small size which average utilization was measured to be only little bit more than 30 %. In these small KLT boxes are often stored special wires about the size of only few centimeters and order size of only a few tens or hundreds of pieces. Most of the volume of KLT remains unused which means the storage capacity is wasted. As shown in Table 2, 70% of small KLT utilization is less than 25%. The overall average occupancy of all measured KLT reaches only about 45%. It could be said that when you increase the utilization of KLT for about 70% can get savings of up to about 30% of storage space.

Table 3 Utilization of Internal KLT

<table>
<thead>
<tr>
<th>Utilization Level/KLT Type</th>
<th>600x400x250mm</th>
<th>600x400x120mm</th>
<th>400x300x120mm</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 %</td>
<td>6</td>
<td>1 %</td>
<td>50</td>
<td>5 %</td>
</tr>
<tr>
<td>10-25 %</td>
<td>214</td>
<td>20 %</td>
<td>363</td>
<td>39%</td>
</tr>
<tr>
<td>25-50 %</td>
<td>348</td>
<td>33 %</td>
<td>322</td>
<td>34%</td>
</tr>
<tr>
<td>50-75 %</td>
<td>334</td>
<td>32 %</td>
<td>159</td>
<td>17%</td>
</tr>
<tr>
<td>75-100 %</td>
<td>149</td>
<td>14 %</td>
<td>41</td>
<td>4 %</td>
</tr>
<tr>
<td>Average Utilization (%)</td>
<td>59.71 %</td>
<td>44.60 %</td>
<td>31.47 %</td>
<td>45.26%</td>
</tr>
</tbody>
</table>

About 15446 KLT packaging was used in the company at the moment of measurement, according to purchase records. The main idea of measures increasing the overall utilization is that content of less utilized boxes should be moved and stored in smaller boxes. As a sufficient desired level of capacity utilization two highest
levels were adopted. It means all the boxes which are utilized on at least 50 % (levels 50-75 %, 75-100 %) are considered to be well used. For those products that were previously stored in large KLT 600x400x120mm, whose workload was lower, it was proposed to use KLT size of 600x400x120mm. A similar measure was adopted for products previously stored in KLT dimensions 600x400x120 mm. For small-scale contract causing low utilization of KLT 400x300x120mm of less than 25% has been proposed to use the new mini-sized KLT and their location in a separate rack. Because that would measure necessitated adjustment of shelves used in the production halls, it was suggested alternative solution using KLT size 400x300x50, which are fully compatible with existing packaging - can be stored on itself and in existing shelves both in stores and in production and have half volume compared to hitherto smallest KLT. The effect of the proposed measures can be simulated via conversion made measurements, see Table 3.

Table 4 Simulated Utilization of Internal KLT after new size implementation

<table>
<thead>
<tr>
<th>Utilization Level/KLT Type</th>
<th>600x400x250mm</th>
<th>600x400x120mm</th>
<th>400x300x120mm</th>
<th>400x300x50mm</th>
<th>SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>10-25%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>6</td>
<td>0%</td>
</tr>
<tr>
<td>25-50%</td>
<td>0</td>
<td>0%</td>
<td>214</td>
<td>363</td>
<td>47%</td>
</tr>
<tr>
<td>50-75%</td>
<td>334</td>
<td>69%</td>
<td>507</td>
<td>374</td>
<td>49%</td>
</tr>
<tr>
<td>75-100%</td>
<td>149</td>
<td>31%</td>
<td>41</td>
<td>22</td>
<td>614</td>
</tr>
<tr>
<td>Average Utilization (%)</td>
<td>82.71%</td>
<td>65.11%</td>
<td>56.35%</td>
<td>100.00%</td>
<td>73.96%</td>
</tr>
<tr>
<td>Measured Share (%)</td>
<td>18%</td>
<td>29%</td>
<td>29%</td>
<td>23%</td>
<td></td>
</tr>
</tbody>
</table>

Based on the measurements and calculations was proposed to expand the portfolio of internal packaging and add the new size. Given the current ratio of containers of different sizes, 3000 pieces of new size was proposed to buy to respect the resulting ratio of the size of packaging 20:30:30:20. By implementing the proposed measures 53% of the largest KLT (about 3955 pieces) and 19% (about 1,066 units) of low KLT will be released empty to be used in a future. In contrast, the measures entail buying about 2,000 pieces of KLT of dimensions 400x300x120 (recent smallest size). Total cost of the new packaging has been estimated at about 18500EUR.

Table 5 Original and estimated new storage need and savings

<table>
<thead>
<tr>
<th>KLT Type</th>
<th>600x400x250mm</th>
<th>600x400x120mm</th>
<th>400x300x120mm</th>
<th>400x300x50mm</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Quantity</td>
<td>3089</td>
<td>4634</td>
<td>4634</td>
<td>3089</td>
<td>15446</td>
</tr>
<tr>
<td>Volume (m3 / Pc)</td>
<td>0.06</td>
<td>0.0288</td>
<td>0.0144</td>
<td>0.006</td>
<td>-</td>
</tr>
<tr>
<td>New Storage Need (m3)</td>
<td>185.352</td>
<td>133.4534</td>
<td>66.72672</td>
<td>18.5352</td>
<td>404.06736</td>
</tr>
<tr>
<td>Original Quantity</td>
<td>7044</td>
<td>5700</td>
<td>2702</td>
<td>0</td>
<td>15446</td>
</tr>
<tr>
<td>Original Storage Need (m3)</td>
<td>422.64</td>
<td>164.16</td>
<td>38.9088</td>
<td>0</td>
<td>625.7088</td>
</tr>
<tr>
<td>Difference (Pcs)</td>
<td>3955</td>
<td>1066</td>
<td>-1932</td>
<td>3089</td>
<td>0</td>
</tr>
<tr>
<td>Total Storage Saving (m3)</td>
<td>221.64144</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Storage Saving (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35%</td>
</tr>
</tbody>
</table>

The aim of the study was not only to increase the utilization of internal packaging in the company but also to save the storage space in the warehouse. As the first target was met with the final utilization of more than 70 %, the second target was met with significant savings of space, in total more than 220 m³ (35 % of original 625 m³), see Table 5. The space saved is about to be used in the future to meet the demands of increasing volume of production which is expected to be around 20 % increase a year.
Several other measures were proposed to deal with registration, accounting, purchasing and rules for the use of internal packaging in the company. To ensure effective management of internal packaging, control their use and the possibility of collecting, analyzing and utilizing data on the flow of individual container is necessary to ensure traceability of individual containers and assign the appropriate packaging for each of the products. During the current state analysis was found that situations when the suitable size of the containers is not available at the workplace occurs quite lot. Workers are forced to use other containers, usually larger size, which is then less effectively used. Barcode labeling system is implemented in the company for some processes such as stocking materials, tracking production orders, identify some workplaces and stock positions, but not for the identification and tracking of internal packaging. Marking all internal packaging with a unique bar code will not only allow to track their accurate records, but also ensure the availability of data on the number of different types of packaging in the various workplaces, as well as the ability to check the accuracy of using various sizes of packaging for various products. Setting of restrictive conditions in the enterprise information system will be directly avoiding the possibility of the use of inadequate packaging without the authorization of the authorized person. When manipulating staff will try to check and stock the unmatched barcode and product packaging system will not allow stocking. An integral condition is also unambiguous assignment of appropriate size of packaging for each product. Recommendations for the purchase of containers mentioned above are based on the analysis of the existing portfolio of packaging. After identification of all products, assignment of container sizes and analysis of data on manufactured quantities of each product, estimation of the required quantity of each pack sizes can be refined. Data on need of various sizes and early detection of needs is currently missing for the effective purchase process. The new management system of internal packaging must also set the appropriate insurance and signal supply levels of packaging so as to prevent their depletion.

4. CONCLUSION

Internal logistics and management of internal packaging in a manufacturing company plays an important role, especially in the context of storage needs. Costs for storage of materials and sub products are a considerable cost factor. Not only for economic reasons we should attempt to lead the company to the highest possible utilization of internal packaging, as well as for their effective management. The aim of this study was to study the utilization of various types of packaging propose solutions to manage internal packaging that would allow an increase in the utilization of internal packaging at least to the level of 70% and serious saving of storage capacity. Implementation of the measures proposed will not require significant capital investment, but will help to significantly increase the utilization of storage space. The proposed measures achieved the increase in average occupancy of internal packaging from the original level of about 45% above the required 70%. Increasing utilization had a positive effect on the storage capacity needed to store semi products with the considerable saving of about 220 m3 (35% of original 625 m3). Although this study was just an initial task of long term logistics efforts in the company, the results are very promising and the future efforts will be focused on more in deep analysis of internal logistics. Further optimization efforts in this area should lead to the very efficient internal packaging management and maximal utilization of packaging, as it is the crucial issue not only because of storage needs in warehouse but especially because of work in progress of each workplace.

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GENERATION OF THE WORLD CLASS MANUFACTURING SYSTEMS

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Abstract

World-Class manufacturing was the term introduced for referring to the goal of achieving and/or sustaining World-Class competitiveness through manufacturing excellence, attained through best practices. The mission of World-Class manufacturing is to bring manufacturing closer to the market by eliminating waste. This mission is translated into reality through the objectives of cost reduction, quantity control, quality assurance and respect for humanity. During the last 20 years the concept of WCM has evolved by changing its basic pillars. The article deals with the changes in the perception and construction of the concept. The author proposed the 3rd generation concept of WCM system based on agility.

Keywords: WCM, world class manufacturing generations

1. DEFINITION OF WCM

Attaining the highest level of manufacturing system organization requires low-cost structural flexibility [1] and the associated response speed and adaptability to the changing market and technological environment. Such postulates can only be met by the best presently defined form of organization called World Class Manufacturing (WCM). A literature review carried out within the WCM concept has shown that there is no universal, recognizable and worldwide accepted WCM definition [2,3]. However, it could be accepted that world class manufacturing is a manufacturing system organization method that enables the highest possible level of manufacturing organization to be achieved by implementing modern management methods. According to the WCM guidelines, organization means presently the highest achievable manufacturing organization level [4]. WCM is currently the standard of organizing contemporary manufacturing activity and may constitute a model for organizing the activity of the entire industrial enterprise. However, due to the diversity of the environment and the speed of changes in the conditions of functioning of enterprises, it is increasingly difficult to maintain its consistent standard in each enterprise, so:

- either x Production Systems (xPS) are designed, which are based on so called production agility adjusted individually to the needs of each production enterprise,
- or existing systems are transformed towards increased production agility.

In economic practice, therefore, sets of uniform organizational guidelines (concepts, methods, tool, etc.) are created, which come within the scope of the implementation capabilities of any enterprise. This is necessary, as there is a wide latitude in establishing individual path to reaching the world class.

2. ORIGIN AND DEVELOPMENT OF WCM

Striving after manufacturing excellence and pursuing continuous improvement programmes in all aspects of functioning of enterprises contributed to the attainment of a leading position by the Japanese economy. Aspiring to attaining the highest level of utilization of production capacity, in a broad sense, contributed, therefore, to the formation of a unique form of manufacturing organization, which enabled the status of world class manufacturers to be achieved. Studies conducted on this subject at that time allowed one to draw the conclusions that of the greatest importance to achieving the competitive advantage in a long-term horizon is to develop organizational factors and human resources in the manufacturing structure [5].
The notion of WCM was first used in 1985 (Hayes and Wheelwright) for describing the organizations that had achieved global competitive advantage as a result of utilizing their possessed manufacturing capabilities and incorporating them into a strategy [6]. The term World Class appeared in many studies to describe the practices developed by Japanese and German companies, which enabled them to effectively compete in global markets. Those enterprises showed many mutual similarities, which the authors named Six World Class Manufacturing Practices, arguing that they are the key to the building of competitive advantage. These practices included [6]: the development of the skills and abilities of employees, the development of the technical competences of managerial staff, competition through quality, the stimulation of the involvement of direct production workers, rebuilding the manufacturing engineering through investments into technological innovations, and incremental improvement methods. At the initial stages of development, the WCM concept was used for determining the leaders in efficiency in individual industries, to distinguish them from traditional manufacturers. A world class manufacture is the one who is able to compete with the best ones in any place in the world [7].

The WCM concept appeared also in studies by Hall, who gave the term World Class Manufacturing to the approach to managing an organization’s functioning that fundamentally differed from the known approach [8], and by Gunn, who defined WCM as a set of innovative technologies that help to achieve competitive advantage [9].

The development of the WCM concept, as proposed by Hayes and Wheelwright, was continued by, fascinated by the advantage of Japanese enterprises, Schonberger who expanded the set of practices up to 16 world class manufacturing principles, including cultural, operational and strategic issues (the practice originally proposed by Schonberger were referred to a the Programme of Actions Towards the Manufacturing Excellence [10]. On the grounds of the good practices proposed by Hayes, Wheelwright and Schonberger, Giffi, Roth and Seal defined the set of attributes that should be possessed by a world class production enterprise, by grouping them into categories related to the manufacturing strategy, production capabilities, management methods, organizational factors, human resources, technology and the measurement of productivity [11]. Subsequent studies extended the WCM concept by focusing their attention on two aspects: the implementation of innovative technologies as a success factor and the importance of the customer in carrying out manufacturing processes [12].

A breakthrough in the concept of WCM compatible organization was the inclusion of lean manufacturing practices in it. Womack argued that the principles of lean manufacturing could be used identically in any industry worldwide [13], and initial research showed that an integral part of world class manufacturing were: the knowledge and skills of employees (hence the need for their improvement), ability and capability to compete through quality, employee involvement in carrying out processes, and continuous improvement. It was also recognized that a prerequisite for the implementation of good WCM practices was the emphasis on developing organizational culture and the construction of the appropriate organizational structure assuring the proper fulfilment of those practices [14]. In turn, by making a synthesis of his studies, Voss isolated 46 detailed practices and means that made up world class manufacturing, including the practices recognized previously as the foundation of WCM, associated with employee skills and capabilities, competing through quality and employee involvement in conducted processes. They were grouped in six key areas [15]: organization and organizational culture, logistics, manufacturing organization, lean manufacturing, concurrent engineering and focus on quality. On the grounds of their studies on good practices within WCM, Motwani, Kumar, Kathawala made an attempt to systematically identify the critical factors making up organizational requirements for world class production. As those factors, they categorized the following [16]: elimination of losses, delivery quality management (timeliness of high quality deliveries), manufacturing control, employee involvement and orientation to quality. Clark, in turn, supplemented the practices used within WCM by including quality management and the JIT concept, naming them New Manufacturing Practices [17]. In turn, Farsijani and Carruthers (1996) made the classification of 28 most commonly used techniques and tools within the WCM concept [18]. In 1997, the team of B.B Flynn, R.G. Schroeder, E.J. Flynn, S. Sakakibara and K. A. Bates
ultimately defined the set of practices proposed by Hayes and Wheelwright and developed by Schonberger and others [19]. A comprehensive synthesis of practices used within WCM were studies by Sharma and Kodala, who made the analysis of identified 23 structures and 252 WCM elements [20]. The grouped good practices (concepts, methods and tools) provided foundations for building the concept of the WCM organization based on so called technical and management pillars.

3. CONTEMPORARY WCM INTERPRETATION

WCM is currently perceived in the world as a set of operation management methods which contribute to an improvement in the productivity of enterprises [21] and make it possible to build a strong competitive position in the market. WCM is a way to solve the problem of how to manufacture at the lowest possible costs, while ensuring acceptable order delivery times and generating the highest possible added value for the customer. There are many operation management methods that try to solve this problem, including [21]: Lean Organization, Six Sigma, Theory of Constraints, Total Productive Maintenance, Reliability Centered Maintenance, Quick Response Manufacturing, Benchmarking, Supplier Relationship Management, Total Quality Management or Total Industrial Engineering. Taking them into consideration enabled common WCM principles to be worked out, which include [21]: dedication to quality, employee involvement, measurement, continuous improvement, achieving growth in top line.

At present, enterprises wishing to take account of the environmental variability, as well as increasing customer requirements, have to be very flexible and, at the same time, thrifty (that is agile). So, the current WCM concept fundamentally differs from the concept of good practices proposed by Hayes and Wheelwright and Schonberger, which is due to its natural evolution. It is recognized as a management model, which is used by the management of organizations having the world's best manufacturing systems, and which relies on the following basic principles [21]: employee involvement, new way of work, accident prevention, customer's voice, respect for established sets and standards, consistent and rigorous use of all methods and tools, no tolerance to losses, visualization of error, removing causes rather than effects.

The contemporary understanding of world class systems is based on the agile manufacturing paradigm. The agile manufacturing paradigm is presently a new competition model, which came into being as a result of combining the principles of mass and lean manufacturing with the modern form of network industrial cooperation in the supply chain. Industrial cooperation allows the system operation efficiency to be increased through the synthesis of innovation in manufacturing, information and communications technologies with thorough restructuring of the organization and new market strategies [22]. Agile manufacturing has developed because of the occurring organizational limitations and shortcomings of lean manufacturing, resulting from constant and unpredictable changes in the turbulent environment. By assuming the effectiveness of the use of resources by minimizing losses and adding values, lean manufacturing was unable to quickly and effectively respond to environmental changes (to use opportunities), while maintaining its resource flexibility and reducing the so-called band of resource-available opportunities. The effect of the progressing global competition was the need for meeting the requirements of customers (different in local markets), who expected products with innovative features and new functional values, at a low cost and a high quality level [23]. In a general meaning, agile manufacturing is understood as the manufacturing that provides enterprises a fast response to dynamic changes in customer requirements and as a way of responding to critical production problems [24]. Quick response is most often associated with the operational capabilities of the system (its flexibility), while the identification of customer demands, with strategic-marketing tools. Presently, agile manufacturing, in a general meaning, encompasses fast product delivery, highly flexible manufacturing and the integration of dispersed enterprises [25]. As stressed by the literature, the main advantages resulting from the implementation of agile manufacturing are [26]: short time-to-market, fast new product development, short / fast order processing, low volumes, low quantities, high product mix, configurable components, fast supplier deliveries, short lead times,
short cycle times, highly flexible and responsive processes, highly flexible machines and equipment, quick changeover, empowered employees.

The natural evolution of the WCM concept, taking place under the influence of both environmental changes and the conditions of conducting manufacturing activity, has developed many models which can still be successfully used.

4. SELECTED WCM MODELS

All models have come into being by the modification of the base WCM model comprising the set of best practices. Nachiappan et. all [27] added that lack of clear consensus and systematic reason or background in the process of selection of tools to form WCM models, has resulted in an inconsistency between different tools and techniques, and increased the chance of unavailing implementation in various conditions. For this reason, the majority of models were formed by grouping good practices into sets of methods and concepts and attributing to them common effects of influence on enterprises. Figure 1 summarizes selected WCM models and their basic components.

The most widely known WCM models include:

1) Schonberger's model (1986). It is based on the set of good practices written in the form of rules. The WCM status can be achieved by any of the two parallel paths: the quality path, and the JIT production path. Hence the presence of concepts, such as: TQC (Total Quality Control), JiT (Just in Time), TPM (Total Productive Maintenance).

2) Hall's model (1987), which is based on three pillars: TQC, JiT Manufacturing, TPI (Total People Involvement), and in practice is often referred to as the value-added manufacturing model.

3) Gunn's model (1987). It is based on the set of good practices grouped in three pillars: CIM (Computer Integrated Manufacturing), TQC, JiT Production.

4) Maskell's model (1991). It is based on the set of good practices grouped in four pillars: TQC, JiT, WM (Workforce Management), FP (Flexible Production).

5) Sharma and Kodali's model (2008). It is based on the set of good practices grouped in four pillars: TQM (Total Quality Management), LM (Lean Manufacturing), TPM, JiT, called also the ME/WCM model (ME - Manufacturing Excellence).

6) Nachiappan et. all model (2009). It is based on the set of good practices grouped in three pillars: TPM, 6S (Six Sigma), LM.
7) Gandhi et. all model (2011). It is based on the set of good practices grouped in four pillars: LM, FCIM (Flexible Computer Integrated Manufacturing), AM (Agile Manufacturing), I&RD (Innovation and R&D).
8) Okhovat et. all model (2012). It is based on the set of good practices grouped in two pillars: L6S (Lean Six Sigma), TPM.
9) Dudek (2013). It is based on the set of good practices grouped in three vertical pillars: TPM, L6S, AM, and two horizontal pillars: TFM (Total Flow Management) and TSM (Total Service Management) [1].

All of the presented contemporary models (since 2008) are based on the classic system of two pillars: technical and managerial. Technical pillars are sets of organizational guidelines in the most important production areas, responsible for so-called production adaptivity. Managerial pillars are a complement to the technical-area pillars. The creation of individual world class manufacturing systems involves the definition and selection of, most often, ten basic technical and managerial pillars from the set of the available areas of potential improvements.

5. WCM SYSTEM GENERATIONS - EXAMINATION RESULTS

Based on the analysis of the components and the concepts, methods and tools most often used in the business practice of Polish production enterprises organized on the WCM basis, the key (crucial) changes in the perception, understanding and evolution of WCM components. Most changes were observed in the areas of perceiving quality, productivity, efficiency and flexibility. Those changes influenced the concepts, methods and tools used in ongoing activity. The analysis of these changes, as well as the moments of their occurrence, helped to create the time-frame and distinguish three generations of WCM systems:

- first-generation systems are based on main concepts, such as: TQC, TPM, JiT,
- second-generation systems are based on main component concepts, such as: TQM, TPM, LM,
- third-generation systems are based on component concepts, such as: L6S, TPM, AM.

The studies carried out have been consistent with the analysis of literature on this subject indicating the occurrence of also two breakthroughs in the understanding of WCM concepts (the introduction of production leanness and the introduction of production agility). These breakthroughs constitute, therefore, the conventional boundaries of division of selected WCM models into 3 generations. Their conventional division is shown in Figure 2.

![Figure 2 Selected WCM models and generations](image-url)
In the case of both the empirical studies and the literature review, the division boundaries result from the natural evolution and from the changes in understanding and interpreting individual component concepts. Thus,

- the first boundary (I/II) results primarily from the exchange of the TQC concept for TQM/6S; change, in particular, in the area of so-called common involvement and the comprehensive perception of quality (both for the quality of products and for their comprehensive effectiveness in processes), and change from the implementation of lean thinking to organizational processes (which resulted, inter alia, in the inclusion of JIT in the set of the basic principles of lean production);
- the second boundary (II/III) results chiefly from the partial inclusion of the LM concept in the 6S area (the simultaneous elimination of the variability and wastage through the effective management of customers, processes and employees) and in the AM area (balancing of the flexibility and leanness of processes through, inter alia, low-cost flexibility [1]).

6. CONCLUSIONS

Evolution, or the process of passing from simple forms into increasingly complex and perfect forms, applies also to world class manufacturing processes. The change process discussed in the paper resulted both from the changes in the enterprises' environment (e.g. tough competition, globalization, escalation of customer requirements) and from the internal need for adaptation to those unpredictable changes (especially to changes in technology, computerization and automation, and increased intellectual involvement backed by the systems of analyses and assessments).

The analysis of the change processes made based on selected Polish enterprises organized on the basis of the original WCM postulates has found, inter alia, that:

- world class systems are built based on different models, most often, however, those categorized into the second generation,
- implemented organizational solutions are, more often, based on an enterprise's own individual compositions of particular base concepts (xPS),
- there is a shortage of tools increasing the response speed at the strategic level,
- a predominant model, upon which world class manufacturing systems are now to be built, should be the agility model,
- in practical solutions, attaining the manufacturing agility should normally be accompanied by a transient state, which is lean manufacturing (concepts, methods and tools that are used in practice are generally those that have been developed by the lean manufacturing paradigm, assuming that agile manufacturing is a natural extension of lean manufacturing),
- a dedicated organizational criterion integrating activities in the manufacturing agility area should be the criterion based on the network of relationships, used for acquiring and integrating dispersed resources from the network (such integration results in an increase in the flexibility of actions, while maintaining the lowest possible system operation cost).

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WHOLE CHAIN MANAGEMENT (WCM) - THE NEW CONCEPT - THE NEW COMPETITIVE ADVANTAGE

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Abstract

Up to now, all the supply chain concepts (LARG, SCM 2.0, Sustainable) have been solving the efficiency of satisfying customer wishes in the supply chain by analysing the efficiency of particular chains or its interactions. The most important practices and methodologies were integration, process management, production value added, automation, leaness, agility, resiliency etc. responding to the actual business environment. The potential of these attitudes have been almost exhausted. Thanks to the system thinking, discovered in 50´s, there is the opportunity to use the new methodology, solving supply chains not only as interacting parts but as the unified whole with the one goal, KPI and methodology. This new concept supports not only doing things right but even during the right things. The whole, Whole Chain Management (WCM), could efficiently and effectively solve problems, such as partial optimizations, partial KPI´s, management of separated parts instead of unified wholes, solving of the opposing goals either in one department or chain in supply chain, etc. None of them has been systematically solved yet. The new methodology could complement analytical approach by synthetic approach solving the properties of the wholes and its utilization for the management of all operational, tactical and strategic processes guaranteeing successful business results - satisfied customers.

Keywords: Supply chain management, demand chain management, system thinking, wholeness

1. INTRODUCTION

System thinking introduced to the technical sciences in 50´s could be used for management of social systems as management of chains fulfilling the final customer wishes. System is described as the whole with the properties which none of its parts have. System is not possible to divided into individual independent parts and its properties are derived from the cooperation of the particular parts, not from the performance of the isolated parts. However most of the supply chains, social systems, are currently managed by particular optimization of the individual parts and their integration in the whole, without the consideration of the real properties of the whole. Current supply chains are managed and optimized to maximize its particular output without interconnection to the properties of the whole. All current supply chain management concepts (LARG SCM, Sustainable SCM, SCM 2.0, Demand chain) have the same logic, just analytical attitude and for the purpose of this paper could be all seen as Old chain management (OCM) concepts. The proposed new conceptual framework, whole chain management (WCM), complete understanding of the wholeness by synthesis and solve the problems such as particular optimization, solving of opposing goals in the supply chains, following just partial KPI´s, etc. The goal of the article is describing the importance of wholeness (fusion of analysis and synthesis) to create systematic interconnection of currently managed independent parts. Wholeness emphasize the properties of wholes, derived from the superior system, which is researched system a part of. Propose concept will be verified on the practical example of management of chains in automotive industry.
2. LITERATURE REVIEW

System thinking has roots in General System Theory, GST [1]. Its goal is the formulation and derivation of those principles which are valid for systems in general. They are of physical, biological or sociological nature. It could be called as the general science of the whole. In modern science, GST presents the focus on interactions of the parts of the system creating the whole, replacing the previous era of Descartes's scientific reductionism focusing on the analysis of the properties of the parts creating the whole. After the introduction of GST in 50's, the main focus of system thinking development was oriented on cybernetics or technical systems [2], [3]. The sociological part of the systems thinking development has become relevant from the 90's [4]. Interactions between the parts creating the whole systems are the corner stone of the systemic thinking used in social sciences, which understands synthesis as tool to create the whole after taking the system apart by analysis [5]. Ackoff proposed an altered definitions of the system, which are used in methodological part describing system thinking [6]. Such an understanding of the synthesis and ability to understand is critical but has not been applied in the social system yet. Latest development of the supply chains management concepts, especially LARG SCM, describes the strong correlation between changing conditions in business environment and aspiration of academic sphere to develop the new and efficient SCM attitudes [7, 8, 9]. Christhoper argues to change the logic of managing of supply chains because of enormous variability and increasing turbulence [10] and utilization of customer oriented principal by implementation of pull principle not only between customer and marketing department of the final producer but even in the all previous chains and processes [11]. The latest Sustainable SCM (SSCM) is defined as a wise balance between economic development, environmental stewardship and social equity [12] or equal balancing for economic stability, ecological compatibility and social equilibrium [13]. SSCM is conceptualized as the strategic, transparent integration and achievement of an organization’s social, environmental, and economic goals in the systemic coordination of key inter organizational business processes for improving the long-term economic performance of the individual company and its supply chains [14].

3. DESIGNED METHODOLOGY

The system is the whole which is not possible to divided into independent parts. The essential properties of any system, the properties that define a system, are properties of the whole which none of its parts have, the essential property of the system originates outside the system, not inside. System thinking is the fusion of analysis and synthesis. Analysis has 3 steps. The first is taking system apart. The second is understanding the parts taken separately. And the third is to aggregate understanding of the parts to understand the whole. Synthesis has 3 steps. The first is identification of the superior system, where is researched system working. The second is understanding of the superior system. And the third is identification the role or the function performed in the upper system. Up to now, there has been focus in the OCM to the analytical attitude only. (see Figure 1). Synthetical part should be add to complete the whole understanding. However, there is common misunderstanding that synthesis is only collection of analytical facts. Due to this misunderstanding, the wholeness loses 50% of its identity. System is the whole with the properties, which none of its parts have. Furthermore, the properties of the superior system depend on the properties of the interactions of the parts, not on the properties of the parts taken separately. Technical system, an automobile, has the superior property to move from point A to point B. None of its parts can do that separately, even the engine. Using only the 3 steps of analysis to technical system an automobile, causes the loosing of the property of the whole and importance of the interactions and properties of the parts as well.
Understanding the wholeness due to synthesis needs 3 more steps. Identification of the superior system, where the examined system is working. The superior system in the case of the car is the society which is using the cars. Second step, understanding the superior system. Superior system is using left side driving, right side driving or the average number of people in average family, representing the number of seats in the car. The car in concrete society needs to have proper side of driving and proper number of seats derived from the superior system which is car a part of, the concrete society, for example. OCM concepts are using just 3 steps of analysis to manage the chain in management of particular chains. The importance of understanding of the context and wholeness in managing of the chains will be described in two critical assumptions.

**Assumption 1.** OCM solve all the important aspects of managing of supply chains analytically by separation of the supply chain in to individual chains (suppliers, forwarders, logistics services providers, producers) and then separated each chain to its particular departments (purchasing, quality, logistics, production, expedition, marketing etc.). Management of the chains in the supply chain or even departments at each individual chain is separated to strategic, tactical and operational planning level. OCM solve the management of these 3 levels of planning analytically by separation them to the disconnected parts (see Figure 2).

**Figure 1** Relation of part of wholeness to management of chains

**Figure 2** Interconnection of types of planning in OCM vs WCM concepts
The 3 steps of analysis take operational apart, understands the parts and put them back to understanding the whole. All the operational processes for example in the warehouse are analyzed separately. At the same time, the analysis of the tactical level, doesn’t mean synthesis of the operational one. There are no systematically solved interaction between these two levels, either horizontally or vertically direction. The same attitude is made for tactical and strategical level of the logistics processes. OCM approach is missing the 50% of the wholeness. There are no systematically solved interactions between these 3 levels of management in the businesses. All the functions and processes are not connected either horizontally or vertically to other processes, so the OCM system is missing the interactions and consequences. KPI helps to manage efficiency of OCM. This efficiency refers only to its separated parts. Separated KPI’s are not able to describe the influence of improved parts either to the next processes in horizontal or vertical integration or to the KPI describing the effectiveness of the whole. See picture 2. OCM approach uses current KPI connected with particular optimization and the targets are set in percentage reduction of each department without connection to opposing goals of each department and its influence to the total costs, for example. WCM benefits from systematically solved horizontal and vertical interactions. Due to the 3 steps of synthesis, it is possible to understand the interactions and managed the superior properties of the operational, tactical and strategical system derived from the outside environment.

Assumption 2. Management of innovations in OCM status and WCM status (see Figure 3)

OCM concepts are focused on analysis of efficiency of particular parts (departments, chains in the supply chain). Simulations, new technologies, industrial revolutions (Industry 4.0) improves the parts, the chains without understanding the properties of the whole and importance of interactions of its parts. OCM concept including 3 steps of analysis as so far missing 3 steps of synthesis, synthesizing the properties of the whole and its interactions. Any processes improved by simulations, new technology, using BSC or Industry 4.0, doesn’t systematically solved, measure and managed the interactions without understanding its influence to the other part of the department in the particular chain or chains in the management of more chains. System thinking focuses on the properties of the whole and derives the performance of the parts and its interactions. The method used to synthesize and innovate the property of the whole is not research but design. Innovation of effectiveness and efficiency at the same time is made by change of the design of the whole chain or management of chains, not by research and analysis of each individual parts.
4. **CASE STUDY**

Application of the new conceptual framework WCM and its two assumptions will be verified on concrete example of worldwide OEM (original equipment manufacturer) from central Europe. The daily production of 3000 cars is supported by flow of 2500 trucks a day, 100 containers and 200 wagons from its 1250 active suppliers. The range of current supply chain is defined as flow of active and passive components in logistics system including material flow, information and human resources from suppliers, forwarders, logistic’s services providers to the assembly line of the OEM.

**Assumption 1** is recognized in management of current vertical and horizontal integration. Vertical integration describes operational, tactical and strategic plans and logistics departments. Horizontal integration connects suppliers, sub-departments in logistics (warehousing, transportation), production warehouses up to assembly line. Current combination of OCM is described by analytical attitude. Each department has its own goal and KPI’s without connection to vertical and horizontal consequences. Improving efficiency expressed by the logistics costs or CO2 emissions is done with the focus of maximum improvement of each individual component of OCM. The results without consequences caused that the most effort of current management to improve is focused on processes with less than 10% of the total logistics costs or 5% of total CO2 emissions. WCM with its analytical and synthetic attitudes systematically defines total logistics costs and CO2 emissions on the operational, tactical and strategic level. Due to the synthetic approach in the each level of horizontal and vertical integration all the management decisions could be focused on 100% of total logistics costs and CO2 emissions. The potential results of improvement in the whole chain management and not only in particular parts without interactions is significant: 10x or 20x higher.

**Figure 4** Ability to interact in KPI’s measuring OCM vs WCM concepts

**Assumption 2** describes the role of innovation in analytical attitude connected with OCM or WCM concepts. Particular innovations are currently focused on technological innovations influencing cost reduction,
ergonomics and CO2 emissions (last SCM concept Sustainable SCM) in production, warehouses and internal transportation in the assembly plant. All these processes are improved by simulations, automated technologies, Industry 4.0 etc. The problem is that all these innovations are not accepted after evaluation of influences not only to its particular performance but the horizontal and vertical interactions influencing the efficiency and effectiveness of the WCM as well. The second thing is, they are made to do things faster, quicker without man power help (bigger trucks, faster truck, automation in warehouses and assembly line supported by simulation, big data, internet of things, cyber-physical system, etc.) without understanding how it influences surrounding environment around, all the departments and chains in OCM. The example of opposing goals like transportation costs vs warehousing costs made by analysis results to improvement of warehouse processes, improvement of transportations costs, but the result of the both improvements to total cost is 0. Why? The more improved transportation causes the less efficient warehousing and vice-versa. Without understanding the whole, without changing the design of the whole inbound processes following the customer (currently defined as assembly line) satisfaction. These particular improvements are still focusing on doing things right, however without understanding doing the right things. The property of the superior system is hidden outside the researched system. One of the system solution, which respects the wholeness are milk-run deliveries improving efficiency and effectiveness dramatically. However, it is utilized to organize inbound logistics processes in described central European automotive producer in less then 0.1 % cases of the all inbound deliveries. In comparison, Toyota Motor Corporation which is understand as system managed organization uses Milk Run deliveries in most than 50 % of all inbound deliveries in to its assembly plants.

![Sources of Innovations](image)

**Figure 5** The scope of OCM vs WCM concepts innovations

Innovations developed by changing of the design of inbound processes doesn’t necessarily need advanced technologies improving speed, volume and accuracy. It does need to manage the consequences and interactions focusing on not only efficiency but even effectiveness in management of chains as the whole, not only particular parts. The difference between impact of OCM innovations and WCM innovations to the whole costs, CO2 emissions is significant (See Figure 5). The very good example describing it in detail is utilization of Value stream mapping tool to improve the total time of delivery of the complete customer order, developed by Toyota motor corporation.
5. CONCLUSION

OCM concepts intended to solve end to end supply chain system including changes in surrounding business environment. The main methodological approach is analysis of the all vertical and horizontal departments, chains in current OCM and the surrounding business environment. Analytical attitude enables to see the whole end to end supply chain only in disconnected parts (departments, chains or even business environment). Christhoper or SSCM concept have tried to apply systemic or end to end solutions influenced by outside business environment, however there hasn’t been used systematic approach, understanding the system thinking especially the properties of the wholes and its influence to the efficiency and effectiveness of parts and its interactions so far. Complete horizontal or vertical integration haven’t been systematically possible yet.

WCM concept is able to describe the whole situations in the business environment and business markets in context. It is possible either due to analyzing the performance of the parts or synthetizing the performance of the interactions and the properties of the wholes derived from the outside environment. The potential of the analysis was exhausted and thanks to system thinking there is the new source of competitive advantage connecting efficiency and effectiveness together which improves customer satisfaction significantly. 2 assumptions of WCM were described on the example of worldwide automotive producer from the central Europe. The holistic approach, well known as the big picture attitude, is used to overcome day to day routines and operational fire-fighting currently protecting to improve not only efficiency but even effectiveness in managing of chains significantly.

Any manager of any company, department or whole chain would appreciate to have systematic KPI enabling him to measure not only the performance of the parts but its interactions creating the whole with other departments, chains or even the changing business environment. Measuring and managing innovations in management of chains with context of the whole costs, emissions and social aspects is significant competitive advantage in current demanding worldwide business environment.

ACKNOWLEDGEMENTS

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REFERENCES


EFFICIENCY EVALUATION OF TRANSPORT INCLUDING SELECTION OF ROLLING STOCK TO TASKS IN SUPPLY CHAINS

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Abstract

To evaluate the efficiency of transport subsystem in complex logistics structures it should be assessed in terms of quantitative and valuable assessment. The quantitative assessment of its efficiency testifies such indicators as performed tonne-kilometers, the number of items handled, the actual working time of transport, the quantity of goods carried, transport costs per tonne-kilometer and per consignment, utilization of working time and transport capacities owned means of transport. The article indicated, that the systemic approach to the assessment, large role play the technical aspects. They take into account the issues, among others: rational use of means of transport, effective operation and their renewal, maximizing the utilization of means of transport, minimizing empty runs.

Keywords: Transport efficiency, efficiency indicators, effective operation

1. INTRODUCTION

In the era of market economy, enterprises devote a lot of space efficiency of performed tasks. Efficiency is treated as feature of the system, which takes into account the impact of the most significant features of the system and the environment on the results of its operation. Thus, the overall efficiency reflects the corresponding relationship between the effects, objectives, expenditures and costs in terms of structural and dynamic [1][3][7][13][14].

To evaluate the functioning of the different classes, including eg. enterprise, supply chains, supply chains is determined certain indicators through which expresses the degree of adaptation of the system to perform a function referred to it. The efficiency of the system is the assessment of its operation and is a measure of the efficiency of its action.

Measuring the efficiency of transport in supply chains is a key factor in the success of the company and gain a competitive advantage [4][5][8][13]. The authors of the studies [34][35] point to two main difficulties in measuring performance, eg. supply chains: firstly the existence of a very extensive and diverse measures of efficiency and efficiency of the elements of supply chains require a variety of data, secondly potential conflicts between participants in supply chains associated with the values of individual measures [9][12].

In the study, the efficiency of transport, special attention is put on the analysis of the technical - technological organization of transportation services and logistics businesses [1][6][7][8]. While creating, shaping, designing and reorganization of the supply chain should be aware that their high efficiency also depends to adapt their equipment to the performed tasks [4]. The efficiency of the transport is one of the basic objectives of supply chain management. Both in terms of supply chain management and analysis of technical - technological organization of transport service enterprises an important issue is the efficiency of choice of means of transport or handling equipment for tasks [5][9][11].

The article analyzes the specific problems of assessing the efficiency of the selection camp for the tasks in supply chains, taking into account of technical and organizational.
2. ALGORITHM FOR CONSTRUCTION EFFICIENCY INDICATORS

To evaluate the quality and efficiency of the system are used in a variety of efficiency indicators for determining the extent to adapt its equipment to perform the tasks. As noted by M. Brzezinński indicators of the logistics system may be either [5][9][11]:

- structural, when they are referred to the structure of the flows of material goods,
- productivity, they are referred to the implemented system tasks,
- economy, they are referred to the cost,
- qualitative, they are referred to the level of customer service.

To formulated efficiency indicators allowed for a proper assessment processes carried out in the test system, recognized the problem in a comprehensive manner. For example, to evaluate the effective organization of supply chains, transport services and the configuration of the supply chain should beehive consider both elements of point and linear.

Many authors believe that the basis for the formulation of a variety of indicators of the effectiveness of the system, eg. Transport or supply network, it is given a set of objectives and targets which is to execute the system. The basic condition for the assessment of any element is to determine the indicators or a set of indicators showing the consistency that will ensure the elimination of conflicts of objectives while determining the boundaries of the areas studied. The algorithm formulation of indicators to assess the efficiency of the selection of the tasks can be represented as in Figure 1.

![Figure 1 Algorithm for construction assessment indicators of the selection means of transport to the tasks](image)

As indicated in the algorithm of the first stage of the construction of indicators to develop guidelines in terms of data availability and ease of calculation and the links to the practice of taking into account the standards and regulatory requirements. The definition of a number of indicators to assess include logistic logistics infrastructure and ongoing processes in the literature is presented in the works of, among others. For example, the author of the work indicates that in order to assess the efficiency of the logistics subsystem "subsystem of transport" should be the quantitative assessment and evaluation valuable. The quantitative assessment of efficiency is determined by such indicators as kilometers, number of means of transport, number of employees of transport department, or the number of failure modes. In the opinion of value as indicators of partial author assumes, among others, transport costs, the value of their means of transport and depreciation costs attributable to transport.
The second phase of construction of performance indicators is the identification of activities that make up the process of transport service. As indicated by the authors [2][13][14] the transport service is the implementation of various types of freight transport, that the required level of service and at an acceptable cost of meeting the needs of customers (traders) located in a given area. At the same time it is determined by the structure of transport tasks, which are determined by both the type and amount of cargo and the relationship movement of cargo and the date of delivery.

The third step is to identify indicators divided into four groups, i.e.: economic indicators, technical indicators, indicators of organizational, qualitative indicators. Assessing the efficiency of the transport subsystem to be made not only by the use of quantitative and qualitative indicators in each group, but also using indicators of productivity. Indicators of productivity, enable the assessment of the reliability and flexibility of transport and the number of damaged goods during transport. Among the indicators to assess the transport lists to e.g. : tonne-kilometers performed, the number of completed shipments, the actual working time of transport, utilization of means of transport and economic indicators such as. Transport costs per tonne-kilometer or shipment.

The last step is the selection of the most important indicators of each group. Among the most important indicators are mentioned, such as: tonne kilometers, the number of items, the actual working time of transport, the quantity of goods carried, transport costs per tonne-kilometer or per consignment, utilization of working time and the ability to transport their means of transport.

For the assessment of the efficiency of the implementation of tasks in the supply chain using various means of transportation, a measure of efficiency changes sd-this variant of the supply chain will be the difference between the performance indicators obtained for variants using s-the means of transport and the variant (in transport) fixed as the base. The relative change in efficiency can be determined as the quotient of the difference of the performance indicators for the base and variant and the efficiency ratio adopted for the base variant in a fixed time interval. This approach allows the comparison of the implementation of the tasks set transport by various means of transport and selecting more efficient because of the considered indicator. This can save the formula [4][5]:

$$\Delta \Xi(s, sd) = \frac{\Phi(s, sd) - \Phi(s, sd)^*}{\Phi(s, sd)^*} * 100\%$$

where:

- \( \Delta \Xi(s, sd) \) - the relative change in the efficiency of the implementation of tasks for sd-th variant of the supply chain in relation to the basic,
- \( \Phi(s, sd) \) - efficiency indicator of tasks implementation for sd-th variant of the supply chain,
- \( \Phi(s, sd)^* \) - efficiency indicator of tasks implementation for sd*-th basic variant.

Calculation of the value of efficiency \( \Delta \Xi(s, ld) \) allows answer the question by how many percent in the given period of time the value of the efficiency indicator \( \Phi(s, sd) \) of implementation of tasks in sd-th variant of the supply chain differs from the efficiency indicator value \( \Phi(s, sd)^* \) in the base variant.

3. **SPECIFICATIONS OF SELECTED TRANSPORT EFFICIENCY INDICATORS**

As the criteria for evaluating the effectiveness and efficiency of logistics processes can be used: the criterion of the time flow of materials and information, the criterion of the level of service quality, cost criterion and the criterion operability action. In assessing the transport efficiency can be distinguished as shown in Table 1.
Table 1 Selected indicators of transport efficiency

<table>
<thead>
<tr>
<th>Technical indicators</th>
<th>Economic indicators</th>
<th>Qualitative and environmental indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>- the degree of effective operation of the device, means of transport, etc.</td>
<td>a) absolute measures:</td>
<td>- loss of time of delivery,</td>
</tr>
<tr>
<td>- the degree of capacity utilization of means of transport in case of realization of transport in transit between cells supply network,</td>
<td>- the cost of executed service,</td>
<td>- duration of logistics tasks,</td>
</tr>
<tr>
<td>- utilization of transport equipment, eg. in warehouse facilities,</td>
<td>- annual operating costs,</td>
<td>- the reliability of logistics tasks,</td>
</tr>
<tr>
<td>- number of means of transport,</td>
<td>- transport costs,</td>
<td>- the risk of lack of delivery measured</td>
</tr>
<tr>
<td>- the number of working hours means of transport,</td>
<td>- the value of means of transport,</td>
<td>the probability of failure of delivery,</td>
</tr>
<tr>
<td>- vehicles mileage</td>
<td>- depreciation of transportation,</td>
<td>- the average number of handling</td>
</tr>
<tr>
<td>- the average mileage of mean of transport,</td>
<td>- the cost of personal transport department,</td>
<td>operations measured</td>
</tr>
<tr>
<td>- the number of failures of mean of transport,</td>
<td>- the cost of storage,</td>
<td>the probability of failure of</td>
</tr>
<tr>
<td>- the degree of storage areas filling in warehouses,</td>
<td>b) relative:</td>
<td>delivery measured,</td>
</tr>
<tr>
<td>- daily working time in storage facilities,</td>
<td>- the share of transportation costs</td>
<td>- the ratio of time moving to the</td>
</tr>
<tr>
<td>- maximization of capacity utilization, vehicles, etc.</td>
<td>in total costs,</td>
<td>waiting time for the storage</td>
</tr>
<tr>
<td></td>
<td>- transport costs per unit of freight,</td>
<td>transshipment, etc. given with</td>
</tr>
<tr>
<td></td>
<td>- maintenance costs of mean of transport for a month, a</td>
<td>respect to the unit load,</td>
</tr>
<tr>
<td></td>
<td>year,</td>
<td>- unit time of the service logistics</td>
</tr>
<tr>
<td></td>
<td>- the cost of the transition units of material through</td>
<td>divided into individual cells supply</td>
</tr>
<tr>
<td></td>
<td>the warehouse facility,</td>
<td>network,</td>
</tr>
<tr>
<td></td>
<td>- costs per tonne-kilometer,</td>
<td>- number of failures means of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>transport,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- minimize the emission of harmful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exhaust emissions,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- minimize congestion in the supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>network.</td>
</tr>
</tbody>
</table>

As previously mentioned the measurement efficiency can have many uses, among which: the choice of means of transport to the tasks, the selection of applied technologies, increase the efficiency of logistics processes, reducing time tasks, reducing costs eg. a reduction in fuel consumption.

4. SELECTED EFFICIENCY INDICATORS FOR EVALUATION OF THE ROLLING STOCK

4.1. General Assumptions for the Designation Efficiency Indicators of the Rolling Stock

For the formal record the following assumptions were adopted:

- with variable s are numbered types of vehicle classes. $S^{ab}$ is a set of numbers, types of classes of vehicles that carry loads in the relationship (a,b), so the $s \in S^{ab}$; wherein payload capacity of the vehicle of s-th typy in tonnes was designated as $q(s)$,

- for each relationship (a,b) $E$ is set volume $Q^{(a,b)}_n$ of weight of the n-type of load in tonnes, and the number $j q^{(a,b)}_n$ - as number of homogeneous palletized units of n-th type of load in the relationship (a, b) in plu, and $q_p(s)$ - as the cargo capacity of s-type vehicle in jlp,

- for each s-th vehicle is set, that the rate of capacity utilization of the vehicle is $q (s)$, wherein it is sought that $q (s) = 0.70 - 0.8$.

- the number of realized deliveries $LD(s)$ determines how many courses must complete s-th mean of transport to realize transport task in relation supplier recipient. This is the max of two values: number of deliveries resulting from the weight of the load $LD_q(s)$, and the number of deliveries resulting from the cargo capacity expressed in a jlp $LD_p(s)$, which can be written with the formula:

$$LD(s) = \max\{LD_q(s); LD_p(s)\} [-]$$
Because the number of realized deliveries affects the duration of the task and the total cost of transport, so the smaller it is the lower the costs of transport and delivery time. In addition, reducing the number of deliveries allows for better utilization of transport means which in the saved-up time can perform other tasks.

4.2. Time and Cost as Significant Efficiency Indicators of the Rolling Stock

Transport time \( T_p(s) \) in (a,b)-th transport relations is the sum of the components of the times, which can be written with the formula:

\[
T_p(s) = t_x(s) + t_j(s) + t_r(s) + t_d(s) \ [h]
\]

where:

- \( t_x^{(a,b)}(s) \) - loading time of s-th type of vehicle written by formula:
  \[
  t_x^{(a,b)}(s) = \frac{\Sigma_{\text{NE}} \theta_{(a,b)}(s) \cdot t_{x_n}(s)}{60} \ [h]
  \]

- \( t_j^{(a,b)}(s) \) - driving time of s-th type of vehicle written by formula:
  \[
  t_j^{(a,b)}(s) = \frac{d(p^{(a,b)}(s)) \cdot [x^{(a,b)}(s) \cdot \frac{1}{v(s)}]}{h} \ [h]
  \]

- \( t_r^{(a,b)}(s) \) - unloading time of s-th type of vehicle written by formula:
  \[
  t_r^{(a,b)}(s) = \frac{\Sigma_{\text{NE}} \theta_{(a,b)}(s) \cdot t_{x_n}(s)}{60} \ [h]
  \]

- \( t_d^{(a,b)}(s) \) - additional time in which the vehicle carries out operations resulting from idle and maneuvering time

With economic assessment indicators of the selection of vehicles for tasks is the cost of realization of the transport tasks in relation (a, b). It is the sum of the costs of vehicle operation \( K_p^{(a,b)}(s) \) and \( K_i^{(a,b)}(s) \) cost of the work load, which can be written by formula:

\[
K_{st}^{(a,b)}(s) = K_p^{(a,b)}(s) + K_i^{(a,b)}(s) \ [zł]
\]

wherein:

- \( K_p^{(a,b)}(s) \) - the cost of work of s-th type of vehicle in the carriage in relation (a, b) is the sum of the components incurred in realization of this task which can be written by formula:

\[
K_p(s) = k_{w}^{(a,b)}(s) + k_{2p}^{(a,b)}(s) + k_{og}^{(a,b)}(s) + k_{e}^{(a,b)}(s) + k_{od}^{(a,b)}(s) + k_{uk}^{(a,b)}(s) + k_{ps}^{(a,b)}(s) + k_{a}^{(a,b)}(s) \ [zł]
\]

where:

- \( k_{w}^{(a,b)}(s) \) - compensation expense of drivers in the realization of the task

- \( k_{2p}^{(a,b)}(s) \) - the cost of fuel consumption in the realization of the task

- \( k_{og}^{(a,b)}(s) \) - the cost of tire wear in the realization of the task

- \( k_{e}^{(a,b)}(s) \) - the cost of environmental charges in the realization of the task

- \( k_{od}^{(a,b)}(s) \) - the cost of fees for the use of roads in the realization of the task

- \( k_{uk}^{(a,b)}(s) \) - the cost of motor insurance in the realization of the task

- \( k_{ps}^{(a,b)}(s) \) - tax cost of means of transport in the realization of the task for s-th type of vehicle

- \( k_{a}^{(a,b)}(s) \) - depreciation cost of means of transport in the realization of the task for s-th type of vehicle

Formal record of all components of the cost of transport can be found in [5] [12].

While the cost of loading work at transport task realization in relation (a, b) for s-th type of vehicle results from hourly cost of human labor at the loading activities for s-th type of vehicle in zł / h, the hourly cost of operation of the equipment at the loading activities for s-th type of vehicle in zł / h and the time of loading and unloading s-th type of vehicle.
As is clear from the foregoing considerations the cost of implementing one transport is dependent on the amount of load, labor costs of people and equipment and operating costs. Detailed analysis of the cost of implementation of transport tasks can be found in [12]. Reducing the cost of transport increases the efficiency of transport services.

5. CONCLUSION

In the study, the efficiency of transport, special attention is put on the analysis of the technical - technological organization of transportation services and logistics businesses. While creating, shaping, designing and reorganization of the supply chain should be aware that their high efficiency also depends to adapt their equipment to the performed tasks.

In the assessment of value for the partial indices can be assumed, among others, transport costs, the value of their means of transport and depreciation costs attributable to transportation.

Greater efficiency means that while incurring lower costs will be carried out tasks at a level not worse than expected. In other words, the higher the efficiency, the higher is the efficiency and efficiency of resource use for the implementation of tasks in the system.

REFERENCES

THE APPLICATION OF MULTI-REGRESSION ANALYSIS IN AN ENTERPRISE SALE FORECAST

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Abstract

This paper deals with multi factor analysis to obtain more reliable forecast. The sale is influenced very strongly by the prices of offered products especially in retails. And thus, the aim of the paper is to show, how the forecasted volume could be influenced by the price expectation in near future. The forecast uses the application of the multiple linear regression.

Keywords: Forecast, multi-regression analysis, sale, retails

1. INTRODUCTION

Nowadays, at daily consumption products, people look more for the price than quality when deciding which product to purchase. Quality is mostly considered as a standard and that is why people stopped differentiate the quality differences among products of the same kind [1, 2]. Therefore, the quality of these products is not considered much while buying decisions. This thinking of people is also used by many chain stores and supermarkets, so they can regulate the price. When analyzing the sales of chosen daily consumed foods on the basis of data obtained from one big supermarket chain, which uses massive price sales promotions and discounts, the deformation of the real needs in the market was found and it makes more difficult to create any (even short-term) forecasts [3]. This paper tries to bring simple application of one of the multi-factorial methods i.e. method where the outcome depends on several variables. The one of such methods, which includes multi-factorial consideration is the multi-regression analysis. The chosen method is linear, to keep the calculation simple and is able to use in the following case.

Multiple linear regression is used for data where one data series is a function of, or depends on, other data series [4, 5].

The goal of multiple linear regression is to find an equation that most closely matches the historical data. Multiple linear regression finds the coefficients for the equation:

\[ Y_t = b_0 + b_1 x_{1,t} + b_2 x_{2,t} + b_3 x_{3,t} + \ldots + b_n x_{n,t} + e_t \]  

(1)

where: \( b_1, b_2, b_3, \ldots, b_n \) - are the coefficients of the independent variables, \( b_0 \) is the y-intercept constant,
\( x_1, x_2, x_3, \ldots, x_n \) - are the parameters,
\( e_t \) - is an error in time \( t \).

This multiple regression equation is linear and it means that coefficients \( b_0, b_1, b_2, \ldots, b_n \), if applicable, are calculated by the least square method. It is recommended to use a computer program, because of a complication procedure [6].

2. INPUT DATA AND THE METHOD APPLICATION

There were chosen two groups of daily consumed foods (bread and beer) and 4 items of each kind for the mentioned application of linear multi-regression analysis. Data, that a retail supermarket chain provides,
contain monthly sale reports, from years 2013 and 2014 with the average final prices within the month (Table 1 - bakery products and Table 2 - the beer products).

Table 1 The sale volumes of the chosen bakery products

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>BUN CEREAL 60g</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
<th>FRENCH BAGUETTE 105g</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
<th>WHITE BAGUETTE SMALL 49g</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
<th>STANDARD ROLL 40g</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>January</td>
<td>15178</td>
<td>0.13</td>
<td>4408</td>
<td>0.15</td>
<td>30148</td>
<td>0.11</td>
<td>97363</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>17717</td>
<td>0.13</td>
<td>5511</td>
<td>0.15</td>
<td>26890</td>
<td>0.11</td>
<td>92324</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>21326</td>
<td>0.13</td>
<td>5253</td>
<td>0.15</td>
<td>33186</td>
<td>0.11</td>
<td>105289</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>18812</td>
<td>0.13</td>
<td>3970</td>
<td>0.15</td>
<td>28730</td>
<td>0.11</td>
<td>95498</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>20080</td>
<td>0.13</td>
<td>4898</td>
<td>0.17</td>
<td>23732</td>
<td>0.10</td>
<td>110652</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>21730</td>
<td>0.12</td>
<td>4773</td>
<td>0.16</td>
<td>24750</td>
<td>0.10</td>
<td>100184</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>July</td>
<td>25352</td>
<td>0.12</td>
<td>5898</td>
<td>0.16</td>
<td>29220</td>
<td>0.10</td>
<td>93148</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>27164</td>
<td>0.10</td>
<td>6588</td>
<td>0.16</td>
<td>35125</td>
<td>0.11</td>
<td>90615</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>23766</td>
<td>0.11</td>
<td>7269</td>
<td>0.16</td>
<td>29393</td>
<td>0.11</td>
<td>92216</td>
<td>0.05</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>21891</td>
<td>0.13</td>
<td>7814</td>
<td>0.16</td>
<td>27251</td>
<td>0.11</td>
<td>93221</td>
<td>0.05</td>
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<tr>
<td></td>
<td>November</td>
<td>20462</td>
<td>0.13</td>
<td>6851</td>
<td>0.16</td>
<td>27811</td>
<td>0.12</td>
<td>97583</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>18484</td>
<td>0.13</td>
<td>7589</td>
<td>0.16</td>
<td>25480</td>
<td>0.12</td>
<td>104701</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>January</td>
<td>17770</td>
<td>0.13</td>
<td>5495</td>
<td>0.16</td>
<td>19864</td>
<td>0.14</td>
<td>96357</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>15841</td>
<td>0.13</td>
<td>4528</td>
<td>0.16</td>
<td>14102</td>
<td>0.13</td>
<td>83725</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>21021</td>
<td>0.10</td>
<td>7477</td>
<td>0.15</td>
<td>17217</td>
<td>0.13</td>
<td>96535</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>18448</td>
<td>0.11</td>
<td>5643</td>
<td>0.17</td>
<td>16189</td>
<td>0.13</td>
<td>90613</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>7618</td>
<td>0.13</td>
<td>2052</td>
<td>0.16</td>
<td>5529</td>
<td>0.13</td>
<td>28610</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>7082</td>
<td>0.13</td>
<td>4096</td>
<td>0.16</td>
<td>11198</td>
<td>0.12</td>
<td>43712</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>11026</td>
<td>0.12</td>
<td>5838</td>
<td>0.16</td>
<td>18268</td>
<td>0.12</td>
<td>73871</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>13464</td>
<td>0.12</td>
<td>4851</td>
<td>0.16</td>
<td>19374</td>
<td>0.12</td>
<td>74743</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>12863</td>
<td>0.11</td>
<td>7603</td>
<td>0.16</td>
<td>18827</td>
<td>0.12</td>
<td>70043</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>13246</td>
<td>0.11</td>
<td>7299</td>
<td>0.16</td>
<td>18595</td>
<td>0.12</td>
<td>77081</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>10315</td>
<td>0.12</td>
<td>7541</td>
<td>0.16</td>
<td>18670</td>
<td>0.12</td>
<td>70791</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>7860</td>
<td>0.12</td>
<td>6868</td>
<td>0.15</td>
<td>21280</td>
<td>0.12</td>
<td>81240</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The forecast for the first three months was done by a computer program. The results forecasted quantity to be sold by the price assumption is in the following table:
Table 2 The forecast of sold volumes in Jan. - Mar. 2015 influenced by the price assumption (bakery prod.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>BUN CEREAL 60g</th>
<th>Price assumpt. [€]</th>
<th>FRENCH BAGUETTE 105g</th>
<th>Price assumpt. [€]</th>
<th>WHITE BAGUETTE SMALL 49g</th>
<th>Price assumpt. [€]</th>
<th>STANDARD ROLL 40g</th>
<th>Price assumpt. [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>January</td>
<td>14775</td>
<td>0.10</td>
<td>6675</td>
<td>0.15</td>
<td>21399</td>
<td>0.10</td>
<td>N / A</td>
<td>no assum.</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>14097</td>
<td>0.10</td>
<td>6734</td>
<td>0.15</td>
<td>20935</td>
<td>0.10</td>
<td>N / A</td>
<td>no assum.</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>13418</td>
<td>0.10</td>
<td>6793</td>
<td>0.15</td>
<td>20472</td>
<td>0.10</td>
<td>N / A</td>
<td>no assum.</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>9019</td>
<td>0.12</td>
<td>6554</td>
<td>0.16</td>
<td>15942</td>
<td>0.12</td>
<td>67382</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>8340</td>
<td>0.12</td>
<td>6613</td>
<td>0.16</td>
<td>15479</td>
<td>0.12</td>
<td>65809</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>7662</td>
<td>0.12</td>
<td>6672</td>
<td>0.16</td>
<td>15015</td>
<td>0.12</td>
<td>64236</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>9019</td>
<td>0.13</td>
<td>6433</td>
<td>0.17</td>
<td>15942</td>
<td>0.12</td>
<td>57765</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>5462</td>
<td>0.13</td>
<td>6492</td>
<td>0.17</td>
<td>10022</td>
<td>0.14</td>
<td>56192</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>4783</td>
<td>0.13</td>
<td>6550</td>
<td>0.17</td>
<td>9559</td>
<td>0.14</td>
<td>54619</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>MAPE</td>
<td>18.4%</td>
<td>11.7%</td>
<td>20.0%</td>
<td>6.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 The sale volumes of the chosen beer products

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>ZLATY BAZANT 10% 0.5l BOTTLE</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
<th>SMADNY MNICH 10% 0.5l BOTTLE</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
<th>ZLATY BAZANT 12% 0.5l BOTTLE</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
<th>SARIS 12% LIGHT LAGER 0.5l BOTTLE</th>
<th>Sold pcs.</th>
<th>Av. Price [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>January</td>
<td>139</td>
<td>0.54</td>
<td>1795</td>
<td>0.48</td>
<td>892</td>
<td>0.69</td>
<td>305</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>236</td>
<td>0.53</td>
<td>1147</td>
<td>0.45</td>
<td>2423</td>
<td>0.59</td>
<td>308</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>445</td>
<td>0.50</td>
<td>1017</td>
<td>0.45</td>
<td>1757</td>
<td>0.59</td>
<td>427</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>805</td>
<td>0.50</td>
<td>1021</td>
<td>0.45</td>
<td>2382</td>
<td>0.59</td>
<td>370</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>724</td>
<td>0.54</td>
<td>2517</td>
<td>0.39</td>
<td>2589</td>
<td>0.64</td>
<td>518</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>553</td>
<td>0.52</td>
<td>1604</td>
<td>0.39</td>
<td>1380</td>
<td>0.65</td>
<td>955</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>653</td>
<td>0.52</td>
<td>1643</td>
<td>0.39</td>
<td>1804</td>
<td>0.64</td>
<td>662</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>430</td>
<td>0.51</td>
<td>1103</td>
<td>0.39</td>
<td>964</td>
<td>0.66</td>
<td>414</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>745</td>
<td>0.49</td>
<td>601</td>
<td>0.39</td>
<td>1553</td>
<td>0.62</td>
<td>395</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>689</td>
<td>0.49</td>
<td>587</td>
<td>0.42</td>
<td>1709</td>
<td>0.59</td>
<td>270</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>891</td>
<td>0.53</td>
<td>578</td>
<td>0.44</td>
<td>1569</td>
<td>0.59</td>
<td>231</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>252</td>
<td>0.50</td>
<td>547</td>
<td>0.45</td>
<td>2516</td>
<td>0.62</td>
<td>285</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 4: The forecast of sold volumes in Jan. - Mar. 2015 influenced by the price assumption (beer products)

<table>
<thead>
<tr>
<th>Year (continue)</th>
<th>Month</th>
<th>ZLATY BAZANT 10% 0.5l BOTTLE</th>
<th>SMADNY MNICH 10% 0.5l BOTTLE</th>
<th>ZLATY BAZANT 12% 0.5l BOTTLE</th>
<th>SARIS 12% LIGHT LAGER 0.5l BOTTLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>January</td>
<td>350</td>
<td>0.49</td>
<td>401</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>1021</td>
<td>0.50</td>
<td>206</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>737</td>
<td>0.51</td>
<td>403</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>660</td>
<td>0.51</td>
<td>2450</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>125</td>
<td>0.52</td>
<td>777</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>886</td>
<td>0.51</td>
<td>1100</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>456</td>
<td>0.49</td>
<td>977</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>729</td>
<td>0.49</td>
<td>964</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>1071</td>
<td>0.49</td>
<td>498</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>613</td>
<td>0.49</td>
<td>1482</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>681</td>
<td>0.49</td>
<td>654</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>742</td>
<td>0.49</td>
<td>370</td>
<td>0.45</td>
</tr>
</tbody>
</table>

The data reflects the sold volumes of various beer products in January to March 2015, with columns indicating the predicted volumes and the average price per unit. The table also includes the Mean Absolute Percentage Error (MAPE) for each month, ranging from 10.2% to 24.7%.
3. RESULTS

Figure 1 The diagrams of sale behavior and forecast intervals of the observed products
The graphical results from the forecasts have proved that the sale of bakery products is a slightly smoother. It means that the forecasting of these products is more accurate what is also proved by MAPE indicators [7]. It is still need to be remained that the consumption of both groups are quite dynamic and the use of the multiple linear regression is limited and for orientate purpose only.

4. CONCLUSION

The sale of products in the big chain store is GREATLY influenced by its price. It is an important tool to influence the volume of a sale. This paper brings the simple prediction model of a sale volume, when the price is determined. The practical use of the model is possible at preparing the sale discount, which is usually done each week. The forecast horizon of one week is quite short period to create relatively suitable prediction of the sale volume of particular product. There are cases of smaller supermarkets too, where the sale of the product is not so turbulent and the usage of such tool can be even more relevant.

ACKNOWLEDGEMENTS

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REFERENCES

WHAT HAVE BEEN DEVELOPED FOR LOT-SIZING AND SCHEDULING PROBLEM SINCE THE EOQ MODEL WAS INTRODUCED

KSIĄŻEK Roger¹, GDOWSKA Katarzyna¹, KSIĄŻEK Dawid¹

¹AGH University of Science and Technology, Faculty of Management, Kraków, Poland, UE

Abstract

The paper is devoted to the selected heuristics for lot-sizing and scheduling problem for identical parallel machines. The lot-sizing and scheduling problem is a well-known problem in industrial engineering and logistics management, since it is crucial for inventory control and production planning. In 1913 the Economic Order Quantity (EOQ) concept was presented and the EOQ model was developed - it was a very useful tool for production and purchase planning, however, it simplified the reality significantly. Over the last century lot-sizing and scheduling problem was examined and numerous more advanced models, which consider multiple aspects of manufacturing process, were developed. In this paper a review of approaches to lot-sizing and scheduling problem are reviewed from the perspective of specific goals adopted, models developed for the problem, and methods used for solving them.

Keywords: Lot-sizing, scheduling, parallel machines, production planning, inventory control

1. INTRODUCTION

The Lot-sizing and Scheduling Problem (LSP) is a well-known problem in industrial engineering and logistics management, since it is crucial for inventory control and production planning. Since the LSP had been introduced to the scientific literature [1] numerous advanced models were developed; these formulations consider multiple aspects of manufacturing process, inventory control, and industrial logistics [2-6]. The main differences between various formulations of the lot-sizing problem are caused by aspects included (e.g. identical and non-identical parallel machines, the number of types of manufactured product, the level of safety stock, time limitations, constant, deterministic or stochastic demand) as well as the method used for solving the problem (e.g. mixed-integer linear programming (MILP), non-linear programming, heuristics, meta-heuristics) [7-20].

In this paper approaches to lot-sizing and scheduling problem are reviewed from the perspective of specific goals adopted, models developed for the problem, and methods used for solving them. Our study begins with the classical Economic Order Quantity (EOQ) concept - known also as Economic Lot Size (ELS) - introduced by F.W. Harris [1] and analyzed in details by R.H. Wilson [2]. Next, we focus on the newest advances to the parallel machines scheduling problem - due to the manifold of aspects taken into account in different approached we present a general perspective of this issue. We end our review with stochastic models that introduce uncertainty which is to be observed in the manufacturing processes. In this brief review of selected works we focus on the objective and the scientific meaning of the whole concept instead of the well-known mathematical model and formula to compute the optimal lot size. When analyzing scientific papers referred to above mentioned issues, it can be observe that there is a need for methods and tools for effective lot-sizing and scheduling in manufacturing and industrial management. Therefore, a retrospective review of the LSP development seems to be helpful to grasp the importance of the general idea of the problem.

2. THE ECONOMIC ORDER QUANTITY MODEL

In 1913 the Economic Order Quantity concept was presented in the classical article “How many parts to make at once” published in the scientific journal “Factory, The Magazine of Management”. We do not intend to
present EOQ mathematical model here, since this material is covered in every elementary textbook on production planning and management science. We focus on the concept itself and its objectives just to remind that EOQ concept was a real milestone for industrial logistics. This is how the author, Ford W. Harris, introduced the lot-sizing and scheduling problem in his original paper: “Every manufacturer is confronted with the problem of finding the most economical quantity to manufacture in putting through an order. This is a general problem and admits of a general solution, and, however much it may be advisable to exercise judgment in a particular case, such exercise of judgment will be assisted by a knowledge of the general solution” [1].

The objective was to formulate a general concept that makes it possible to determine the size of lot for which the total manufacturing and holding costs are minimized (see Figure 1). Harris presented the EOQ model where the optimal lot size is computed with the formula that includes the unit manufacturing cost, set-up cost, unit carrying cost, and constant and continuous demand.

![Figure 1 Manufacturing Quantities Curves - reprint of the figure illustrating the Economic Order Quantity (EOQ) concept provided by F.W. Harris in [1]](image)

Harris was fully aware of simplifications adopted in his model, however he reached his goal - the concept is a general formulation of the problem as well as it introduced a mathematics-based tool for the lot-sizing problem, so that the optimal solution can be obtained easily and quickly. Certainly, it is possible, because a series of assumptions are adopted in this concept, what result in significant simplification of the lot-sizing and scheduling problem. The author concluded his paper as follows: “... the method given is not rigorously accurate, for many minor factors have purposely been left out of the consideration. [...] Such refinements, however, while interesting, are too fine spun to be practical. The general theory as developed here is reasonably correct and will be found to give good results” [1]. What should be noted here is the fact that Harris developed a mathematical model that automated decision-making process on the lot size and manufacture schedule. Far reaching simplifications adopted in this model can be considered as intentionally made sacrifices, so that the solution was obtained quickly and without advanced computation machines. In result, his formulas for
economic lot size, cycle length, and minimal total costs became useful tools for scheduling large-scale serial production.

3. THE DEVELOPMENT OF THE LOT-SIZING AND SCHEDULING PROBLEM

Since the paper by Harris was published the LSP has been formulated in many different ways due to different aspects of the problem; researchers have taken into account different combinations of such characteristics as: types of machines, organization of the manufacturing process (single machines or parallel machines), types of products, sequence of operations etc. Various models have been developed and different methods - both exact methods and heuristics - were employed to solve them. In this section a selection of advances to the LSP are presented. We begin with classic single machine and a single product LSP for which a dynamic programming model and a heuristic algorithm were developed. Then we briefly present considerably new approach to the single machine problem for which mixed integer linear programming models and heuristics were developed. Next, we focus on the newest advances to the parallel machines scheduling problem - due to the manifold of aspects taken into account in different approaches we present a general perspective of this issue. We end our review with stochastic models that introduce uncertainty which is to be observed in the manufacturing processes.

Next milestone for LSP was an approach to the single machine single product LSP presented by H.M. Wagner and T.M. Within, where demand for the product did not has to be constant and continuous. Planning horizon is divided into planning periods, and demand is determined for each planning period. For such a formulation they developed a method based on Dynamic Programming, where the objective is to minimize total setup and holding costs. Solutions obtained with this method for LSP with a single product are optimal, however the method cannot be successfully utilized for problems where multiple products are to be scheduled [14].

Another important issue addressed by researchers is to determine production quantities over a medium size planning horizon, so that demand is met, scarce production facilities are not overloaded. A. Drexl, K. Haase and A. Kimms developed the Capacitated Lot-sizing and Scheduling Problem, which is based on the assumption that for each lot produced in a period setup cost is incurred. They emphasized that in practice the machine setup can be preserved over idle time very often, and in such cases the setup cost of a CLSP solution can be reduced by linking the production quantities of an item which is scheduled in two adjacent periods. The CLSPL is formulated by Drexl and Haase as a mixed-integer programming model, but they also developed a heuristics algorithm for the CLSPL, where a sampling method is introduced, which is backward oriented and relies on so called randomized regrets [4-6, 16].

Multiple product capacitated lot-sizing and scheduling problem was examined also by W. Kaczmarczyk, who developed MILP models for the Proportional Lot-sizing and Scheduling Problem with set-up operations overlapping multiple periods and for the Proportional Lot-sizing and Scheduling Problem with identical parallel machines. The effectivity and practical applicability of those models are assured by tightening models with constraints describing specific character of the industry to which models are dedicated. The planning horizon is divided into planning periods, and each machine capacity in each period is limited and must not be exceeded. The objective is the same as in the previously presented models: to minimize the total setup and holding costs in all periods [7, 12].

An important aspect of lot-sizing and scheduling problem is the case with parallel machines. The aim of this problem is to sequence a set of \( n \) jobs on \( m \) parallel machines in order to minimize the performance indicator. The parallel machine scheduling problem can be divided into following categories with respect to the type of machines. Machines may be identical, uniform, or completely unrelated and have different speeds; identical machines - the processing times are the same for every machine, uniform machines - machines have different speeds but each machine works at a consistent rate, unrelated machines - machines can work at different rates and a given machine can process. For parallel machines scheduling problem numerous models and
heuristics were developed, e.g. genetic algorithms, artificial immune system algorithm, or vibration damping optimization algorithm [21, 22].

Table 1 Advances in lot-sizing and scheduling problem - a selective literature review

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Paper</th>
<th>Year</th>
<th>Problem</th>
<th>Objectives</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.W. Harris</td>
<td>How Many Parts to Make at Once [1]</td>
<td>1913</td>
<td>single machine, single product, single planning period,</td>
<td>to minimize total manufacturing and holding costs</td>
<td>mathematical programming</td>
</tr>
<tr>
<td>H.M. Wagner, T.M. Within</td>
<td>Dynamic version of the economic lot size model [14]</td>
<td>1958</td>
<td>single machine, single product, multiple planning periods,</td>
<td>to minimize total setup and holding costs</td>
<td>dynamic programming</td>
</tr>
<tr>
<td>W. Kaczmarczyk</td>
<td>Wybrane modele planowania wielkości i szeregowania partii produkcyjnych [7]</td>
<td>2011</td>
<td>single machine, identical parallel machines, multiple planning periods, multiple products,</td>
<td>to minimize total setup and holding costs</td>
<td>mixed-integer linear programming</td>
</tr>
<tr>
<td>E. Mehdizadeh, R. Tavakkoli-Moghaddam, M. Yazdani</td>
<td>A vibration damping optimization algorithm for a parallel machines scheduling problem with sequence-independent family setup times [21]</td>
<td>2015</td>
<td>parallel machines, sequence-independent family setup times</td>
<td>to minimize the total weighted completion time</td>
<td>vibration damping optimization algorithm</td>
</tr>
<tr>
<td>K. Schemeleva, X. Delorme, A. Dolgui</td>
<td>A memetic algorithm for a stochastic lot-sizing and sequencing problem [23]</td>
<td>2015</td>
<td>assembly line, sequencing problem, uncertainty on defective items due to the machines’ imperfection, uncertainty on repair time</td>
<td>to maximize the probability of overall demand satisfying</td>
<td>memetic algorithm</td>
</tr>
<tr>
<td>S. Özpeynirci, B. Gökgür, B. Hnich</td>
<td>Parallel machine scheduling with tool loading [17]</td>
<td>2016</td>
<td>parallel machines, tool magazines capacity constraints, tool assignment constraints</td>
<td>to minimize the makespan (Cmax)</td>
<td>mixed integer programming, tabu search algorithms</td>
</tr>
<tr>
<td>M. Afzalirad, J. Rezaeian</td>
<td>Resource-constrained unrelated parallel machine scheduling problem with sequence dependent setup times, precedence constraints and machine eligibility restrictions [22]</td>
<td>2016</td>
<td>parallel machines, resource constrains, sequence-dependent setup times, different release dates, machine eligibility constraints, precedence constraints</td>
<td>to minimize the makespan (Cmax)</td>
<td>genetic algorithm, artificial immune system algorithm</td>
</tr>
</tbody>
</table>

Another important contribution to the development of the lot-sizing and scheduling problem is so-called lot-sizing and sequencing problem under uncertainties, which introduces stochastic processes and probability into models. The objective here is to maximize the probability of overall demand satisfying by a system in which rejects and breakdowns occur. It should be emphasized here that, when a company faces lot-sizing and scheduling problem they realize that the problem is composed of: a manufacturing line that process items of several types, an automatic storage device that stocks processed items, an assembly line assembling final
products with stored items. At each stage of those processes some uncertainty may appear - mostly connected to rejects and breakdowns. Lot-sizing and scheduling problem becomes even more complicated in such circumstances and models dedicated to it are NP-hard. Well-known approach to this problem is a 3-level decomposition of the lot-sizing and scheduling problem with abovementioned uncertainties, where the 1st level is a complete enumeration of \( n \) possible solutions, the 2nd level is an equivalent to the Asymmetric Travelling Salesman Problem, and the 3rd is an extension of the Knapsack problem. It should be emphasized here that the 2nd and 3rd levels are NP-hard, therefore even if MILP model is developed for the lot-sizing and sequencing problem under uncertainties, it was necessary to employ other methods to solve this problem. Dolgui et al. developed a method using Dynamic Programming procedure, and Schmeleva et al. introduced a special genetic algorithm called memetic algorithm [23, 24].

4. CONCLUSIVE REMARKS

In this paper the brief review of selected directions of advances in lot-sizing and scheduling problem is presented. Over 100 years manufacturing process has changed a lot, as well as scientific approach to manufacturing optimization. From the general concept of computing the optimal lot size the lot-sizing and scheduling problem has evolved in various formulations and advanced models.

It should be noted that when more advanced models for lot-sizing and scheduling problem are being developed formulations known from assignment problem or travelling salesman problem appear. It results in NP-hardness of problems. For that reason for many years heuristic algorithms were developed, since they can find solutions with acceptable optimization gaps in reasonably short time. It matters, because lot-sizing and scheduling model is the core of computer-aided tools for generating manufacturing schedules. In many cases parameters change unexpectedly and it is needed to re-schedule production plan quickly. However, nowadays it is to be observed utilization of exact methods, since the increase of computing power makes it possible to get results with such methods in reasonably short time.

ACKNOWLEDGEMENTS

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REFERENCES


MODEL OF ASSESSING THE LOGISTICS OPERATORS IN SUPPLY CHAIN

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Abstract
The aim of this article is to demonstrate the importance of the reliability of the selected links of the logistics chain. For companies operating on the steel market, this means the need to develop new terms of cooperation based on different segments of customers. Logistics operators are those links that fall within the structure of efficient logistics chains. In order to meet market expectations, steel plants must be in possession of the tools to verify the different links forming part of their respective logistic chains.

To verify the research objective, the following theoretical tools were used: analysis, synthesis, generalizations, comparisons. In terms of practical methods, the following found application: observation method (collecting information about the partners in logistics chain, interviews with employees, determining interferences within and between the links) as well as calculation method and Delphi method.

The article, based on the research conducted in the selected links of the logistics chain of the steel industry, has shown model of assessing the logistics operators in supply chain. A method of evaluation of logistics operators was proposed, with the aim of minimizing interferences in the chain.

Keywords: Logistics chain, steel market, logistics operators, Delphi method for evaluating logistics operators

1. INTRODUCTION
Logistics operators are those links that fall within the structure of efficient logistics chains. In order to meet market expectations, steel plants must be in possession of the tools to verify the different links forming part of their respective logistic chains.

Interference can be defined as an event that is either expected or not, causing unplanned, negative deviations in the process of supplying products and the services carried out in accordance with the objectives of the organization [10]. The term interference relates to both the occurrence of an adverse effect as well as the consequences it entails. The majority of discussions concerning interferences in the logistics literature refers to the definition of risk in logistics processes. Risk means the existence of risk factors specific (typical) for logistics processes, having a certain probability (frequency) and causing certain effects (expressed in terms of costs). Risk factors in the logistics processes affect changes in the added value fulfilled by the primary processes of the organization. This change is most often negative [7]. The relationship between threat, adverse event and risk is explained in the literature as follows: operation in hazardous conditions exposes the entity to the occurrence of an adverse event (interference), although not necessarily; likely occurrence of an adverse event (interference) that will entail consequences means risk.

For example, a threat may be cooperating with an unreliable provider, an adverse event (interference) will be non-receipt of on-time delivery, and risk will be the likelihood of the company not receiving on-time delivery and the impact of this fact on its objectives [11].

As the interest in various forms of cooperation in the logistics chain increases, there are studies showing inter-organizational relations as one of the sources of interferences causing deviations in the logistics and production processes [9].
The implementation of various concepts of management, enhancement, quality improvement etc. of logistics processes, including those related to reducing logistics costs, increases susceptibility of logistic chains to any kind of interference.

Interference in the logistics chain can be anything that affects the flow and supply of raw materials, constituent elements, components and finished products at any stage of the flow from the source of origin to end points where there is a demand. [8]. R Handfield, K. McCormack define interference as major delays in production, distribution or supply nodes, that have consequences on the performance of other nodes of the supply chain [3]. Interferences are usually the bottleneck in one of the nodes that spreads along with its consequences to the entire supply chain. Every single event - such as fire, quality issues with manufactured goods, machinery failure, delayed customer orders - may trigger significant interferences throughout the logistics chain [6].

In the more complex supply chains, i.e. those where there is a lot of nodes, the number of potential interferences increases accordingly. Efficient and effective management and cooperation in such a logistics chain requires, first of all, identifying those nodes that are most vulnerable to the consequences of extraordinary events and are critical links from the standpoint of the chain as a whole. These include, inter alia, logistics operators providing transportation and storage services.

2. USING THE DELPHI METHOD TO ASSESS THE LOGISTICS OPERATORS

The study began with the development of a catalog of probable interferences that should be considered when recruiting new partners of the logistics chain of the steel industry. Based on the well-established method of score-based evaluations of suppliers, a method of point-based evaluation of the logistics chain partners was developed, taking into account measurable factors that may contribute to the occurrence of interferences.

The choice of partner in the logistics chain is a complex task since not all factors influencing this decision are measurable in economic terms. Helpful in such cases is the Delphi method (relying on a panel of experts) which implements opinions and evaluations of deliberately-opted experts. The basis of experts’ considerations is to analyze selected factors that can be measured or at least comparatively assessed. Based on the literature sources [11, 12], an algorithm for selection of suppliers was developed. This algorithm consists of the following stages:

Stage 1. Determining the set of potential providers of logistics services in the field of transportation and / or warehousing. Analysis of logistics operators’ offerings and their initial selection allows for choosing a couple of potential operators. It is, of course, assumed that after the initial selection, there is still a choice, i.e. that at least two potential operators remain, whose expertise with regard to logistics infrastructure and organizational capacity meet the requirements of the logistics chain in question and who enjoy positive reviews on the market.

Stage 2. Determining the evaluation criteria. The starting point is to select those criteria that are important for the partners of the logistics chain and are to some extent measurable, comparable with each other. They will form the basis for establishing parametric evaluation criteria. Based on the criteria determining the choice of operator / operators. On the basis of the research conducted, the following criteria were determined:

- Information flow between the logistics operator and links of the logistic chain
- Timely delivery / timely availability of storage spaces, warehouses
- Completeness of deliveries
- Occurrence of failures
- Occurrence of accidents
- Service quality (correct shipping documentation, handling complaints).

Stage 3. Determining the scoring rules in relation to specific criteria. Each of these criteria was awarded 0-100 points, adding reference points to allow for proper evaluation. The data is contained in Table 1. Scoring
individual criteria may be the result of evaluation and experiences of the evaluator, as well as the offerings of individual operators. The evaluation can be made together or separately for transportation and warehousing services, in accordance with the criteria specified in offering-related requests.

**Table 1** Data collection for assessing the partners of the steel plant’s logistics chain

<table>
<thead>
<tr>
<th>Evaluation criterion</th>
<th>Factors that may cause interference</th>
<th>Criterion score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information flow between the logistics operator and links of the logistic chain</td>
<td>Form of order placement, Website, Response time to e-mails, phone calls, Completeness and accuracy of documentation, GPS or other system, Possibility of shipment tracking</td>
<td>100 - without reservations, 50 - in the case of deviations in some or all forms of communication, 0 - no contact</td>
</tr>
<tr>
<td>Timely delivery / timely availability of storage spaces, warehouses</td>
<td>Processing orders, Reliability in meeting deadlines, Distance of the logistics operator from individual (or selected) links of the logistics chain, Arrangement of working time, Route-planning</td>
<td>100 - right on time, 100 - (x * number of days after the deadline); x - depends on the parameter of evaluation, Cases where the operator has warned about the change of date should be analyzed separately.</td>
</tr>
<tr>
<td>Compleness of deliveries</td>
<td>Bad loading in terms of quantity and material, Loss of goods during transportation (bad packaging), External theft, Internal theft, Loading inability, Unloading inability</td>
<td>100 - deviation up to 10%, 80 - deviation of 11 - 20%, 50 - deviation of 21-50%, 20 - deviation of 51 - 80%, 0 - deviation exceeding 80%</td>
</tr>
<tr>
<td>Occurrence of failures</td>
<td>Vehicle breakdowns, Failure of loading and unloading equipment, Drivers’ sickness</td>
<td>100 - deviation up to 10%, 80 - deviation of 11 - 20%, 50 - deviation of 21-50%, 20 - deviation of 51 - 80%, 0 - deviation exceeding 80%</td>
</tr>
<tr>
<td>Occurrence of accidents</td>
<td>Number of accidents per service expressed in time unit</td>
<td>100 - deviation up to 10%, 80 - deviation of 11 - 20%, 50 - deviation of 21-50%, 20 - deviation of 51 - 80%, 0 - deviation exceeding 80%</td>
</tr>
<tr>
<td>Service quality</td>
<td>Covering costs of transportation/warehousing, storage, Handling complaints, Shipping documentation, Willingness to maintain inventories, Assistance in difficult situations</td>
<td>100 - high level, 80 - satisfactory level, 50 - acceptable level</td>
</tr>
</tbody>
</table>

Source: own study.

**Stage 4.** Determining the scales for each criterion. The evaluation criteria may have different meanings for the steel company. For this reason developed was a scale system that accentuates these criteria that a given
The company deems to be the most important, and lowering scales of the other criteria. Proposals of these scales are shown in Table 2.

Table 2 Data collection for assessing the partners of the steel plant’s logistics chain

<table>
<thead>
<tr>
<th>Evaluation criterion</th>
<th>Criterion scale</th>
<th>Criterion score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information flow between the logistics operator and links of the logistic chain</td>
<td>0.3</td>
<td>100 - without reservations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 - in the case of deviations in some or all forms of communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - no contact</td>
</tr>
<tr>
<td>Timely delivery / timely availability of storage spaces, warehouses</td>
<td>0.15</td>
<td>100 - right on time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 - (x * number of days after the deadline); x - depends on the parameter of evaluation. Cases where the operator has warned about the change of date should be analyzed separately.</td>
</tr>
<tr>
<td>Completeness of deliveries</td>
<td>0.15</td>
<td>100 - deviation up to 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 - deviation of 11 - 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 - deviation of 21-50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 - deviation of 51 - 80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - deviation exceeding 80%</td>
</tr>
<tr>
<td>Occurrence of failures</td>
<td>0.1</td>
<td>100 - deviation up to 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 - deviation of 11 - 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 - deviation of 21-50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 - deviation of 51 - 80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - deviation exceeding 80%</td>
</tr>
<tr>
<td>Occurrence of accidents</td>
<td>0.1</td>
<td>100 - deviation up to 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 - deviation of 11 - 20%</td>
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<tr>
<td></td>
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<td>50 - deviation of 21-50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 - deviation of 51 - 80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - deviation exceeding 80%</td>
</tr>
<tr>
<td>Service quality</td>
<td>0.2</td>
<td>100 - high level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 - satisfactory level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 - acceptable level</td>
</tr>
</tbody>
</table>

Source: own study.

The total scale of the criteria is 1, the scales are assigned separately for each criterion from 0 -1, assuming that those considered to be most important have a high rank, and those of lesser importance - low rank.

Stage 5. Rating logistics operators according to the criteria and calculation of evaluation rates. The primary source of information used by the experts in the evaluation of the operators is the conditions required for offering-related requests. This audit should be carried out before the formal signing of the contract with the operator, and the results should be recorded. The audit should also involve the employees of organizational units of the company (Warehouses, Quality Control Department, Purchasing Department, Production Departments) [4]. The results of the calculations of the evaluation are carried out based on Formula (1):

\[ K_i = O_i \times W_i \]  

(1)

\( K_i \) - evaluation criterion
\( O_i \) - criterion score
Wi - criterion scale

Stage 6. Analysis of the results of calculations and selection of a logistics operator. The latter is determined by the highest total score calculated on the basis of evaluation rates. The choice proposed by the experts based on these criteria - albeit difficult to be precisely (mathematically) grounded - is nevertheless objective. It is difficult to exclude the possibility that the decision regarding the selection may also be influenced by subjective reasons (immeasurable or partially measurable), e.g. informal relations between companies’ management that stem from the beneficial effects of cooperation. The decision of choosing the supplier made solely on the basis of these criteria must be confronted with marketing activities and market strategy of the company.

Stage 7. Preparation of evaluation sheet concerning the logistics operator. In many companies, such sheet is drawn up for each potential supplier and the same sheets can be made when choosing a logistics operator. These sheets, apart from possibly full technical and economical address information, contain results of the scoring evaluation as well as the overall result of the evaluation. One can also specify the number of points qualifying or disqualifying a logistics operator for cooperation. A sample evaluation sheet will be presented in the case study conducted for Huta Malapanew in Ozimek.

The presented method and the criteria for selection of logistics operators should be treated as an inspiration to seek one’s own solutions to the specifics of the logistics chain.

3. APPLICATION

In the company, the logistics operators of the Huta Malapanew steel plant were assessed. The study involved 12 experts (employees of the Department of Logistics) from the Opole University of Technology. After the initial selection, taking into account the criteria that were of interest to the company, selected were 2 potential logistics operators denoted in the publication as A and B.

Table 3 Score method of evaluating partners of the steel plant’s logistics chain

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Information flow (…)</td>
<td>0.3</td>
<td>70</td>
<td>55</td>
<td>21</td>
<td>16.5</td>
</tr>
<tr>
<td>Timely delivery / timely availability of storage spaces, warehouses</td>
<td>0.15</td>
<td>80</td>
<td>90</td>
<td>12</td>
<td>13.5</td>
</tr>
<tr>
<td>Completeness of deliveries</td>
<td>0.15</td>
<td>80</td>
<td>95</td>
<td>12</td>
<td>14.25</td>
</tr>
<tr>
<td>Occurrence of failures</td>
<td>0.1</td>
<td>50</td>
<td>80</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Occurrence of accidents</td>
<td>0.1</td>
<td>85</td>
<td>85</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Service quality</td>
<td>0.2</td>
<td>70</td>
<td>85</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>∑</td>
<td>1</td>
<td></td>
<td></td>
<td>72.5</td>
<td>77.75</td>
</tr>
</tbody>
</table>

Source: own study.

Stage 2 Assessed Criteria: information flow between the logistics operator and links of the logistic chain, timely delivery / timely availability of storage spaces, warehouses, completeness of deliveries, occurrence of failures, occurrence of accidents.
Stage 3 Adopted was the score specified and Stage 4 Adopted were the scales specified and Stage 5 Evaluation calculating evaluation rates - see Table 3.

Stage 6 After analyzing the obtained results of the evaluation, the team opted for Logistics Operator B
Stage 7 Preparation of the logistics operator’s evaluation sheet and entering on the list the logistics operators cooperating with the plant

4. CONCLUSION

The publication, based on the study and mostly on interviews with the employees, has shown that the piling-up of issues in one partner generates issues with other partners. This results in an additional increase in costs and longer time to remove and restore the stability of the production and logistics system.

The research accounted for the factors contributing to the occurrence of interferences and used them to develop - based on the Delphi method - the method of evaluation of logistics operators before establishing cooperation with them, and also to verify the currently cooperators in the logistics chain in order to identify those of them whose performance makes the number of interferences in the implemented logistics chain exceed the acceptable level, essential for key partners.

Controlling parameters such as quality and safety of cooperation with logistics operators reflects in the quality of the implemented logistics processes and consequently in the quality of final products, in this case steel.

REFERENCES

LOGISTIC ASPECTS OF COMPLAINTS PROCEDURES AGAINST SUPPLIERS OF ALUMINIUM COILS

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Abstract

The paper presents logistic aspects of procedures connected to complaints against suppliers of aluminum coils that are used in a production process of beverage cans. The process of shaping a body of a can from aluminum stripes is exceptionally precise and thus, the material has to meet standardized requirements. Any deviations from the standards may cause several problems in the process from increased number of jams in a press to the damage of shaping tools or problems with mechanical parameters of final products. The procedure of complaints consists of several stages that involve transport of the withdrawn coils and the exchange of documentation between various departments in a company and its supplier’s representatives. The paper shows the path that is defined by the procedure of complaints accompanied by its formal representation in documentation. The path is illustrated from the moment when the problematic coil is transported to a production line and first problems appear to the acceptance of the complaint and the moment when the problematic coil is collected by a supplier.

Keywords: Supplier, B2B complaint, transportation, waste, beverage can

1. INTRODUCTION

There is no company that could exist and function as an isolated unit independent of other companies. Customers, competitors and suppliers have a significant influence on a given unit. One of them is especially interesting in the context of complaint, that is the relationship between a customer and a supplier, especially when it is a business-to-business relationship. It is obvious that apart from many other factors that influence the relationship, returns and complaints about a product are a problem that may have a significant impact on it. Thus, it is important to create clear procedures that are acceptable for both sides, and which will assure efficient and fast complaint handling. This issue is more complicated in asymmetric business-to-business context, that is when one of the partners is a much bigger company that the other.

Another aspect that is not often discussed is the internal costs of complaints that the customer need to incur because of the occurrence of a non-conformity. In the context of beverage can production process, these costs emerge mainly from the waste of time on a production line, and at the same time logistic operations resulting from the non-conformity, mainly transport and storage operations.

Can making process is precise and fast. Thus, it is important that aluminum stripes used as the input material meet highest standards. If a complaint against the material appears, the main aspect which is usually taken into consideration is: the cost of wasted time on the production line, wear of tools and possible costs that may appear if a deliverer does not accept the complaint. However, since a coil weights about 10 tones, logistic aspects including its transportation should also be taken into account as a cause of additional costs as well as additional potential danger for employees.

The aim of the paper is to present logistic operations resulting from non-conformities concerning aluminum stripes used as input material in can making production process. The aspect is described from the customer’s point of view. The paper concerns non-conformities that are observed and identified after the coil is loaded on the line and the production process is already started. Another aim of the article is to show a complaint against
a supplier into B2B environment, also asymmetric one, as a specific type of a relationship which also
determines the complaint procedure that is realized in the customer company.

2. LITERATURE REVIEW

2.1. Complaints as an element of relationship between a customer and supplier

Contemporary marketing involves studies over relationship between market participants. Cooperation between
suppliers, their customers and other business organizations is a base for long-term relationships, preferably
based on trust, commitment and mutual dependence and investments [10]. On the other hand, it is hard to find
a long-term business relationship without conflicts or problems, especially in an asymmetric bond, that is when
one of the companies is significantly larger than the other. Some studies showed that most business
relationships involve some degree of stress often related to the imbalance between the partners [11]. While
some relationships between companies are already studied and explained in detail, others, involving the
aspects of conflicts and stress which often result in complaints have been neglected in research. Stresses and
further complaints are with no doubt a phenomenon that occurs occasionally, however complaint management
influences the relationship between a customer and supplier [13]. It is important to emphasize that complaint
occurrence does not always need to be a negative aspect. Sometimes it may be treated as a present, although
an expensive one, as it is an information about the internal efficiency and quality status of the process.


Since the paper concerns the aspect of complaints against a supplier, it is important to analyse the subject.
While complaints are widely analysed and examined in the field of business-to-consumers relationships, the
aspect of complaints in B2B is less frequently studied. [4]. The main differences between B2B and B2C are
shortly described in [5]. These are:

Complexity of issues - the issues in B2C space are less complex and involve less back and forth
communications than in B2B, thus the problems in B2C space require shorter time than issues in B2B
environment, of which the customers are usually aware. As a result, it may be assumed that the time period in
which a given problem is solved is not as crucial in B2B as it is in Business-to-consumer space [5]. However,
as it can be seen in [6], fast reaction and solution of a complaint should help develop long-term relationship
between customers and suppliers in B2B space [7].

Number of customers and scale- In B2B environment it is rare to have as many customers as in B2C while the
scale of sales is much bigger. As a result, in the case of a return from a consumer who is not satisfied with a
product, the company may lose the equivalent of value of a product. On the other hand, in B2B environment,
where often deliveries are worth thousands and are counted in tonnes, a customer who is not satisfied with a
supplier’s product may have a big impact on the company.

Knowledge about customers - the number of customers in B2C is usually so big, that it is hardly possible to
have close relationship with all of them, especially when products are sold by agents. As a result, when a
customer is not satisfied with a product, he is usually anonymous when he contacts the company for the first
time. In B2B, on the other hand, the sales process brings some data and basic information about a customer,
so in the case of a recall or a complaint, the supplier already possesses a profile of the customer. What is
more, in some cases, in B2B areas, cooperation may result in personal friendship or other good personal
relationships which is rarely observed in B2C.

Multiple Contact Potential - A contact within B2C is generally a contact with a single person who bought the
product. In B2B space such a contact is rare. Usually many people use the product within the same customer
company and thus various people may contact a supplier with various problems concerning its quality.
However, it may also happen that many people will contact a supplier with an issue concerning the same problem.

### 2.3. Complaint proceedings in the context of small and large companies

Apart from differences between individual customers and industrial companies, another important aspect of B2B are customers’ expectations towards complaint management that result from asymmetric character of the relationship between a supplier and customer. Although, the research included in [10] does not clearly prove the assumption that smaller companies differ from large ones in the aspect of their expectations toward complaint resolution because of the uneven position in contrast to the partner, an assumption may be made that such factors as size or power differences between a supplier and a customer have impact on the complaint management [13]. What is more, it may be assumed that large companies who are more powerful than their suppliers, may negotiate better conditions for resolutions, and at the same time, smaller customers may be more accommodating and focused on keeping good relationship with an important supplier [10].

Such asymmetric relationship may be observed in aluminum beverage can industry. There are large and smaller companies on both can producers’ and material suppliers’ sides. The relationships between them often have roots in strong and long-term cooperation, however the conditions of the cooperation may differ from one another which may result from the imbalance of power in some of the relationship. The imbalance may also influence procedures and actions of customers, which was called by Clark [8] as ‘available zones of manoeuvre’.

### 2.4. Complaint procedures in B2B

In many B2B spaces, the best moment to check quality of delivered products is the moment of goods receiving. It is the best moment to check both the condition and volume of the delivery. However, in some cases, quality control of a delivered product at the moment of receiving is not carried out, and the customer relies on the quality management system of a supplier. In such cases, a complaint procedure should be started as soon as problems with a product are observed [9].

The theory usually focuses on inter-company complaint procedures and says, that the non-conforming product should be immediately isolated and left to carry out actions connected to complaint. The basic document of the procedure is a complaint protocol that should include at least such information as: name of the product, the volume of recalled product, description of the defect and the customer’s request. According to the agreement between a supplier and a customer, the complaint protocol is either sent by fax or email and is based on a form proposed by any of the partners [9]. A supplier should consider the complaint within the fixed time and either accept it or deny. If the complaint is accepted, if it is possible to fix the defect in customer’s company, the customer should agree on it, but it is a supplier who incurs the costs. Otherwise, the product should be sent back to the supplier where it will be fixed. To prevent further delays in production, a customer may ask the supplier to deliver replacing products for the time of repair [9].

If the product cannot be fixed, it should be broken up for scrap on supplier’s expense. In such cases, it is necessary to prepare a scrapping protocol. The supplier should also realize a supplementary delivery [9].

Apart from standard procedures concerning complaints, some other agreements are worth implementing, for example [9]:

- The customer informs the supplier about non-conformities immediately after they are detected
- The supplier implements correcting actions immediately after a complaint is issued and presents them in 8D report
- The non-conforming product that cannot be fixed should be marked and isolated in a special area
The non-conforming products are left in an isolator for a fixed time in which a supplier may carry out its own analysis. After the time period, the customer breaks the product up for scrap on the supplier’s expense, and any remarks from the supplier will not be taken into consideration after that time.

3. **BEVERAGE CAN PRODUCTION PROCESS**

The production process of beverage cans is known as a very precise and fast one. While the annual production of beverage cans may be counted in hundreds of billions [10], the speed of a press shaping a can body is 350 cans per minute [10]. At the same time, the material used in the process is an aluminium stripe of thickness between 0.270 and 0.245 mm while the wall thickness of a final product does not exceed 0.160 mm (for 33 cl cans) [10].

Moreover, the production process consists of several operations in which the quality of a stripe and conditions of shaping tools are crucial. **Figure 1** presents a schema of the production process.

**Figure 1** A diagram presenting the aluminium beverage can production process. [11]

The process starts from loading a stripe on a feeder with lubricator. Then the stripe is transported to a vertical press called ‘cupper’ where 2 operations take place - blanking and drawing [13]. The cups are then transported to horizontal presses where can body is shaped. Several operations are realized in only one stroke, these are: redrawing, 1st, 2nd and 3rd ironing and dome shaping (in the bottom of a can) [13]. The cans are then trimmed and washed from all lubricants and coolants that are used in presses. After drying operation, cans are decorated and lacquered, as well as the internal coating is put on [13]. Later, a neck and a flange are shaped which allows for closing with a lid after filling a can with a liquid. **Figure 2** presents the evolution of shape after each forming operation from a blank to a final shape of a can.
3.1. Complaints in a can making process

The material used in this production process is aluminium stripe from 3XXX series aluminium alloy in H19 temper. The requirements that the stripes have to meet concern 3 main aspects:

1) High strength
2) Good formability
3) Good corrosion resistance.

The first aspect is important from the point of view of the final product. High strength determines also parameters of final cans, such as: axial load, dome reversal pressure, dome growth caused by exposure to a set internal pressure. Finally, good corrosion resistance is important from the point of view of the use of beverage cans. Because they serve as packaging for various beverages, cans need to be resistant to corrosion, otherwise they could not be used with a contact with food. Strength and formability of stripes are determined by parameters of production process which includes hot and cold rolling.

The important aspect of stripes is that they are delivered as about 10t coils of length counted in kilometres. Because of that, it is hard to check the quality of coils on the length of the coil. Thus, some beverage can producers rely only on certificates delivered by suppliers that ensures quality of the stripes. Such certificates contain information about:

- Chemical composition
- Yield stress
- Ultimate strength
- Elongation
- Anisotropy
- Dimensions: i.e. width, thickness.

However, it is important to emphasise that obviously certificates may be based only on data that is collected from samples taken at the beginning of a stripe (it is not possible to take samples from the middle or end of a coil). As a result, it is possible that in the case of some problems during production process of aluminium stripes, some defects are not revealed in the final quality inspection realised by suppliers. The problems, on the other hand, may appear on a production line of beverage cans and result in a complaint.

Complaints against suppliers may have many causes that may be divided into 3 groups presented in Figure 3.

The first group consists of evident defects that may be visible on the stripe, for example inclusions, scratches, holes, etc. The procedure concerning complaints caused by defects form this group is simple, as there is no difficulty in proving the supplier that the material does not meet basic requirements.
Another group of complaints is more complicated and is based on poor mechanical or visual parameters of final cans. Quality management in companies which produce beverage cans involve tests of mechanical and visual parameters of final cans.

Figure 4 presents parameters of final products of can production process. The parameters concern such aspects as:

1) Dimensions: height of a can, internal and external diameters, height of a flange, thickness of thin and thick wall of a can
2) Mechanical properties, including dome reversal pressure, dome grow under internal pressure, axial load, and drop test.
3) Aesthetics of a can: quality of decoration
4) Safety of a can: quality of internal coating, leaktightness and cleanliness of a can
5) Other: friction coefficient of a bottom and wall which determines cans mobility, unproblematic transportation of filling lines of a producer and customer.

From the perspective of complaints against suppliers, the most important group is the group including mechanical properties. These parameters are crucial from the point of view of a customer. Thus any problems concerning low values of dome reversal pressure or axial load need to be identified and solved as soon as possible. The experience of can producers shows that the main cause of poor quality performance of final cans is mainly caused by insufficient mechanical properties of input aluminum stripes. In such cases, the best solution to prevent further costs is to recall the coil from a can production line and isolate the batch.

Another problems with parameters of final cans are their aesthetics properties. Several defects of aluminum stripes may cause insufficient quality of a surface. In this case it is also important to observe the scale of the defect and take up some actions.

If there are any significant deviations from the set standard, the quality department should inform a production department about their observations. The department may then decide to recall the coil and start complaint procedure.
The most interesting group of complaints is the group including the problem of increased number of jams on presses, especially jams on horizontal presses, called ‘short cans’. The term includes all problems during shaping a can body that cause damage in the product and consequently the jam on a horizontal press. This group is the most interesting because of the procedure of complaints that is different from procedures concerning other 2 groups.

![Figure 4 Properties of final cans that are a subject of concern for customers.](Source: Own elaboration)

Every beverage can producer sets an acceptable value of ‘short cans’ per million of cans produced on a line. The term ‘short can’ does not only concern cans that do not reach standard height, but also many other defects in a can that cause jams in a horizontal press, for example: tearing off or breakage along a side wall. Some examples are presented in Figure 5. There are a few factors that may influence number of short cans, for example the condition of forming tools, lubricant parameters, machine adjustment, however, one of the most important is quality and parameters of an aluminium stripe. Apart from evident defects of a stripe such as inclusions or holes, such parameters as poor formability or insufficient UTS, high anisotropy may strongly increase the value of short cans. However, because of the complex nature of the phenomenon which results from many factors that influence production process at a given time period, it is important to ascertain that the particular problem is really caused by parameters of a stripe.

As a result, some beverage can producers decided to introduce a procedure of complaint that includes a ‘double check’. This means that if the value of a short can exceeds the set value, a coil is recalled from the production line and placed in an isolator for non-conforming materials. After some time, usually after exchange of some shaping tools, the coil is used again. If the high level of a short can is then maintained, the production department decides to start the procedure of an external complaint.

This approach is based on cooperation with suppliers and helps to maintain positive relationship between aluminium stripe producers and their customers. In other words, suppliers may be sure that the stripe was checked more than once, and in different conditions concerning, for example, tools exchange. If the stripe causes the decrease in efficiency of the process because of jams in horizontal presses, although other factors
that may influence this phenomenon are changed, it is likely that it is the material that does not meet fixed requirement. The character of complaint procedures may be also determined by the differences in size on power of the partners. However, the procedure based on a rule of ‘double check’ seem to be reasonable.

![Image of defects](image.png)

Figure 5 Examples of defects that are classified as ‘short cans’
(Source: Own elaboration)

4. LOGISTIC OPERATIONS SUPPORTING CAN MAKING PROCESS

Logistic operations which support can making process include operations of transportation of a coil. The standard procedure of coil transportation within the customer company starts at the moment of delivery. The first transportation usually takes place when coils are transported from a truck to the material store where they wait until the internal orders for them are issued (S1). The next operation is transportation from the material store to the transit store next to production line (S2). The third operation is realized when the coil is loaded into a feeder. If the production process lasts without any problems, logistic operations concerning the coil finish at the moment when the internal roll from the coil is removed while another coil is loaded (S3).

However, in the case of problems on presses, especially horizontal presses, and when the value of ‘short cans’ increases significantly (each can making producer may set its own level of acceptable value of ‘short can’), some actions need to be implemented.

The first step in such cases is usually a modification of lubrication conditions or exchange of tools. However, if these actions do not bring acceptable improvement in the situation, the Production Department decides to remove the coil from the production line. However, as it was mentioned before, it is not a moment when the external complaint procedure is started (S4).

The coil is placed in an isolator with the easily visible label including such information as: date, producer, volume, description of the observed problem, and decision of a Production Department about further actions,
for example ‘to recheck’. At this stage no further actions are implemented and no information is sent to any other department. This stage is fully realised only within Production Department (Figure 7).

**Figure 6** Scheme presenting distribution of transportation in a factory.
(Source: Own elaboration)

After this stage, and some time depending on production and maintenance plan, a coil may be reloaded on the production line (S5). If there are no significant problems, the procedure is finished at this moment. However, in the other case, the coil is removed from the production line and placed again in the isolator of non-conforming materials (S6).

At this moment the Production Foreman starts the external complaint procedure and asks for blockage of the coil in ERP system, while the Line Supervisor decides about further proposal of disposal. Then, the Purchase Department issues a Complaint Protocol to a supplier, discusses the complaint and negotiates the conditions of resolution. If there is an agreement, the Director of Purchase Department accepts its conditions. If the complaint is successfully resolved, the actions are confirmed later by a Production Manager, and further, together with correcting actions presented by a supplier in an 8D report, are approved by the Head of Factory. All the stages of an example complaint procedure are presented in Figure 6.

In other words, in the case of coils without evident defects, it is practiced that a coil is loaded on a production line 2 times before the complaint proceedings are started. It helps to prove non-conformity of the coil. These decisions are made internally in the Production Department. Figure 8 presents the steps of complaint procedure concerning aluminum stripes and Figure 7 presents a scheme of logistic operations concerning coil
transportation resulting from standard and complaint procedures in time and distance. In Figure 7 green lines stand for logistic operations realized within standard procedures, while red color indicated those logistic operation which result from complaints.

![Figure 7 Scheme presenting transportation and time consumption.](Source: Own elaboration)

As it is seen, logistic operations concerning coil transportation in the case of problems with the material on a production line exceed the number of standard logistic operation in this field. Taking into consideration the velocity of production, wasted time on a production line due to the problems, as well as the volume of a coil and the necessity of its unnecessary transportation because of the insufficient quality, it is worth considering what costs suppliers need to refund within a scope of a complaint.

5. CONCLUSION

The article presented logistic aspects of complaints concerning insufficient quality of aluminum stripes used in beverage can making process.

The schema present all additional operations of transportation of a coil due to problems during production and further complaints against a supplier of an aluminum coil. These operations are illustrated with a red color and generate additional costs that are not usually paid by a supplier who in the case of an approved complaint is obliged to cover cost of the material.

What is more, documentation connected to complaint proceedings involves workers from many departments, e.g. Production Department, Purchase Department, Head of Factory which causes additional waste of job
potential that according to Lean Management belongs to the list of ‘wastes’ that ought to be eliminated from a company.

Thus, it seems to be justified to introduce a method to decrease the number of coils that cause problems during production process and negotiate conditions of resolutions with suppliers, which however may be difficult in asymmetric relationships between a supplier and can producer, when the former is a larger market player.

Figure 8 A scheme presenting an example of a complaint procedure concerning poor quality of a stripe resulting in the increased number of ‘short cans’. (Source: Own elaboration)
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REFERENCES


NETWORK CAPABILITY CONFIGURATIONS FOR SERVICE OFFERINGS IN SERVITISED ENVIRONMENTS

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Abstract

The aim of the paper is to analyse the linkages between the types of services (product-centric and knowledge-centric services) that manufacturers deliver to their customers and their (manufacturers) network capabilities configurations. The present study intends to contribute to the logistics and servitisation literature by drawing from the resource-based view and configuration theory to investigate which components of network capabilities are most important to enable manufacturers to develop and deliver services. Manufacturers are moving from selling products to providing solutions, offering innovative combinations of products and services. In the literature, this phenomena has been refers to as "servitisation". Literature begin to highlight importance of different capabilities for product-service provision such as operational capabilities, digitalization capabilities, dynamic capabilities, network management capability and service innovation capability. The present study concentrates on network capabilities because of their strategic importance. Buyer-supplier relationships are critical for successfully providing services. Nonetheless, buyer-supplier relationships in servitised contexts have received little research attention until recently. Furthermore, many researchers study the abovementioned capabilities and their sub-components in isolation from one another. To explore the causal relationships a DEMATEL technique is adopted. Using sample data from nine Polish manufacturers (buyers and suppliers), this study contributes to the literature of servitisation in several ways. First, it must be concluded that not all industrial services require the same configurations of network capabilities. Second, when moving from product-centric to knowledge-centric services, the establishment of relationship-specific adaptations and cooperative norms increases.

Keywords: Network capability, servitisation, DEMATEL method, resource-based view, dynamic-based view

1. INTRODUCTION

Competition is no longer solely based on products or services. Since the late 1990s, a range of researchers has studied the adoption, development and implications of servitisation as a competitive strategy. [1] The literature classified the transformation from product to solutions provision under diverse topics. This phenomena in the literature is regarding as servitisation, service-dominant logic, product-service systems, hybrid offerings, and solutions. [2] All of them lead to a common problem of understanding how manufacturing companies achieve successful transformation. Literature begin to highlight importance of different capabilities for product-service provision such as operational capabilities, digitalization capabilities, dynamic capabilities, network management capability and service innovation capability.[3]

The present study concentrates on network capabilities because of their strategic importance. Network capability refers to the ability to build, handle, and exploit relationships. In order to gain competitiveness from selling products to selling an integrated product and service, service suppliers require processes, guidelines and strategies for their production and operations that differ from those associated with traditional manufacturing. [4] Effective value creation in customer service interactions requires improved relational capabilities and customer relationship management, which facilitates effective cooperation. [5] According to Capaldo and Petruzzelli (2011) the concept of inter-organizational relational capabilities needs to be developed further. [6] Raddats et. al (2015), state that buyer-supplier relationships in servitised contexts have received
little research attention until recently. [7] In particular, research to date has not investigated how buyer-supplier relationships are linked with the types of services. [8] Prior studies present some evidence of the role of network capabilities in producing positive relational outcomes, whether functional [9, 10, 11] or financial [5, 9, 10].

A number of exploratory studies have discussed the resources and capabilities that enable the development and delivery of successful services. For example, based on 22 case studies, Ulaga and Reinartz (2011) concluded that there were four critical resources and five capabilities which were important for success. [12] Other studies have developed theoretical frameworks. Thornton et al. (2013) conceptualize organizational networking as four sets of anticipated outcome-driven behaviours, specifically information acquisition, opportunity enabling, strong-tie resource mobilization and weak-tie resource mobilization. [13] The current literature has focused heavily on factors such as trust, commitment, coordination, formalization, and social ties that are now acknowledged as helping firms develop effective collaboration with suppliers and customers to enhance financial performance. [14] However, many researchers study the abovementioned sub-capabilities in isolation from one another. Those lead to the question about interdependencies and interplay among the identified capabilities for advanced service offering. [3] Thus, researchers need to study the capabilities' configurations to offer services. To address this knowledge gap, the present study intends to contribute to the servitisation literature by drawing from the resource-based view, dynamic-based resource view and configuration theory to investigate which components of network capabilities are most important to enable manufacturers to develop and deliver services. More specifically, the purpose of this study is to identify and explain capability configurations for two different types of services (product-centric and knowledge-centric services) offerings in manufacturing firms. To achieve this purpose, the present study applies a DEMATEL technique. Sample data was gathered from nine Polish manufactures, included a range of manufacturing industries, mechanical equipment, electronic equipment, and steel service centers. Empirical evidence suggests that not all industrial services require the same configurations of network capabilities. When moving from product-centric to knowledge-centric services, the establishment of relationship-specific adaptations and cooperative norms increases. The paper is organised as follows: Section 2 provides a literature review on components of network capability and service types. The sample was described in Section 3. Section 4 illustrates the research methodology. Section 5 describes the empirical findings, which are then discussed in Conclusion in the light of the extant literature. Implications for research and practice as well as the limitations of this research are discussed in Conclusion, too.

2. THE COMPONENTS OF NETWORK CAPABILITY AND SERVICE TYPES

The main idea for a supplier and customer firm engaging in a relationship is to work together in a way that creates value for them. [15, 16] Value can be regarded as a trade-off between benefits and sacrifices. [17] Marketing literature has developed two distinct research streams: the value of (augmented) goods and services, and the value of relationships. [18] Network capability (NC) includes the adoption of a long-term relationship, fostering of collaborative communication, design and use of cross-functional teams, and involvement of supply-chain partners, plays a key role in creating customer value [e.g. 19]. Network capability can help to develop collaborative business relationships. [15] According to Mitrega et al. (2012) creation of value needs mutual learning in order to be able to develop and exploit shared resource configuration in the focal dyad. [14] NC can be viewed as all firm-level activities to increase mutual understanding, coordination, and adaptation, such as resource as well competence adjustments between cooperating companies. [14] Johnsen et al. (2000) and Walter et al. (2006) distinguished the following activities: information sharing, communication between partners, joint decision making, risk and benefit sharing, as well as knowledge sharing, coordination, managing relationship conflict.[20,21]

Cannon and Perreault's (1999, p.441) well-known model of business relationships presents a set of connectors, which the authors define as the “dimensions that reflect the behaviors and expectations of behaviour in a particular buyer-seller relationship”. [22] The authors specify five dimensions of buyer-supplier
relationships: information exchange, operational linkages, legal bonds, cooperative norms and buyer-supplier adaptations. They assume, like the others (e.g. [23]) that the source of a company's competitiveness lies partly outside the company (in its relationships with other business actors). More specifically, inter-organizational relationships consist of various dimensions, such as technical, social and knowledge-related aspects.[14] Walter et al. (2006) conceptualize and operationalize network competence and capabilities.[21] According to Ritter et al. (2002, p. 120), network competence is "the degree of network management task execution and the degree of network management qualification possessed by the people handling a company's relationships".[24] Walter et al. (2006, p. 546) defined network capabilities as "abilities to initiate, maintain, and utilize relationships with various external partners".[21] They distinguished four types of capabilities: coordination, relational skill, partner knowledge, and internal communication. Dyer and Singh (Dyer and Singh 1998) defining relational capabilities, they stressed that are the strategic activities which provide common benefits for all involved partners.[25] Similarly, Johnsen et al. (2000) suggest targeting mutual benefits as the factor distinguishing networking from other activities.[20] In the present study was assumed, according to Mitrega et al. (2012, p.741), that network capabilities are the set of activities and organizational routines which are implemented at the organizational level of the focal company to develop business relationships for the benefit of the company. [14] This study conceptualizes NC from the perspective of a focal company with regard to its set of direct business relationships with their customers.

The importance to which customers perceive value depend on the type of service. Service value creation is examined by structural factors such as operant or operand resources, asset specificity or collaboration dynamics, organizational leadership, and information systems. [17] According to Saccani et al. (2014), it is possible to outline four different service categories that may be included in servitized firms offerings: product support services, customer support services, process related services, process delegation services. [8] Beuren et al. (2013) distinguished two other service types: product-centre and knowledge-centre services, which were considered in this paper. [26] For the purpose of this study is assumed that: (1) product-centric services, aims at ensuring a product's functioning, include processing standardized raw materials to the specific sizes, shapes and tolerances required by customers, engineering and construction services, stockholding, logistics services and (2) knowledge-centric services, aims at improving and/or optimising the customer's processes and includes business consulting, consulting over process optimization, product and process design, process-oriented R&D services, consultancy and professional services for process engineering, test, simulation, design and construction services, process-related training services, help desk for remote support, a website hosting product-related forums, FAQs and chats.

Conceptualization of NC proposed by Mitrega et al. (2012), Cannon et al. (1999) and Raddats et al. (2015) was adopted in this study. Measurement model of NC included five components and some subcomponents: (1) leaders and personnel: my company’s senior management are committed to growing the services business, my company’s senior management have an intimate understanding of our customers' business challenges, my company’s services staff are technical experts in their field, my company is able to retain its best services staff, (2) collaborative approach: organize social events, motivate employees to create close social ties with business partners, socialize at networking events, establish relationships with multiple stakeholders (across functional areas), (3) information exchange: my company uses knowledge management to share best service practice, my company uses proven methodologies to enhance its services, my company’s service business uses IT tools to enhance performance, (4) conflict management: formalised procedure on how to deal with conflict with business partner and across functional areas, train employees on how to handle conflict with business partner, (5) Relationship-specific adaptations (by the buyer or the supplier): supplier / buyer changed its product's features, supplier / buyer changed its personnel, supplier / buyer changed its inventory and distribution, supplier / buyer changed its marketing, supplier / buyer changed its capital equipment and tools.
3. THE SAMPLE

In this study the case selection was purposive. Companies were selected on conceptual grounds [27] following a two-step process: first, the suppliers were selected and subsequently the buyers. Exactly, set of suppliers was formed according to three criteria: variety, relevance and access to data. The sample included a range of manufacturing industries, including mechanical equipment, electronic equipment, and steel service center. The selected suppliers operate in different industries and maintain relationships with different buyers, deliver different types of services. Referring to relevance, companies were selected that are acknowledged as high performers in their industries. The average turnover from service is 21%, which, following Fang et al. (2008), is in the range of 20-30%, at which a company reaches the critical mass required to obtain a sustainable pay-off from service. [28] Finally, regarding access, companies were selected for which you could be done interview with high-level managers as well as in the buyers companies. The experts were representing several different and distinct organizational functions within the firms: chief executives, finance directors, production directors, R&D managers, business sector managers, senior market managers, technical sales managers, and those responsible for quality control. Each of them had at least five years of experience in design, development and managing of services.

For each suppliers, one or more buyers were chosen. The selection was carried out in a way that it was possible to investigate at least one buyer-supplier relationship in correspondence with the delivery of each service type (product-centric and knowledge-centric services). When supplier provided a service type to more than one buyer, a highly representative buyer was selected (in terms of size, service volumes). In this study was analysed well-established relationship between buyer and supplier. Each supplier was involved in a long-term (at least five years) relationship with the buyer. The research was conducted among employees of nine manufactures located in south part of Poland. Each of the manufacturers offer a wide range of services to its customers including manufacturing, assembling, supply-chain-management, consulting, technical customer support, seminars, tailored packaging and transport solutions, consultancy and professional services for process engineering, test, simulation, design and construction services, process-related training services, installation and commissioning, repair services, provision of spare parts and consumables, decommissioning and disposal service.

4. THE RESEARCH METHOD

The research process consisted of five phases: (1) framework development - identified network capabilities and service types based on literature reviewed, (2) conducted expert interviews to obtain the direct-influence matrix derived from the pair comparisons, (3) assessed the competence of informants with respect to their knowledge, (4) analysed the in-depth of the interrelation among the network capabilities configurations and relation between network capabilities and service types by utilizing the DEMATEL method, and (5) result interpretation. Following O'Cass, Heirati, and Ngo (2014), was assessed the competence of informants with respect to their knowledge about the questions asked and their confidence in their ability to answer questions on a seven-point Likert-type scale, anchored at “1 = not at all” to “7 = very much so”. [29] Respondent who scored below four on any of the two items was rejected. At the end of the survey respondents were asked to indicate, using a seven point scale (1 = “very limited” to 7 = “very substantial”), how knowledgeable they were about issues covered by the survey. Four respondents indicating a knowledge level of three or below were deleted from the study, resulting in 26 remaining respondents. The analysis is done on data from 4 manufacturers-suppliers and 5 manufacturers-buyers that engage in business-to-business selling.

The DEMATEL method is used to solve the complicated and intertwined problem group. It is a sophisticated method for establishing a structural model involving causal relationships among complex factors. [30] It is one of the methods which can identify the interdependence among the variables / attributes of a system. DEMATEL has been successfully applied to many research fields with the purpose to render sophisticated problems and
transform complex systems into structurally causal and effect relationships. [30] Therefore, DEMATEL can be extended in solving causal relationship issues of core competences of an industry or company, which in turn, provide improvement options. [29] It not only provides a way to visualize causal relationships between criteria through an impact-relationship map but also indicates the degree to which criteria influence each other. DEMATEL is also used for identifying critical success factors in a number studies. [e.g. 30, 31] The DEMATEL model construction process consists of four main steps. [30] Step 1: Generating the direct-influence matrix $Z$. The measurement of the relationship between factors $i$ and $j$ requires construct scales of evaluations using pairwise comparisons of dimensions. The measurement criteria of 0, 1, 2, 3, and 4 are used to illustrate no influence, low influence, medium influence, high influence, and extremely high influence, respectively. The direct-influence matrix is constructed based on the degrees of relative impacts derived from the pair comparisons. The integer score $x_{ij}$ is given by the $k$th expert and indicates the influential level that factor $i$ has on factor $j$. Step 2: Normalizing the direct-relation matrix. On the basis of the direct-relation matrix $Z$, the normalized direct-relation matrix $X$ can be obtained by normalizing the direct-relation matrix. The sum of each row $j$ of matrix $Z$ represents the direct effects that factor $i$ gives to the other factors. Step 3: Attaining the total-relation matrix. Once the normalized direct-relation $X$ is obtained, the total-relation matrix $T$ can be calculated. Step 4: Producing a causal diagram. The sum of rows and the sum of columns are separately denoted as vector $D$ and vector $R$. The vector $(D + R)$, named “Prominence,” represents the importance of the criterion. Similarly, the vertical axis $(D - R)$, named “Relation,” divides criteria into a causal group and an effect group. The factor belongs to the causal group if $(D - R)$ is positive, and the factor belongs to the effect group when $(D - R)$ is negative.

5. RESULTS AND ANALYSIS OF THE RESULTS

Following step 1 to step 4, the components of network capabilities importance ($d + r$), relations ($d - r$) and types are shown in Figure 1. The experts were asked to evaluate the direct impact of any factors using pairwise comparison. The judgments were made in two rounds. The goals of first round were: (1) explained the factors evaluated (the resource configurations), (2) made the judgments by the experts and simultaneously, given explanations of judgments. Twenty six experts were interviewed in this round. The goal of the second round was to confirm / change previous assessments (explaining the reason of change his / her judgments). Twenty one experts were interviewed in the second round. Therefore, five expert judgments from the first round were not taken into account for further research evaluations. In the end, judgments of twenty one experts were the basis to build the direct-relation matrix $Z$. The impact of one factor to another was assessed using a five-item scale (from 0 to 4). The two types of services were evaluated separately. The row and column sums, $d$ and $r$, represent the strength of influence that a criterion / dimension has given to and taken from others. The summation $(d + r)$ indicates the correlation intensity or prominence of the criterion element. The summation with higher value means stronger effect. The difference $(d - r)$ shows the direction of the relationship of one criterion toward other criteria. Positive $(d - r)$ means that the criterion is the cause of other criteria while negative value indicates that the criterion is affected by other criteria.

<table>
<thead>
<tr>
<th>Components</th>
<th>$D+R$</th>
<th>$D-R$</th>
<th>Type</th>
<th>Components</th>
<th>$D+R$</th>
<th>$D-R$</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information exchange</td>
<td>4.38</td>
<td></td>
<td>0.22</td>
<td>Cause</td>
<td>6.56</td>
<td>-0.14</td>
<td>Effect</td>
</tr>
<tr>
<td>Relationship-specific adaptations</td>
<td>4.28</td>
<td></td>
<td>0.28</td>
<td>Cause</td>
<td>6.15</td>
<td>0.07</td>
<td>Cause</td>
</tr>
<tr>
<td>Collaborative approach</td>
<td>3.98</td>
<td></td>
<td>0.16</td>
<td>Cause</td>
<td>6.19</td>
<td>0.92</td>
<td>Cause</td>
</tr>
<tr>
<td>Conflict management</td>
<td>4.39</td>
<td></td>
<td>0.64</td>
<td>Cause</td>
<td>5.87</td>
<td>0.12</td>
<td>Cause</td>
</tr>
<tr>
<td>Leaders and personnel</td>
<td>4.69</td>
<td></td>
<td>0.69</td>
<td>Cause</td>
<td>6.63</td>
<td>1.18</td>
<td>Cause</td>
</tr>
<tr>
<td>Product-centric service success</td>
<td>3.99</td>
<td>-1.95</td>
<td>Effect</td>
<td>Knowledge-centric service success</td>
<td>4.66</td>
<td>-2.14</td>
<td>Effect</td>
</tr>
</tbody>
</table>

Figure 1 Components of network capabilities importance ($D + R$), relations ($D - R$) and types (product-centric service - left side, knowledge-centric service - right side)
Overall, in both types of services, product-centric and knowledge-centric services, “Leaders and personnel” is the most important factor with influence strength index \((d + r)\) of 4.69 and 6.63, respectively. All five components of network capabilities in knowledge-centric service group was higher assessed than in product-centric service group. In knowledge-centric group, “Leaders and personnel” followed by “Information exchange” \((d + r = 6.56)\), “Relationship specific adaptation” \((6.19)\), “Collaborative approach” \((6.15)\) and “Conflict management” \((5.87)\). At the same time, “Information exchange”, “Relationship specific adaptation” and “Conflict management” are influenced by “Leaders and personnel” and “Collaborative approach”. The criterion “Information exchange” has the lowest (negative) value of \((d - r) = -0.14\), and is the most easily influenced by other criteria.

In product-centric group of services, besides the “Leaders and personnel”, the most important factors are “Conflict management” \((d + r = 4.39)\), “Information exchange” \((d + r = 4.38)\), “Relationship specific adaptation” \((r = 4.28)\) and “Collaborative approach” \((3.98)\). The results show that “Leaders and personnel” and “Collaborative approach” have the strongest effects on other criteria in product-centric services group. On the other hand, “Collaborative approach” and “Information exchange” have the relation index values \((d - r)\) of 0.16 and 0.22, respectively.

6. CONCLUSION

Complex, knowledge-centric service provision requires the development of new capabilities [12]. However, few studies attempt to identify the network capability configurations in different types of service offerings require and complex causal interdependencies between them. [32] To further the understanding of these complex patterns of causal interrelationships, this study uses DEMATEL technique to identify and explain the specific combination of network capabilities that enables firms to offer product-centric or knowledge-centric service offerings.

The study contributes to the literature of servitisation in several ways. First, the analysis shows that different types of services require different configurations of network capabilities. Knowledge-centric services are more knowledge-intensive and customised than product-centric services. Moreover, it is more difficult to standardise knowledge-centric service operations and processes. [33] Coordination provide a governance mechanism that may be used to simulate hierarchy in exchange when vertical integration is impractical. [22] However, coordination in knowledge-centric services is not as effective as in the other service types and should be supplemented by informal mechanisms and relational governance. Finally, significant relationship-specific investments are required by both parties. Therefore, it must be concluded that building and maintaining trust, which requires long-term investments, it may be more profitable to offer basic, product-centric services, without investing in development of network capabilities. Offering complex and knowledge-intensive services containing vast information asymmetries is more profitable for firms that are able to build high relational capital in their customer relationships. [5] These services include improving and/or optimising the customer's processes, business consulting, consulting over process optimization, product and process design, test, simulation, project management, among others.

Second, findings suggest that there is no one way to manage buyer-supplier relationships in servitised environments. Instead, you argued that the type of service outsourced acts as a contingent factor influencing the characteristics of these relationships. Therefore, by analysing how network capabilities configurations appear for different type of services, in particular, it is found that when moving from product-centric to knowledge-centric services, the establishment of relationship-specific adaptations and cooperative norms increases. The technical information needed by a supplier should be coupled with an increasing degree of knowledge of customers, of the customer's business processes, and ultimately with thorough knowledge of the whole service offering. This entails an increase in the amount of information exchanged as well as the establishment of relationship-specific adaptations and of cooperative norms.
Third, all of five components of network capabilities in knowledge-centric service group were higher assessed than in product-centric service group, therefore knowledge-centric services are more customer centricity than product-centric services. Business model scholars frequently stress that the customer should be at the centre of the business model and its primary goal is to create value for the customer (e.g. [34]). Frankenberger et al. (2013) conceptualized customer centricity on the basis of three dimensions: (1) customer-oriented values and beliefs guide actions of the organization from the top, (2) the structure of the organization uses dedicated customer-facing units and (3) the focus of the organization is on customer needs discovery and satisfaction. [35] Let us assume that: (1) “Leaders and personnel” reflects customer-oriented values, (2) “Relationship-specific adaptations” reflects the structure of the organization uses dedicated customer-facing units and (3) “Collaborative approach” and “Information exchange” reflect the focus of the organization on customer needs discovery and satisfaction. Moreover, recalling what mentioned above, that general all five components of network capabilities in knowledge-centric service group was higher assessed than in product-centric service group, one can states that knowledge-centric services are more customer centricity than product-centric services. However, according to Frankenberger et al. (2013) knowledge-centric services are labour intensive and require intense face-to-face interaction between a supplier and its customer. [35] Thus, such services are not easy to offer to a wide range of clients. However, knowledge-centric service may be offered to a few key customers, which resonates well with.

This study has limitations that could be addressed in future work. First, the findings were worked on too small sample. Therefore, the generalizability of the results cannot be proven. Second, DEMATEL model is highly dependent on the judgments of the experts. Thus, it is needed statistical analysis on a broader sample to confirm presented results.

REFERENCES

CORPORATE SOCIAL RESPONSIBILITY REPORTING AND GREEN SUPPLY CHAIN MANAGEMENT - CASE OF POLAND

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Abstract
The nature of Corporate Social Responsibility (CSR) and the expectations regarding disclosures in this area are changing rapidly. In addition, nowadays companies are increasingly encouraged to explore and report on details of impacts in the entire supply chain. The environmental dimension of CSR concerns the company’s inputs and outputs as well as diverse environmental impacts related to the product and services. This article presents an analysis of CSR reporting in Poland in order to identify the current scope and specificity of disclosures of the Green Supply Chain Management (GSCM) practices. The results of empirical research have shown that CSR reports in Poland depict quite extensive activities and indicators related to implementation of cleaner technologies and environmentally friendly processes. There is much less information on requirements for suppliers and subcontractors to maintain relevant environmental standards, inclusion of environmental criteria in the supplier selection, consideration of environmental issues in the selection of transport modes and distribution channels or commitment to environmental protection in marketing activities. However, disclosures of actions that concern the life cycle assessment of products or incorporation of environmental criteria into the process of design and development of products and services are extremely rare. This means that a great number of CSR reporting companies in Poland have not paid sufficient attention to comprehensive disclosures of the GSCM practices so far. This also suggests that a considerable number of the GSCM issues are not perceived by them as significant impacts.

Keywords: Corporate social responsibility, sustainability reporting, green supply chain management

1. INTRODUCTION
In recent years Corporate Social Responsibility (CSR) reporting has attracted growing interest from academics, business representatives and policy-makers. However, most of the issues related to sustainability reporting have focused on the information and actions that are disclosed rather than on aspects that are not reported. In fact, companies individually choose what and how to communicate their progress in CSR. Sustainability reports focus on economic, environmental and social impacts caused by the company’s everyday activities but there is no single and generally accepted standard according to which such reports should be prepared. The most common are the GRI (Global Reporting Initiative) Standards for Sustainability Reporting that enable organizations to understand, measure and assess sustainability performance and disclose relevant results in a similar way [1].

The Green Supply Chain Management (GSCM) has also gained increasing attention within academia and industry. It integrates environmental concerns into interorganizational practices of the supply chain management. Thus, companies are expected to design environmentally conscious practices that include not just their own operations, but also address impacts of business partners in the supply chain. Although the activities related to the GSCM have already become relatively widespread, the approaches to measuring and communicating the performance of such efforts remain less advanced. Despite the importance of the issue, CSR reports have failed to provide a complete description of the supply chain performance, including environmental aspects. This is why the latest version of the GRI G4 Guidelines has expanded the boundary of reporting and recommended more comprehensive consideration of impacts throughout the entire value chain.
Therefore, this article presents an analysis of CSR reporting in Poland in order to identify the current scope and specificity of disclosures of the GSCM practices. There is still scarce research done in this area and, in addition, it is the first such study ever performed in Poland till now. In particular, it expands and enriches the previous surveys focused on quality assessment of CSR reporting practices in Poland [2, 3].

2. THEORETICAL BACKGROUND

CSR reporting can be considered as synonymous with other non-financial reporting terms such as sustainability reporting or triple bottom line reporting. Nowadays, it is also becoming an inherent part of integrated reporting that combines the disclosure of financial and non-financial performance. The most widespread sustainability reporting guidance comprises the GRI Standards for Sustainability Reporting, the OECD Guidelines for Multinational Enterprises, the UN Global Compact (Communication on Progress) and the ISO 26000 (International Standard for Social Responsibility). The GRI Standards seem to be the most trusted and widely used all around the world with the latest version of the GRI G4 Guidelines. The new GRI G4 Guidelines issued in 2013 introduced, among others, expanded standard disclosures of the supply chain. Therefore, each organization is obliged to describe significant actual and potential negative environmental impacts in the supply chain and the actions taken to mitigate them [1]. This means that, according to the GRI G4, issues related to the GSCM practices should certainly be taken into account in CSR-related disclosures.

The essence of the GSCM is related to consideration of multifaceted associations of all links in the supply chain with the natural environment and comprehensive mitigation of their environmental impacts. The GSCM researchers have identified a few applicable and explanatory organizational theories that have been utilized to expand the understanding and knowledge of this research field [4]. Nevertheless, the GSCM definition varies from one researcher to another. For example, Srivastava describes it as combining environmental thinking with the supply chain management and defines it as including the product design, the material sourcing and selection, the manufacturing processes, the delivery of the product to the consumer and end-of-life management of the product after its useful life [5]. According to Hervani et al. [6], the GSCM consists of green purchasing, green manufacturing / materials management, green marketing / distribution and reverse logistics. This means that numerous environmentally conscious practices should be adopted throughout the GSCM, ranging from green design (marketing and engineering), green procurement (certifying suppliers, purchasing environmentally sound materials and products), total quality environmental management (internal performance measurement, pollution prevention) and environmentally friendly packaging and transportation to various end-of-life practices defined by “the 4 R’s” of reduction, reuse, remanufacturing and recycling. In practice, the GSCM deals with various interorganizational relationships, including customers and suppliers with their respective chains and forming webs of very complex ties.

With regard to disclosures of the GSCM practices, the GRI G4 requires companies to report on significant environmental impacts in the supply chain and on actions taken, together with relevant indicators. Disclosures may consist of a description of processes used to identify and assess significant environmental impacts in the supply chain, practices for assessing and auditing suppliers and their products and services using environmental criteria, actions taken to address the significant environmental impacts identified in the supply chain, incentives and rewards for suppliers for prevention, mitigation and remediation of significant environmental impacts, and expectations established in contracts with suppliers to promote prevention, mitigation and remediation of significant environmental impacts [7]. In addition, the disclosed measurable indicators may comprise, inter alia, the number of suppliers subject to the environmental impact assessment, the number of suppliers identified as having significant environmental impacts, the percentage of new suppliers that were screened using environmental criteria, the percentage of suppliers identified as having significant environmental impacts with which improvements were agreed upon as a result of assessment, the percentage of suppliers identified as having significant environmental impacts with which relationships were terminated as a result of assessment [1].
3. MATERIALS AND METHODS

The research described herein included CSR-related reports published by 42 companies from selected sectors in Poland. These sectors comprised chemical & pharmaceutical products, construction & building materials, electric utilities (generation, transmission, distribution and retail of electricity), financial services (banking and insurance), food processing, IT & telecommunications, mining & metals, oil & gas, transportation & logistics and wholesale & retail trade. It was decided to take account of reports published in 2013 or later and the latest available report for every company was analyzed. The reports were obtained via the global online directory of corporate responsibility reports - http://corporateregister.com and the Polish web page dedicated to CSR reporting issues - http://raportyspoleczne.pl/biblioteka-raportow. The study included 23 corporate responsibility (EHS / Community / Social) reports, 13 sustainable (Environment / Social / Economic) reports and 6 integrated (financial and non-financial) reports. Most of the examined reports (29 items) were developed according to the GRI G4 guidelines, but 4 reports were prepared without any external guidelines. The characteristics of the analyzed reports is presented in Table 1.

Table 1 Characteristics of analyzed CSR-related reports [own analysis]

<table>
<thead>
<tr>
<th>Sector</th>
<th>No. of analyzed reports</th>
<th>Report type</th>
<th>Guidelines declared</th>
<th>External verification</th>
<th>Years covered in report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical &amp; Pharmaceutical Products</td>
<td>3</td>
<td>Corporate Responsibility (2)</td>
<td>GRI G4 - Core (2)</td>
<td>Verified (2)</td>
<td>2013-2014 (1) 2014 (1) 2015 (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integrated (1)</td>
<td>None (1)</td>
<td>None (1)</td>
<td></td>
</tr>
<tr>
<td>Construction &amp; Building Materials</td>
<td>3</td>
<td>Corporate Responsibility (1)</td>
<td>GRI G4 - Core (2)</td>
<td>Verified (3)</td>
<td>2013 (1) 2013-2014 (1) 2014 (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustainable (2)</td>
<td>GRI G3.1 - B+ (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Utilities - EU</td>
<td>6</td>
<td>Corporate Responsibility (3)</td>
<td>GRI G4 - Core (4)</td>
<td>Verified (3)</td>
<td>2012-2013 (1) 2013 (1) 2013-2014 (1) 2014 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustainable (3)</td>
<td>GRI G3.1 - B (1)</td>
<td>None (3)</td>
<td></td>
</tr>
<tr>
<td>Financial Services - FS</td>
<td>6</td>
<td>Corporate Responsibility (4)</td>
<td>GRI G4 - Core (4)</td>
<td>Verified (2)</td>
<td>2012 (1) 2013-2014 (2) 2014 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustainable (2)</td>
<td>GRI G3.1 - B (1)</td>
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</tr>
<tr>
<td>Food Processing - FP</td>
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<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>IT &amp; Telecommunications - IT</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
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<td>2011-2014 (1) 2014 (3)</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Transportation &amp; Logistics - TL</td>
<td>4</td>
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<td>GRI G4 - Core (3)</td>
<td>Verified (1)</td>
<td>2013-2014 (1) 2014 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustainable (2)</td>
<td>GRI G3 (3)</td>
<td>None (3)</td>
<td></td>
</tr>
<tr>
<td>Wholesale &amp; Retail Trade - WRT</td>
<td>4</td>
<td>Corporate Responsibility (3)</td>
<td>GRI G4 - Core (3)</td>
<td>None (4)</td>
<td>2012/13-2013/14 (1) 2013-2014 (2) 2014 (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sustainable (1)</td>
<td>GRI G3 - C (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In brackets: number of relevant reports
Based on own previous research [8], the analysis of the content of CSR-related reports has focused on identification of specific descriptions of actions taken and on measurable indicators disclosed in relation to: (1) environmental impact assessment of products (goods and services) with regard to all stages of their life cycle, (2) incorporation of environmental criteria into the process of design and development of products, (3) implementation of cleaner technologies and environmentally friendly processes, (4) inclusion of environmental criteria in the supplier selection, (5) requirements for suppliers and subcontractors to maintain relevant environmental standards, (6) consideration of environmental issues in the selection of transport modes and distribution channels, (7) commitment to environmental protection in marketing activities, (8) the customer and local communities engagement in environmental protection activities.

4. RESULTS AND DISCUSSION

The empirical research results indicate that CSR reports in Poland contain fairly extensive characteristics of implementation of cleaner technologies and environmentally friendly processes. With regard to this area, all analyzed reports included a description of relevant actions taken and measurable indicators disclosed. There is much less information on requirements for suppliers and subcontractors to maintain relevant environmental standards, inclusion of environmental criteria in the supplier selection, consideration of environmental issues in the selection of transport modes and distribution channels or commitment to environmental protection in marketing activities. In addition, explicit indicators in relation to the aforementioned practices are unfortunately uncommon. However, disclosures of actions that concern the life cycle assessment of products or incorporation of environmental criteria into the process of design and development of products and services are extremely rare. There are also no indicators which present measurable achievements in this respect, but it is worth mentioning that 3 of the analyzed reports included data on carbon footprint calculations.

It should be noted that only in the case of two companies did the CSR reports comprise disclosures related to all analyzed GSCM practices. Both these reports were prepared according to the GRI G4 and verified by a third-party external agency. Nevertheless, in general, the CSR reports developed in accordance with the GRI G4 included merely slightly more expanded disclosures of the GSCM practices than those made in compliance with the GRI G3/3.1. The CSR reports elaborated without any external guidelines addressed the GSCM issues less frequently and seemed to be rather unsatisfactory. Taking into account all the sectors under analysis, the most comprehensive disclosures of the GSCM practices were identified in the CSR reports made by companies representing chemical & pharmaceutical products, construction & building materials and food processing. The results of the study are presented in Table 2.

According to the GRI G4, at the core of preparing a sustainability report is the focus on the process of identifying material aspects that reflect the organization’s significant economic, environmental and social impacts or have a substantial influence on the stakeholders’ assessment and decisions [1, 7]. With regard to this issue, insufficient disclosures of the GSCM practices made by considerable number of CSR reporting companies in Poland might mean that they do not perceive such activities as having a significant impact or affecting stakeholders’ attitudes. This suggests that companies still underestimate the significance of environmental impacts in the entire supply chain. Nevertheless, it should also be emphasized that comprehensive and reliable implementation of the GSCM practices requires involvement of diverse innovative initiatives [9] and adequate forms of cooperation between the key actors in the supply chain [10]. Moreover, this necessitates utilization of appropriate quantitative and qualitative tools supporting eco-design and environmentally friendly development of processes and products [11, 12, 13], including identification and valuation of environmental externalities within the life cycle perspective [14], which usually needs the support of dedicated and complex IT tools [15].
5. CONCLUSION

The empirical research results show that a great number of CSR reporting companies in Poland have not paid sufficient attention to comprehensive disclosures of the GSCM practices so far. The focus of the new approach to the GRI Guidelines is materiality, which means reporting on what matters most to companies. This suggests that a considerable number of the GSCM issues are not perceived by them as significant impacts or factors affecting stakeholders’ attitudes. Nonetheless, it seems inevitable that disclosures of the GSCM practices in CSR reports might be a new challenge for companies and a step forward in helping them to recognize the broader picture of sustainability performance across all relevant activities of the entire value chain, regardless of whether those impacts are within direct or indirect control. Unfortunately, this could be also a source of potential major difficulties for companies.
It is worth mentioning that, for the financial year starting on 1 January 2017, large undertakings (exceeding the average number of 500 employees) which are public-interest entities are obliged to include in the management report a non-financial statement containing information to the extent necessary for the understanding of the development, performance, position and impact of their activity, relating to, inter alia, environmental, social and employee matters [16]. These obligatory statements could also include disclosures of the GSCM practices that most likely will gain increasing attention in the future.

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REFERENCES

THE USE OF VIRTUAL FACTORY CONCEPTS AND MODELS FOR FACILITATING LOGISTIC SYSTEMS AND OPERATIONS

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Abstract

Creating a virtual model takes an individual approach. A company’s structure and organization must always be taken into account. The aim of this publication is to describe and analyze virtual factory concepts and models and their implementation as a means of improving company’s logistics and operation. The publication also analyses key factors that should be considered in order to choose optimal software package. Different methods and stages of creating a virtual factory model are presented. The interrelation between all parts of the model, considering internal and external aspects of company’s activity, was described and analyzed. Also, different ways of combining virtual factory models with efficient supply chains between companies were presented. The solution provided is a basis for creating a corporation and building an integrated supply chain management system, which is characterized by an integral set of market principles. Integrated supply chain management highlights the connection between the aims of company’s activity and those of supply chain. Virtual reality remains flexible and can be adapted to changing circumstances.

Keywords: Virtual Factory (VF), Virtual Reality (VR), Virtual Logistics, Virtual Production, model VF

1. INTRODUCTION

Adjusting company’s activity to customer needs enhances its competitiveness and strengthens business’ position as a producer. Continually changing market of customer demand makes it inevitable for companies to adapt to such changes by upgrading and modernizing their manufacturing processes and adapting logistic solutions to the changing conditions. Large companies like Siemens AG, Daimler AG were among the first to implement the conception of VF. There are many definitions for the term “Virtual Factory” (VF) which in literature also appears as „Digitale Fabrik “(DIFA) [4]. In addition, the literature review [3] offers three definitions of DIFA. Large companies like Siemens AG, Daimler AG were among the first to implement the conception of VF. There are many definitions for the term “Virtual Factory” (VF) which in literature also appears as „Digitale Fabrik “(DIFA) [4]. Literature [3] offers three definitions of DIFA. Danfang Chen, Benjamin Hirsch, Engelbert Westkämper take Digitale Fabrik’s meaning as a reflection of an existing factory with possibility to represent it. Javier Silvestre-Blanes, Daniel Morris, Michael Schenk treated Digitale Fabrik as a conception embracing digital models and methods and the same ensures the possibility of the initial planning of a factory and production prior to shifting it into a real enterprise. Uwe Bracht, Christian Eckert developed the idea by adding that Digitale Fabrik includes the process of a product digital development and perfecting of all the basic factory processes and resources linked with a product. These definitions are close to those of „Digitale Fabrik“ committee composed of the groups of Modeling and Simulation, of the Association of German Engineers (Verein Deutscher Ingenieure- VDI), working in the area of product digital development by the means of digital models and tools to improve the real enterprise [4]. The German VDI guideline VDI 4449 defines as follows: „The Digital Factory is the generic term for a comprehensive network of digital models, methods and tools - among others simulation and three dimensional visualizations - which are integrated by an integral data management. Its goal is the holistic planning, evaluation and continuous improvement of all relevant structures, processes and resources of the real factory in connection with the product“ [13].
The Definition of a model in the German VDI guideline VDI 3633: “A model is a simplified replica of a planned or real system with its processes in another system. It differs from the original in important properties only within specified tolerance levels” [1]. Another definition of a model, which I would suggest, virtual model is a digital model integrated through complex data management, 3D modelling, visualization and simulation. It enables to obtain optimal management and control solutions, as well as considerably contributes to the efficient activity of a real-time factory. The essential role of virtual factory model is adequate responding to the changes in company’s activity through comprehensive planning, risk assessment, improving virtual model processes and resources and implementing innovative solutions for a real company. There are numerous options as far as designing and implementing a virtual model is concerned. [8] There is also a wide selection of tools in the form of software packages, which facilitates accurate virtual model creation and offers efficient solutions for any kind of problems that the company might come across.

The key aspects that should be analyzed when choosing a software package are:

- compatibility with company’s aims and priorities, what software will help achieve these aims and realize priorities;
- versatility; what software performs multiple functions and replaces other software packages as a versatile tool;
- the capacity of software to project individual processes;
- compatibility with company’s needs and expectations;
- reasonable price; whether the software is worth its price

Creating a virtual factory is a complex process that requires prompt responding to any changes within company. Implementation of innovative logistic and manufacturing solutions should be planned with not only one particular process in mind, but all groups of processes should be taken into consideration. Their implementation should be preceded by a thorough and accurate financial analysis of the whole investment [9].

2. VIRTUAL MODEL AS A TOOL FOR ESTABLISHING INNOVATIVE BUSINESS

One of the key elements that determine company’s success is advantage over competitors. Using virtual reality, we can identify downsides and shortcomings of real business. It helps to notice any drawbacks in logistic and manufacturing planning, lack of comprehensive activities, lack of optimization and other weak points (e.g. inefficient manufacturing plans, overloading machines, which imposes limits on their capacity, inefficient logistic planning, etc.). Such an analysis allows us to identify company’s strategic aims. That, in turn, brings about the changes that lead to company’s development. Efficient planning and developing new lines of action. In order to facilitate communication within the scope of design principles, it is advisable to start with a single process’ reorganization and then proceed to combine it with other units until an entire virtual model is created. Taking into account a great variety of company profiles, it must be emphasized that every type of company needs an individual approach when it comes to designing their virtual factory. That is what makes the whole task complex. Companies need to organize their own 3D object libraries, upgrade their computer software to be coherent with a virtual factory software of their choice and introduce many other changes on different levels. All of them are time consuming and require financial resources [2]. The complexity is also present in a constantly changing technical documentation of a plant with coinciding lack of the VF model automatic change. Model VF does not efficiently meet the requirements to be used for plant rebuilding purposes. However, the domination of 2D and 3D technical model of architectonic documentation is observed. Uniting those criteria would result in finding a multiple tool for parallel work of different units. In example, it would give the possibility to manage the logistic process as a single unit of VF model, and the 3D model of a warehouse, created precisely according to technical documentation, to be used for the purposes of rebuilding
of a plant. Such model would also be able to function as 2D model, which avails elasticity in the change of a warehouse format in the real-time. (Figure 1).

Figure 1 Creation of a logistic unit (Source: own elaboration)

A rapid exchange of data within technical teams, effective Communications In the area of project rules remains an important aspect. Such single units of FV model gathered together compose a precise model, which is the VF model comprising external and internal functioning of the entire enterprises. The methods used in the creation of VF model, which should be indicated are:

- method of planning;
- computer simulation;[5]
- visualization;
- animation;
- photogrammetry;
- processing of statistic data;
- processes modeling (BPMN, SADT, UML, Data Flow Diagrams, IDEF0) [11].
Joined methods, like integration of new technological solutions with the planning of installation and production movement flows planning, can also be used. While forming of VF models, the necessary thing is the use of the following key elements in form of models:

- **DiFoR Model** (Digital Factory Operating Reference), based on Tyree key elements "model- method-system" [12].
- **SCM Model** (Supply Chain Operation Reference-Model), supply chain reference model;
- **2D graphic model**, based on planning of a plant production space;
- **3D graphic model**, based on detailing of CAD 3D models creation;
- **Computer simulation model**;
- **Process model**, based on modeling of a plant business processes;
- **Analysis model**, based on three key elements: „interpretation-decision- prognosis“;
- **Standardization**, structuring model of documentation (technical, legal, company, administrative, commercial, etc.).

Another way of models classification exists:

- **Graphic model** (2D and 3D model drawing);
- **Analytical model** (mathematic processing of statistical data);
- **Numeric model** (simulation model).

Usage of an advanced analytical tool allows to acquire input data of factory logistic in the shape of charts, statistic data, analysis of bottle necks. Relations like worker - worker, worker - machine, machine - machine, worker - IT system, largely influence process changes of a production plant. This process results in the appearance of new business models, which ensure availability of information necessary for quick creation of logistic systems digital models and it enables inspection of systems’ characteristics and optimization of their efficiency. For planning of a plant logistics, virtual environment has to contain 2D and 3D graphic models, simulation models and analytical models of data processing [7]. In the process of building a virtual model, operations are visualized using 2D and 3D, and simulation serves as a tool to display the data necessary for optimal usage of resources and flow of materials. Such a rational attitude allows quick creation of dynamic storage processes, as well as taking better decisions and logistic operations [6].

### 3. VIRTUAL FACTORY MODELS IN INTER-CORPORATE LOGISTIC PRINCIPLES

Choosing the adequate strategic direction is of crucial importance for company development. Setting out the right direction in a real time company entails constant and flexible updates of logistics processes in Virtual Factory model. Company’s logistics is usually focused on its internal and external changes. While introducing any changes, it must be remembered that a final stage of any process must match the initial stage of a next one. All the logistic processes must form a consistent unity and complementary adjuncts must not break it. Order fulfilment is subject to changes and is usually associated with reorganization of logistic processes in a factory. However, whenever it becomes necessary to make any changes to the flow of goods management, there is a risk that they may be not delivered to a producer on time. Besides, there might occur some disruptions at semi-finished products level. That implies likelihood of delays in order processing. It is worth to notice how Virtual Factory model functions in multi-factory and multinational corporations. Corporations consist of independent units (production plants) that are joined to form one unity. This unity faces the challenge of creating inter-corporate logistics and supply chain that connect all units in an organized way. Also, effective cooperation with other logistic centers is a key factor. The final link in a supply chain is a consumer and the priority remains to ensure a quality product is delivered to them in a timely and efficient manner (Figure 2).
Inter-corporate logistics consists in the flow of goods between factories, where the circulation of supplies and half-finished products is subject to a flexible production schedule. The first step is to identify final production output and pass that information to a logistics hub, which is a spatial-dimension facility that has its own organization system and infrastructure. These facilities make it possible for independent companies to transfer, store and track the flow of goods all the way from producers to consumers. Responsibility for internal supply chain development is one of the crucial tasks for a company. Supply chain connects different production plants in order to enhance the value added in the whole chain, benefiting units at every stage. That kind of chain might be defined as mega-process, that is, a total of activities, from designing and manufacturing a product to the point of delivering it to a consumer. Each mega-process goes through every single unit of Virtual Factory model. Main processes might be repeated even several dozens of times. Each process can be described by a number of characteristics. Virtual Factory model speeds up order processing. Data exchange is conducted in a uniform virtual environment, which facilitates clear and effective communication. It should be noticed that Virtual Factory model depends not only on the type of products manufactured in the factory, but also on the way they are made to meet consumers specific requirements. There might be even several dozens of such ways - methods, which makes each process in the model quite complex. Both semi-finished product and raw material logistics are related to final product inter-factory logistics. The more factories within a corporation, the more coherent all processes should be. If that becomes the case, the supply chain of final product develops and is reinforced (Figure 3). In such complex supply chains, Virtual Factory model considerably contributes to fast transfer of data and information, which optimizes logistic processes at all levels and reduces expenses. Efficient and effective supply chain management considerably improves customer service. It helps to build
customer trust through ensuring prompt and appropriate order processing, timely deliveries and reducing the number of complaints.

![Diagram of integrated supply chain of final product in internal company logistics](source: own research)

While designing a supply chain it is important to consider company’s localization. Supply chain is influenced by entrance/exit locations to/from each point in integrated structure. As a result, we receive networks that consist of groups of trails and factories connected through these trails. Virtual factory model allows for creating and simulating logistic systems and analyzing logistics at all levels of real time factory designing. It brings about the optimization of the whole supply chain, including global logistics centers, local factories and specific logistic operations [2].

4. CONCLUSIONS

This paper describes the specificity of real-time factory functioning on the basis of Virtual Factory model. The use of Virtual Factory models improves logistic operations, reduces raw material expenses and shortens delivery time, in case of both semi-finished and final products. Virtual Factory models should be adjusted to company profiles; therefore individual approach is required. Companies need to create their own virtual libraries, ensure compatibility between all their programs and adapt their management strategies [2]. There must be a correlation between company’s strategy and Virtual Factory concept. The latter ones must also form a unity. There are different kinds of Virtual Factory models because they must be compatible with individual businesses. A Virtual Factory model must match company’s specific internal logistics. Extending a company or its operations to corporation level makes its supply chain complex. While creating a Virtual Factory model, it is important to consider and take into account all aspects of company’s activity. Only then can we expect tangible results: company becomes more efficient, economically viable and better organized.
REFERENCES


TOWARDS A CIRCULAR ECONOMY IN POLAND: ARE WE MOVING TO A RECYCLING SOCIETY?

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Silesian University of Technology, Poland, EU

Abstract

The growing scarcity of natural resources and increase of consumption have resulted in the adoption of an ambitious Circular Economy Package. It has to contribute to "closing the loop" of product life cycles through more recycling and greater re-use of waste generated through entire life cycle. Moving towards a more circular economy is becoming a crucial issue to pursue resource efficiency economy and underpin priorities related to the Europe 2020 strategy. Implementation of circular economy goals fits perfectly to the concept of reverse logistics aiming at ensuring that the products after use and any waste generated in product life cycle are recycled and reused if it is feasible. This means the necessity of modernizing waste policy and treating waste as a resource. In order to improve the benefits gained from better waste management, the European Commission has proposed municipal waste targets for a move to a recycling society. Therefore, this article analyzes the actions and goals that have been accomplished and planned in Poland in the aforementioned subject area. In particular, the reuse and recycling rates of municipal waste and the recycling rate for packaging waste, including specific materials, have been presented and discussed. The barriers that should be overcome for effective implementation of new required solutions have been also described.

Keywords: Circular economy, municipal and packaging waste management, reverse logistics

1. INTRODUCTION

Moving towards a more circular economy is becoming a crucial issue to underpin the priorities related to the Europe 2020 strategy and, in particular, to the Circular Economy Package. However, the transition from a linear to a circular economy is not easy because it requires changes throughout all value chains (starting from design processes and ending with waste handling). Meeting the circular economy assumptions involves the need to introduce essential changes in all the EU member states, including Poland. The basic targets of the planned package include raising the levels of municipal and packaging waste recycling. In order to determine the prospects of the achievement of the new targets in Poland it is necessary to analyze the actions taken so far and the effects achieved in this area. Considering the above, this paper aims to identify and characterize the circular economy requirements in Poland and identify the barriers to the achievement of higher levels of municipal and packaging waste recycling together with the possibility of overcoming them.

2. FRAMEWORK OF CIRCULAR ECONOMY

The concept of the circular economy has become popular in recent years as a potential way to increase prosperity of society, while reducing dependence on natural resources and energy and reducing waste in product life cycle. Its target is “closing the loop” of product life cycle. In the linear model this loop is described as “Take - Make - Dispose”. The circular model aims to change “Dispose” into "Re-use" through keeping the value in products for as long as possible and increasing the amount of products undergoing the recycling and re-used when they have reached the end of their life. Owing to that, the consumption of natural resources and the amount of disposed waste are reduced.

The circular economy is one that is restorative and regenerative and aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological
cycles [1]. The main principle of the circular economy is designing without waste. This means that the product should be designed and optimized for a cycle of disassembly and reuse, which allows to avoid or significantly reduce the amount of waste. Therefore, the model of circular economy can be described as the model of 4R: Reduce, Reuse, Remanufacture and Recycle. The concept of circular economy has been adopted by EU as an essential action to achieve the resource efficiency agenda established under the Europe 2020 Strategy. According to the Communication COM(2014)398 published by EU Commission in July 2014, waste management has been indicated as one of the key areas, in which changes should be made to allow to move toward circular economy. For that reason, following targets for waste were defined [2]: (1) increase the amount of municipal waste undergoing the process of reuse and recycling to a minimum of 70% by 2030 (2) increase the recycling rate for packaging waste to 80% by 2030, with interim targets of 60% by 2020 and 70% by 2025 and (3) ban the landfilling of recyclable plastics, metals, glass, paper and cardboard, and biodegradable waste by 2025, while Member States should endeavor to virtually eliminate landfill by 2030.

To increase motivation for transition to circular economy, on the 2 December 2015 EU Commission implemented an ambitious Circular Economy Package, which consists of an EU Action Plan for the Circular Economy [3] and revised legislative proposals on waste [4,5,6]. The targets for waste set out in this documents are slightly different from those presented in Communication COM(2014)398. The EU proposes: achieving a minimal level for preparing for reuse and recycling of 65% weight of municipal waste by 2030 and 75% for packaging waste, reduction of landfill of waste to a maximum of 10% of total waste by 2030, prohibition of storage of sorted waste and new minimum targets by weight for preparing for reuse and recycling the packing waste depending on the specific materials contained in packaging waste (Table 1).

Table 1 The minimum targets by weight for preparing for reuse and recycling the packing waste resulting from the introduction of the EU Action Plan for the Circular Economy [6]

<table>
<thead>
<tr>
<th>Targets to achieve</th>
<th>Plastic</th>
<th>Wood</th>
<th>Ferrous metal</th>
<th>Aluminium</th>
<th>Glass</th>
<th>Paper and cardboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>By 31 December 2025</td>
<td>55%</td>
<td>60%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>By 31 December 2030</td>
<td>55%</td>
<td>75%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
<td>85%</td>
</tr>
</tbody>
</table>

The introduction of changes proposed in directives will cause an increase in the amount of waste collected selectively and undergoing a process of re-use and recycling. This means, undoubtedly, the increase in feedback flows of products for reuse or repair and flows of waste for recycling. It could be therefore said, that implementation of circular economy increases the importance of the reverse logistics. However, it requires an analysis of the current levels of recycling of municipal waste and packaging waste and an identification of actions, which should be taken to fulfill the requirements included in Circular Economy Package.

3. RECYCLING OF MUNICIPAL WASTE IN POLAND - THE ACHIEVED AND PLANNED TARGETS

The system of municipal waste management in Poland comprises primarily households (in 2014 the share of generated total municipal waste in this segment reached 79.8%) and other entities generating a similar waste mix: commercial entities, small enterprises, offices, institutions and companies rendering municipal services. The system also constitutes a part of packaging management. Packaging waste is one of the types distinguished within selective collection of municipal waste. In Poland, municipal waste management is regulated by the Act on waste of 14 December 2012 and by the Act of 13 September 1996 on keeping cleanliness and order in communes and municipalities. One of the system tasks is to satisfy the European Commission targets reflected in waste management plans on the national and voivodeships level. In 2001 a requirement was laid down to segregate waste according to the following key fractions: paper and cardboard waste; glass packaging waste (colourless and coloured glass separately); plastic and metal waste; green waste [7]. However, the system of segregation of individual waste fractions is not available to all communes.
and municipalities. In 2014, for the total number of 2478, the segregation system was available in 2290 municipalities for paper and cardboard, in 2451 for glass, in 2409 for plastic, in 1322 for metals, in 430 for textiles, in 676 for hazardous waste, in 2287 for bulky waste and in 1880 for biodegradable waste [8]. The main aim of waste segregation is to facilitate waste recovery, recycling and reprocessing. According to binding legal regulations, each real estate owner must conclude an agreement under which municipal waste is collected from its premises. The fee for waste collection is mass-independent, which is to make the system tighter. In order to promote waste segregation among citizens, the fees vary depending on whether waste is mixed or segregated.

Table 2 shows the data concerning the amounts of generated and collected municipal waste in the years 2005-2014, with a division into principal fractions and with achieved levels of municipal waste segregation and recycling.

### Table 2 Selected indicators related to municipal waste management system in Poland in 2005-2014 [8,9]

<table>
<thead>
<tr>
<th>Year</th>
<th>Total amount of generated* and collected municipal waste [Gg]</th>
<th>Collected selectively by fractions [Gg]</th>
<th>Treated by biological methods [Gg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>------</td>
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<tr>
<td></td>
<td>12169</td>
<td>12235</td>
<td>12264</td>
</tr>
<tr>
<td></td>
<td>9352</td>
<td>9877</td>
<td>10083</td>
</tr>
</tbody>
</table>

* - estimated data for years 2000-2013. From 1.07.2013 all real estate owners are covered by the municipal waste management system; ** - reported by Central Statistical Office of Poland without composting and anaerobic digestion; *** - calculated as a level of collected selectively by fractions and sorted out of mixed waste in total collected municipal waste.

The data in Table 2 show that the municipal waste management system in Poland gives better results with every year. This concerns both general categories and segregated waste fractions. Nevertheless, in the context of the European Commission targets that assume that recycling will have reached the level of at least 65% by the year 2030, this improvement is still not good enough. For this reason, the present system will have to be substantially improved in the nearest future. The indices concerning the possibility of improving the availability and efficiency of both selective waste collection and waste segregation that have been achieved so far are still low. However, this also means that the system can be improved by finding and implementing appropriate solutions in these areas. Another problem is the high number of illegal waste dumps (2371 in the year 2014), which proves how leaky the system is.

### 4. RECYCLING OF PACKAGING WASTE IN POLAND - THE ACHIEVED AND PLANNED TARGETS

Two legal and organizational systems coexist in Poland in relation to packaging waste management. These solutions comprise separate collection of individual fractions from municipal waste (described in
previous section) and packaging waste management requirements imposed on entrepreneurs. Entrepreneurs launching packaged products into the market are responsible for most aspects of securing the recycling of packaging waste generated as a result of their activity.

The new Act on packaging and packaging waste management of 13 June 2013 modifies the existing law (established in 2001) in Poland and takes over a part of the regulations included in the Act of 11 May 2001 concerning the obligations of entrepreneurs in management of certain wastes and product fees. The Act was introduced to make the functioning of packaging waste management more efficient and to help achieve the targets of recycling levels set by the EU. The Act sets out the recycling target of 56% for all packaging waste, with specific targets of 23.5% for plastic packaging, 51% for aluminium packaging and steel packaging, 61% for paper and cardboard packaging as well as for glass packaging and 16% for wood packaging [10]. In addition, the Regulation of the Minister of the Environment on annual levels of recovery and recycling of packaging waste from households [11] sets out annual levels of household packaging waste recycling which should be taken into account by the packaging recovery organization. The established level of household packaging waste recycling in 2020 is to reach 50%. The Act on packaging and packaging waste management also deals with product fees (introduced in 2001) that apply to packages (unit, transport and collective). The aim of these fees is to shape behaviours related to recycling waste and, after segregation, passing it on to appropriate receivers, as well as to provide financing for waste collection, recycling and disposal. The level of product fees is established based on achieved levels of packaging waste recycling. An exemption from the obligation to satisfy the required recycling levels and to pay product fees is provided to entrepreneurs launching packaging into the market with a total weight not exceeding 1 Mg per year. Table 3 presents data concerning the packages launched into the market and the achieved packaging waste recycling levels in Poland in the years 2004-2014. The achieved levels of packaging waste recycling are expressed as a percentage and they are the ratio of the weight of packaging waste recycled in a reference year to the weight of packaging placed on the market in the preceding calendar year.

Table 3 Packaging launched into the market and levels of packaging waste recycling achieved in 2005-2014 [9]

<table>
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</thead>
<tbody>
<tr>
<td>Total amount of packaging launched into the market [Gg], including:</td>
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<td></td>
</tr>
<tr>
<td>- plastic packaging</td>
<td>3174.1</td>
<td>2982.5</td>
<td>3133.7</td>
<td>4181.9</td>
<td>3827.0</td>
<td>4293.0</td>
<td>4611.1</td>
<td>4669.9</td>
<td>4836.4</td>
<td>4846.0</td>
</tr>
<tr>
<td>- aluminium packaging</td>
<td>580.8</td>
<td>580.1</td>
<td>515.8</td>
<td>669.9</td>
<td>677.0</td>
<td>733.1</td>
<td>784.4</td>
<td>831.9</td>
<td>895.1</td>
<td>896.3</td>
</tr>
<tr>
<td>- steel packaging</td>
<td>56.7</td>
<td>62.7</td>
<td>22.1</td>
<td>81.4</td>
<td>77.8</td>
<td>78.0</td>
<td>86.1</td>
<td>91.7</td>
<td>86.9</td>
<td>87.7</td>
</tr>
<tr>
<td>- paper and cardboard packaging</td>
<td>139.7</td>
<td>126.9</td>
<td>132.2</td>
<td>167.2</td>
<td>144.8</td>
<td>166.5</td>
<td>160.9</td>
<td>156.9</td>
<td>160.4</td>
<td>156.8</td>
</tr>
<tr>
<td>- household glass packaging</td>
<td>989.3</td>
<td>1037.1</td>
<td>959.1</td>
<td>1237.0</td>
<td>1196.2</td>
<td>1323.0</td>
<td>1419.9</td>
<td>1493.3</td>
<td>1566.3</td>
<td>1568.0</td>
</tr>
<tr>
<td>- packaging made of natural materials</td>
<td>959.7</td>
<td>699.7</td>
<td>777.5</td>
<td>1019.0</td>
<td>842.8</td>
<td>955.4</td>
<td>1078.8</td>
<td>1056.5</td>
<td>1068.6</td>
<td>1028.0</td>
</tr>
<tr>
<td>Achieved level of recycling in total [%], including:</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- plastic packaging</td>
<td>46.7</td>
<td>62.5</td>
<td>48.2</td>
<td>43.0</td>
<td>36.9</td>
<td>38.9</td>
<td>41.3</td>
<td>41.4</td>
<td>36.0</td>
<td>55.6</td>
</tr>
<tr>
<td>- aluminium packaging</td>
<td>30.3</td>
<td>36.9</td>
<td>28.0</td>
<td>23.9</td>
<td>21.5</td>
<td>20.2</td>
<td>22.6</td>
<td>22.2</td>
<td>20.0</td>
<td>28.6</td>
</tr>
<tr>
<td>- steel packaging</td>
<td>86.7</td>
<td>110.4</td>
<td>82.0</td>
<td>60.9</td>
<td>64.2</td>
<td>60.5</td>
<td>54.2</td>
<td>46.7</td>
<td>34.0</td>
<td>48.1</td>
</tr>
<tr>
<td>- paper and cardboard packaging</td>
<td>23.4</td>
<td>34.1</td>
<td>21.2</td>
<td>26.5</td>
<td>33.6</td>
<td>39.5</td>
<td>40.4</td>
<td>47.1</td>
<td>34.8</td>
<td>55.5</td>
</tr>
<tr>
<td>- household glass packaging</td>
<td>65.4</td>
<td>85.6</td>
<td>69.1</td>
<td>67.2</td>
<td>50.9</td>
<td>57.2</td>
<td>58.7</td>
<td>53.2</td>
<td>49.7</td>
<td>72.9</td>
</tr>
<tr>
<td>- packaging made of natural materials</td>
<td>38.4</td>
<td>48.0</td>
<td>39.7</td>
<td>43.9</td>
<td>41.9</td>
<td>45.6</td>
<td>45.1</td>
<td>51.3</td>
<td>43.4</td>
<td>60.2</td>
</tr>
</tbody>
</table>

Table 3 presents data concerning the packaging launched into the market and the achieved packaging waste recycling levels in Poland in the years 2004-2014.
The data presented in Table 3 show that the total recycling rate achieved in 2014 is slightly lower than the target value of 56% established by the Polish law (this also concerns aluminium and glass packaging), but the other targets have been accomplished. It must be noted that the targets proposed by the European Commission with regard to the circular economy assumptions are much stricter. Their achievement will probably necessitate significant changes in methods of packaging waste collection and packaging waste treatment techniques, as well as modification of economic incentives to improve behaviours related to collection of packaging waste.

5. BARRIERS TO ACHIEVEMENT OF THE INTENDED RECYCLING LEVEL - HOW TO OVERCOME THEM

The issues of municipal and packaging waste recycling discussed herein indicate that there is a great potential for improvement in the waste management system. On the one hand, the results of many years of observation and analysis of the waste management system performance lead to a critical assessment of numerous solutions and identification of barriers to the achievement of assumed goals. On the other, new, more demanding waste management targets have been laid down within the Circular Economy Package. The barriers that have to be overcome as a prerequisite for the achievement of the required levels of municipal waste and packaging recycling comprise problems related to legal, organizational, technical and economic solutions, together with issues of ecological awareness.

In respect thereof, the impact of loopholes and imperfections of the adopted legal solutions is essential. One example is the imprecise definition of “waste holding” in the municipal waste management logistic chain [12], which makes it difficult to optimize the costs of the system functioning and, as a consequence, limits the potential for recycling. There are also no legal regulations concerning the structuring of municipal waste selective collection by communes and municipalities within which a given waste flow comprises waste of one type and one nature only [7,12].

The barriers mentioned above also include institutional solutions which allow non-observance of the hierarchy of priorities in the municipal waste management system (including the privileged position of municipal waste incineration plants in relation to other types of municipal waste processing, which also decreases the flow of waste directed for recycling) [7,12]. These difficulties are increased by the current practice of using municipal waste processing technologies (the mechanical-biological one mainly) that contribute to the low share of recycling in the waste flow directed to the installation. Moreover, there is no synergy between waste management and other sectors of the economy [12] (this includes for example the lack of precise standards for products that could be made of waste).

Another problem to be mentioned in this context is the insufficient use of economic instruments that could be a substantial incentive to encourage selective waste collection by real estate owners and change the way of handling collected waste, which is too often utilized as a raw material to produce fuels [7,13]. Additionally, the public awareness of appropriate municipal waste management, including the need to limit waste generation at source and implement selective waste collection, is generally poor.

The multi-aspect character of the waste management issue makes it necessary to adopt a holistic approach to making changes in the system. The changes should be based on improving legislation to make it possible to optimize the channelling of individual flows of packaging and municipal waste. The new Circular Economy Package proposals set out in the National Waste Management Plan [7] will have a chance of being put into effect if the issue of “waste holding” in every link of the logistic chain, including reverse logistics, is regulated. Also the structuring of municipal waste selective collection needs improving. The process improved organization will enable creation of efficient pathways for individual waste fractions. One of the options is to introduce minimum objective criteria for their efficiency assessment. Regulations are also needed that will make it possible for institutional and organizational solutions to reflect the hierarchy of dealing with waste.
In the Circular Economy Package context it is important that the new solutions are designed in cooperation with the reverse logistics sectors utilizing waste as a raw material. The effectiveness of the new solutions will also depend on implementing an incentive fee system that will promote selective waste collection (replacement of the lump-sum settlement method). With respect to packaging waste, it is particularly important that a synergy effect is achieved between economic and ecological objectives and that good practices are developed for individual waste fractions [13]. Actions should also be taken ceaselessly in the area of ecological education.

6. CONCLUSION

The analysis of the municipal and packaging waste management system in Poland points to a continuing improvement in the indices of the levels of waste collected selectively and of its recycling. This is mainly due to the changes in legislation and the new, systemic, organizational solutions introduced in recent years. Despite the positive effects observed so far, meeting the Circular Economy Package assumptions requires further substantial changes.

The results of the analysis indicate that there is a great potential for improvement in waste management. However, the municipal and packaging waste management effectiveness and efficiency can only be improved if comprehensive modifications are made in legal regulations as well as in the area of organizational, technical, economic and educational solutions. Moreover, initiated changes should affect all links of the logistic chain. This should make it possible for the logistic chain partners to develop good practices and produce the effect of synergy between economic and ecological objectives of waste management.

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Abstract
The observed in recent times cost-oriented approach based on reliability of technical systems operations enforces engineering staff to implement modern attitude in facility maintenance oriented towards preventive inspections as well as continual supervision over the technical condition of machines and equipment. An example of such approach can be a facility management system established by American aviation and arms industry oriented on RCM (Reliability Centered Maintenance). RCM method is of particular importance in technical systems connected with public safety where even the slightest human error or an unexpected failure leads to important consequences. The concept based on RCM makes it possible to be increasingly applied in automotive and electronic industry as well as in specialized branches such as Facility Management.

Keywords: Maintenance, RCM, Facility Management, reliability

1. INTRODUCTION
Using modern technological solutions is very important in production processes optimization, as well as in ensuring continuity of production process of industrial organizations. Modern technologies enable obtaining much more end products with assumed properties, consistent with utility properties declared by manufacturer, while reducing unit costs.

It is critical that efforts are taken by businesses, as early as design phase, to ensure that the selection of production machinery and equipment is optimal not only upon purchase but also during ongoing maintenance and servicing. Selection of machinery and equipment has to account for types and properties of the production line, facility, and components of each machine, and their relations to downstream elements of the process line. The new approach to optimization of processes accounts for selection and maintenance of machine fleet that are consistent with demand and possibility of selling final products. Such an approach eliminates excessive shutdowns, need for buffers and production stock [1].

Frequency of reliability of technical system maintenance, observed in recent years, makes maintenance services provide readiness and availability of machinery, at all cost. The trend of outsourcing maintenance services leads to inclusion in Service Agreements of the requirement to ensure maximum reliability and availability of the machine fleet. In many cases contractual restrictions and competition require substituting traditional maintenance of operations, based on traditional inspection intervals, ongoing remedying of failures and defects, with modern management and engineering methods, such as RCM (Reliability Centered Maintenance) or TPM (Total Productive Maintenance).

2. TECHNICAL CONDITION OF FACILITIES, MACHINES AND COMPONENTS
Technical condition of the specific facility, appliance or machine changes during operation with time. Operation maintenance services may to a great, but limited extent, slow down physical wear by servicing operations, preventive maintenance, scheduled overhauls and conservations.

Changes in technical condition of the facility may be divided as follows [2]:
- critical - posing risk to human health and the environment;
• borderline - posing risk to the efficiency of facility operations;
• admissible - posing risk to rational utilization of the facility.

In order to present the technical condition of machinery and equipment correctly, reference to the standard PN-82/N-04001 is required, which contains the definition of use. Acc. to PN-82/N-04001 "use" is defined as: all purposeful organizational, engineering and economical actions carried out by people with mechanical object and mutual relations between them, from the moment of accepting for use to the moment of disposal.

When dealing with operation maintenance we also have to define reliability. Acc. to the standard PN 80/N-04000 reliability is defined as: all properties of the facility which describe its ability to implement specific functions, under specific circumstances and in specific time.

Extension of machine ability is however limited from the viewpoint of maintaining its technical performance, cost-effectiveness of overhaul, and state of the art, substituting existing machinery equipment with newer and better units. Technical condition of the facility is affected by such factors as loss in cohesion, material fatigue, plastic deformations, thermal impact, corrosion, aggressive working environment. The process of wear with time is shown in Figure 1.

![Figure 1](image)

**Figure 1** Changes in the wear of technical facility component in time [2]

Solving operational issues consists in seeking a general pattern of behaviour corresponding with specific group of issues. Generalization of issue enables building a model for given class of operational phenomena [3]. Using the mathematic model we may generalize and develop suitable principles and operating instructions for given appliance. Mathematic modelling of operations enables to determine, with high accuracy, the probability of failure or defect in given appliance and to respond in advance, in order to avoid serious consequences.

The fundamental value for reliability is probability of correct operation of given facility in given time [13], expressed as:

\[
R(t) = P\{t \leq T\}
\]
The above equation provides the method of determining probability that the engineering facility commencing operations at the moment \( t=0 \) shall be working reliably until time \( t \leq T \).

Following indicators may be included among fundamental reliability metrics:

- reliability of engineering facility (exponential quantification):

\[
R(t) = e^{-\lambda t}
\]  

where: \( \lambda \) - intensity of damage,

- engineering reliability factor [14]:

\[
K_g(t) = 1 - F(t) + \int_0^t [1 - F(t - x)] \cdot \mu(x) dx
\]

where: \( F(t) \) - cumulative distribution function for MTBF

\( \mu(t) \) - renovation density of the facility

It should be noted that presently engineering and technology are closely intertwined with economy, and they need to respond to market behaviour flexibly. Optimization of facility operation by using in its construction materials that are more resistant to preset load and to operating conditions, leads to increase in the initial price, which in the context of ever fiercer competition may lead to fluctuations in demand for given product. Adopted methods to improvement product reliability, such as RCM enable increase in facility lifecycle, and reliability throughout the lifecycle.

3. RELIABILITY CENTERED MAINTENANCE (RCM)

RCM methodology originates from 1960s and US civil aviations sector. When implementing the passenger airliner Boeing 747, the manufacturer was obligated to develop new servicing program, straying from traditional non-economic periodic inspections. The term RCM (Reliability Centered Maintenance) was first published in 1978, in the report on airplane reliability by engineers working for Boeing. Soon, RCM methodology was adopted by other industry sectors, such as nuclear energy, mining, oil, chemical and pharmaceutical sectors. RCM is the procedure that consists in determining necessary actions for maintenance of machinery or equipment in good working order, accounting for their working conditions [4]. RCM is considered as the method that enables selection of the best reliability management model for facilities and operation of engineering systems [5]. RCM methodology is even more important in cases where maintenance of safety critical equipment is concerned.

Due to the fact that costs of repair after failure are 1.5 to 2.0 times the costs of preventive inspections [6], adequate monitoring of facility technical conditions is critical for reliability. Each shutdown generates costs related to pause in the production process, conventional penalties for failure to keep the deadline, and possible loss of customers to competition. Therefore, manufacturers of machinery and equipment set the requirement, at the stage of design, that the risk of failure and shutdown is minimized.

Reliability Centered Maintenance (RCM) is an analytical process to determine suitable failure management program, including requirements concerning periodic inspections and other actions to ensure safe operation of machinery and equipment and their cost-effectiveness. Implementation of RCM methodology covers much broader scope than just RCM analysis.
RCM analyzes various types of failures in given system and takes steps to adequately manage current maintenance. Using the logic of RCM methodology, operations services may define the best strategy, especially for emergency operation mode.

4. IMPLEMENTING RCM METHODOLOGY

Implementation of RCM methodology covers much broader scope than RCM analysis alone. Procedure in case of implementing RCM methodology for given technical facility is shown in Figure 2.

![Figure 2 Implementation of RCM approach](image)

The essence of RCM procedure is establishing adequate operation maintenance schedule, where elimination of unnecessary tasks leads to effective management of reliability centered inspection works.

RCM analysis enables determination whether established preventive measures are effective, and whether other, more effective, measures may be adopted to eliminate the probability of failure. RCM methodology assumes that [8]:

- the purpose of current maintenance is maintaining the functionality of component. RCM aims at ensuring the required level of operation of the whole system or system components.
- reliability level as initially assumed during design may cannot be exceeded. RCM may ensure original reliability for the whole lifecycle of the operated facility.
- for RCM safety is the priority. When safety principles are not critical, the priority is given to economic factors.
- reliability is the base for decision-making process. Analysis of the failed facility is necessary to determine the effectiveness of preventive measures. RCM defines the probability of failure and defect, and not only failure rate, as in traditional methods.
- the concept behind RCM methodology is not only prevention of possible damages, but first and foremost extension of system functionality.

Functional diagram of RCM method, considering individual steps, is shown in Figure 3.
5. THE ESSENCE OF RCM STANDARD

In 1998 the Society of Automotive Engineers presented, in the standard SAE JA-1011 Evaluation Criteria for Reliability Centered Maintenance (RCM) Processes presented guidelines for decision-making processes and servicing engineering facilities considering their reliability. The essence of RCM standard, included in SAE JA-1011, refers to so-called "seven questions":

1) Specification of resource functions. What are functions and related standards of utility requirements to the resource in current operating context?

Answering that question requires functional categorization of specific facility. Functional categorization is conducted by means of top-down method. Specific criteria to be met by given process are:

- defining operational context;
- defining regular and irregular functions of the facility;
- accurately defined value or function, e.g. complete, full, maximum;
- implementation level should meet user requirements.

2) Functional damage. How specific facility may lose its ability to provide given function?

Answer to this question should include definition of emergency situations, deviations affecting operation of the appliance. Mortality may be partial and not causing complete shutdown of the facility. Damages include existing damages, future damages and probable damages, and damages considered in the operational process.

3) Determining the causes of damages. What causes damages?

When referring to the standard SAE JA-1011, potential causes of damages need to be detailed. The cause of damage should be determined on the level of its occurrence, and preventive measures should be presented.

4) What are the consequences of damage?

In case of not taking preventing measures, damage consequences should be detailed, their impact on the facility, surroundings, people and environment.
5) What are the consequences and the meaning of failure?

In case of key sectors, such as railways, aerospace, mining, nuclear energy, the consequences of damage to even the smallest machine or part may have catastrophic effects to the environment and public safety.

6) What preventive measures to take in order to foresee the probability of failure, neutralize or completely eliminate the risk?

- scheduled restoration tasks, consisting in carrying out periodic inspections based on equipment use factors (duration, motor-hours, kilometres, etc.);
- replacing given component before expiration of its maximum lifecycle, irrespective of wear or technical condition;
- preventive measures consisting in evaluation of technical condition by means of diagnostic surveys (laboratory analysis of engine oils, axial shift, errors in shape and position).

7) Other standard measures? What steps to take when no adequate preventive measures are selected?

- inspection aiming at checking the possibility of latent defects (Failure Finding Task);
- redesign - redesigning part of given facility in order for the part or the facility to meet safety assumptions concerning people and environment;
- permitting the damage, in the event that costs of preventive measures exceed costs and consequence of failure.

RCM methodology employs preventive maintenance (PM), control inspections and tests (PT&I), overhauls and preservation techniques, in order to effectively increase the probability of given part or function working reliably throughout the assumed lifecycle, at minimum current maintenance costs. The main goal of RCM methodology is ensuring possible highest availability of given appliance/facility, at possible lowest costs of current maintenance. CRM methodology stresses that maintenance related decisions are based on technical requirements and economic aspects. As is the case with a number of technical processes, there are many types of procedures that enable achievement of the final outcome, which is the satisfactory reliability. RCM analysis may require specification of conditions of functional damages referring to specific damage modes, in order to improve the option of failure management.

6. RCM ANALYSIS

There are a few principles characterizing RCM methodology. First, it needs to be stressed that RCM methodology is the functionality-oriented one [11]. RCM aims to maintain functionality of the whole system, not only functionalities of individual components. In addition, RCM defines ranks of system functions and gives them precedence over component functions of the facility.

Fundamental step in development of RCM analysis is determination of major functional aspects of the system and its components. The example: determination of electric motor failure in water pump using RCM methodology sheet, is shown in Table 1.

Major factors in RCM methodology are [12]:

**Reliability** - RCM stresses mostly the initial reliability, by analyzing data from current maintenance. Improvement in reliability is achieved by ongoing monitoring and adjustment of the existing maintenance program, improving communication between technical services, production planners and designers. Improvement in communication results in providing feedback by operations maintenance services to manufacturers and designers of specific assembly of the appliance or unit, improving its reliability at the stage of design.
Table 1 Electric motor functional failure determination sheet [12]

<table>
<thead>
<tr>
<th>Component</th>
<th>Functional Failure</th>
<th>Failure Mode</th>
<th>Source of Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stator</td>
<td>Motor will not turn</td>
<td>Insulation Failure</td>
<td>Insulation contamination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive contamination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Voltage spike</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Phase imbalance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive temperature</td>
</tr>
<tr>
<td>Bearings</td>
<td>Motor will not turn</td>
<td>Burnt rotor</td>
<td>Insulation contamination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive current</td>
</tr>
<tr>
<td></td>
<td>Wrong speed</td>
<td>Excessive vibration</td>
<td></td>
</tr>
<tr>
<td>Bearing</td>
<td>Motor will not turn</td>
<td>Bearing sized</td>
<td>Fatigue</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improper lubrication</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electrical pitting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Contamination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive Thrust</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive temperature</td>
</tr>
<tr>
<td>Motor controller</td>
<td>Motor will not turn</td>
<td>Bearing sized</td>
<td>Mainline contact failure</td>
</tr>
<tr>
<td></td>
<td>Wrong speed</td>
<td>VFD malfunction</td>
<td>Control circuit failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Loss of electric Power</td>
</tr>
<tr>
<td>Fuse</td>
<td>Motor will not turn</td>
<td>Device Burnet out</td>
<td>Excessive current</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive torque</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Poor connection</td>
</tr>
<tr>
<td>Shaft / Coupling</td>
<td>Pomp will not turn</td>
<td>Shaft / coupling sheared</td>
<td>Fatigue</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Misalignment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excessive torque</td>
</tr>
</tbody>
</table>

Costs - in spite that original outlays on process tooling and personnel training increase costs, temporarily, with time costs are reduced, along with the number and frequency of failures. Preventive maintenance is replaced by monitoring of machinery and equipment technical conditions. Reduction in costs due to adoption of RCM methodology is shown in Figure 4.

Planning - implementation of control tests and inspections reduces unjustified costs of current maintenance and shutdown of machinery and equipment.

![Figure 4 Reduction in current maintenance costs due to adoption of RCM methodology [12]](image)

Effectiveness and efficiency - The first rule of RCM is orientation on safety. The second consideration important for RCM program success is cost-effectiveness. Cost-effectiveness includes functionality and purpose of given unit, and then matches cost level with operating priorities. Cost flexibility of RCM referring to
maintenance ensures taking adequate type of measure precisely when it’s necessary. In the event of maintaining the above assumed costs, servicing is stopped and RCM program no longer applies. RCM promotes multi-aspect approach, with most efficient utilization of given resource. Maintenance is carried out based on utility requirements of given unit and consequences of possible damage.

Replacing parts and assemblies - The fundamental benefit of RCM is maximum utilization of machinery and equipment. Replacement of parts and assemblies is based on wear, and not time interval. Such an approach extends the lifecycle of machines and their components.

7. PRACTICAL USE OF RCM METHODOLOGY IN FACILITY MANAGEMENT SECTOR

Preventive maintenance used by engineering services in industrial facilities, factories or office buildings is one of the most commonly used methods of preventing technical failures. Engineers focusing on preventive maintenance in many cases are unable to answer to what extent preventive maintenance measures affect the reliability of engineering system. According to estimations, ca. 50% shutdowns of the facility occur within 7 days following servicing [15]. RCM methodology enables to tackle system efficiency as regards determination of failure consequences, and elimination of such consequences by their early detection or effective servicing. Many maintenance engineers consider RCM as an addition to preventive maintenance, despite the fact that RCM is the tool that enables changing current maintenance program. Results of RCM analysis may indicate the need to replace components of the device or machine, improvement of technical parameter monitoring process, adding or reducing necessary servicing measures. The majority of engineering facilities demonstrates wear process consistent with bathtub curve shown in Figure 5. In the first phase initial failures occur, until damage, caused by normal wear and tear of machinery and equipment.

![Figure 5 Degree of damage in time] [16]

The practical example of RCM methodology use is the sector of sanitary HVAC (Heating, Ventilation, Air Conditioning). Traditional servicing process consisting in changing filters at specific intervals, inspecting compressors and pumps, would not enable detection of issues affecting the operational effectiveness or efficiency of cooling. Adopting RCM methodology enables focusing on analysis results. Remote monitoring of initial parameters, such as outlet air temperature on evaporator, referenced to preset value, enables detecting issues related to cooling agent.

8. SUMMARY

The main issue regarding the maintenance of operations from the engineering point of view is ensuring adequate availability of machinery, equipment and engineering facilities. In the continuous production process, implanted by many companies, any unscheduled shutdown causes additional indirect costs due to failed deliveries, losing customers, damage to another process line. RCM is not a magic wand, eliminating defects and failures, but it enables significantly minimize the risk of their occurrence, and is an effective tool in the current maintenance of machinery and equipment. The major advantages of RCM methodology is that it may
be successfully applied in solving variety of technical problems and issues [9]. TCM plays an important role in complex railway, aerospace, energy projects, due to its material impact on safety of users and surroundings.

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REWARD SYSTEM FOR LOGISTICS MANAGEMENT OF MANUFACTURING COMPANY BASED ON KPIS

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Abstract

The reward system is one of the fundamental elements influencing the managers’ motivation in most companies. The development of such a system is usually a long and expensive task, and the result is very sensitive to unfairness and mistakes. For that reasons, the authors propose a specific set of processes to build a functional and efficient reward system. The aim of this article is to propose reward system methodology for logistics area of manufacturing companies, which will allow the creation of a system based on an appropriate set of selected key performance indicators (KPIs). The methodology is validated on an example from second tier supplier from automotive industry.

Keywords: Reward system, KPIs, manufacturing company, methodology

1. INTRODUCTION

In most companies there is a reward system whose aim is to motivate the employees in various positions and levels of management to higher performance when carrying out their work duties. A properly designed and defined reward system should also contribute to the fulfillment of company objectives and strategies. The individual reward systems and their practical effects differ significantly, and an incorrectly designed or set system can have low, zero or even negative effect. The basic problem is represented by the great complexity of the entire issue, a number of external factors (e.g. cultural), and the absence of clear links between motivation, performance and rewards [1].

The aim of this article is to propose reward system methodology for logistics area of manufacturing companies, which will allow the creation of a system based on appropriate set of selected KPIs. The suggested methodology is intended to design a system for financial remuneration, which is currently still the most important component of the motivation system. Praise and appreciation (non-financial rewards), benefits or career growth are important parts of employee motivation, but they are not going to be dealt with in this article.

2. LITERATURE REVIEW

An effective reward system should be based on fair approach and truthful information, which is why the proposed methodology is founded on KPIs. The use of KPIs for reward systems has been well established in business practice for several decades, and it is still the most common approach at present. According to a global research [2], it has been applied in more than 70% of companies. The second most widely used approach is connecting reward system to BSC [3], which does not exclude a partial utilization of KPIs at all. The use of KPIs is based on the fundamental idea of “What gets measured, gets done” [4]. This is the reason why it is beneficial for a selected set of KPIs to be based on company objectives and to respect system
approach [4, 5]. It is also important not to split the forces of the entire company and the individual managers by introducing too many KPIs [6]. A suitable solution is to divide a set of indicators into two layers:

- **KPIs** - key performance indicators that are considered as most important for achieving the objectives and strategies of the company and they are linked to the reward system.
- **PI** - performance indicators which have an informational character and serve for better decision-making of individual managers.

The individual KPIs should also respect the rules listed below, modified [7]:

- KPI calculation is based on correct and true data files.
- Calculation of the KPI should not be influenced by external effects and particularly by the evaluated subjects.
- Calculation of the KPI should be easy to understand agreed by the participating parties.
- KPI should provide not only the final value but its context as well.
- KPI should lead to positive actions.
- KPI should be relevant with respect to the current company situation.

3. **PROPOSED METHODOLOGY**

The methodology of a reward system for the managers from the area of logistics includes the following steps (see Figure 1).

- **Definition of logistics processes in the company**
- **Selection of key logistics processes**
- **Definition of KPIs in key logistics processes**
- **Assignment of KPIs to the individual departments**
- **Determining the importance of KPIs for the company and the extent of influence by the individual departments**
- **Determining the importance of KPIs for the individual departments**
- **Assigning KPIs to the individual work positions**
- **Determining the importance of KPIs for the individual work positions**
- **Determining the target values of the individual KPIs**
- **Determining rewards for the individual managerial positions**

**Figure 1** Scheme of designed methodology

**Definition of logistics processes in the company** - logistics processes may have different classification structure in companies. The authors suggest using the classification shown in **Figure 2** as the basis of the analysis.

**I. Selection of key logistics processes** - the individual logistics processes contribute to the achievement of the strategic objectives of the company to varying extent. For the sake of simplicity and efficiency of the entire future reward system, the next steps in its development should select only the key logistics processes the proper management of which represents the basis for the successful functioning of the material, information and financial flows within the company.

**II. Definition of KPIs in key logistics processes** - the selection of suitable KPIs and the setting of their calculation is one of the most important and difficult steps of the whole methodology. In practice, this step often reveals many problems, for example, the lack of or high error rate of data in corporate information systems. The selected KPIs should be incorporated into the reward system before all the problems are eliminated and, at the same time, they should respect the principles described in Chapter 2, and their selection and the final form should be accompanied by an agreement of the whole company top management.
III. Assignment of KPIs to the individual departments - it is common in practice that the logistics processes in company are also within the responsibility of other departments than the logistics one or the organizational structure of the company does not include logistics department at all. In these cases, it is necessary to divide the individual KPIs to departments according to the responsibility for their achievement.

IV. Determining the importance of KPIs for the company and the extent of influence the individual departments have on the KPIs - for an objective proposal of the reward system, it is necessary to distinguish between two basic parameters for each logistics KPI:

- The importance of a KPI for the company expressing its degree of global importance for the whole company and its strategy.
- A degree of impact of the individual departments on the KPI determines to what extent the examined departments, which the indicator was assigned to, can influence the level of its fulfilment.

Both of these parameters are evaluated on a scale of <0.100> representing the percentage accomplishment of the defined properties, while the sum of significance of all KPIs equals 100 and, at the same time, the sum of the degree of impact on each KPI across the departments equals 100.

V. Determining the importance of KPIs for the individual departments - this step is determined by a calculation, where the parameters from step 5 for the individual KPIs in the examined departments are multiplied and the result represents the final weight of the KPIs in the individual departments.

VI. Assigning KPIs to the individual work positions - if the department has only one manager who should be involved in the reward system, steps VII and VIII are redundant and the importance of KPIs for the individual departments is equal to the importance for the work position in question. In practice, however, there is a frequent situation where it is beneficial to involve more work positions from the examined department. In this case, it is good for the simplicity of the system to design an approach where the management decides only whether the worker from a given department affects the indicator or not.

VII. Determining the importance of KPIs for the individual work positions - calculation of the importance of the KPIs for the individual work positions takes the form of the standardization of new values of importance of the KPIs for the individual departments, taking into account the selection of the KPIs for each work position from step VII.

VIII. Determining the target values of the individual KPIs - The outcome of the preceding steps is the determination of a weighted set of KPIs for each interested employee. It is also necessary to determine the
target values for the individual KPIs the achieving of which means the KPI will be regarded as achieved. The target values of the individual KPIs must be in line with the company strategy. The target values should be set so that they are achievable but also motivating for above-average performance. This issue can also adopt different approaches in evaluating whether a KPI was fulfilled, or what fulfilment will make it possible to grant the manager a reward or its aliquot part. The two basic approaches can be characterized as follows:

- Use of binary logic: Reward for the individual KPIs is only granted upon the fulfilment of the KPI to 100% (and more).
- The use of interval logic: Reward, as well as the fulfilment of a KPI, is divided into intervals when the partial fulfilment of a KPI the value is assigned to a predetermined interval, which involves a specified reward. The use of the approach should also take advantage of a progressive formation of intervals so that the manager is always motivated to additional performances.

IX. Determining rewards for the individual managerial positions - this step is intended to determine the total amount of the potential reward and the method of its payment. Determining the total amount of reward is very individual for each company, its situation and management. The methods of payment may vary significantly as well, and the most common methods used in practice for managerial positions are quarterly or yearly intervals, or a combination of them.

4. CASE STUDY

The proposed methodology was verified during the designing stage of the reward system for the management of a production company operating as a supplier in automotive industry. The reward system included all the managers involved in the management of logistics processes, except for the position of the CEO, which has its own evaluation system defined by the parent company.

First, all the logistics processes were gradually defined in the examined company, followed by the selection of the key logistic processes with sets of KPIs defined for them. The result is shown in Figure 3. EBITDA indicator has been chosen because it reflects the fulfilment of the basic objectives of logistics management, which can be defined as follows:

- External logistics goals are focused on meeting the requirements of its clients by offering the so-called logistics services, whose achievement means an increase of revenues
- Internal logistics goals are focused on minimizing the logistic costs.

Service level expresses the performance of supplies to customers at the right time, quantity and quality. EBITDA, along with the service level, have been selected as the global indicators that have been assigned to all logistics processes. This approach should guarantee a mutual cooperation of all departments in the management of logistics processes. Inventory turnover was another selected important indicator determining the cost-efficiency of logistics processes, and it is divided into turnover of purchased parts, work in process and finished goods, according to their links to the individual processes. Production processes in the company are divided into two basic production stages. The key role in the first stage is played by the CNC equipment, which is why the complex indicator of OEE (Overall Equipment Effectiveness) has been chosen as the KPI. The second stage is based on manual labour and that is why OLE (Overall Labour Effectiveness) has been chosen in this case. Other indicators are intended to ensure cost minimization in the processes where the company management sees the highest potential savings (savings from negotiations, the cost of emergency transportation).
Determining the importance of the individual KPIs for the company and the degree of influence by the interested departments, including sales, production and warehouses, are shown in **Table 1**. There is no logistics department in the company.

**Table 1** The importance of the individual KPIs for the company and the degree of influence by the individual departments

<table>
<thead>
<tr>
<th>KPI</th>
<th>Priority for the company (%)</th>
<th>Degree of influence of the department on the indicator (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales</td>
<td>Production</td>
</tr>
<tr>
<td>EBITDA</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Service level</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Material inventory turnover</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>Goods in process inventory turnover</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Finished products inventory turnover</td>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>OEE</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>OLE</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Costs of emergency transportation</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Negotiation savings</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Sum</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Steps VI, VII and VIII of the methodology have been aggregated and the common result can be seen in **Table 2**.

**Table 2** shows what ratio the individual KPIs should use for their participation on the total reward of the individual executive staff.

The applications of the last two steps of the methodology, in which the target values are determined, the amount of rewards and the method of their payment, are left out due to confidentiality of the sensitive data.
Table 2 Importance of KPIs for the individual managerial positions

<table>
<thead>
<tr>
<th>KPI</th>
<th>Priority for company (%)</th>
<th>The possibility of influence of the department on the indicator (%)</th>
<th>Sales</th>
<th>Production</th>
<th>Warehouses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Purchasing manager</td>
<td>Sales manager</td>
<td>Head 1st level</td>
<td>Head 2nd level</td>
</tr>
<tr>
<td>EBITDA</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>Service level</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>Material inventory turnover</td>
<td>10</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Goods in process inventory turnover</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Finished products inventory turnover</td>
<td>5</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>OEE</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>OLE</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Costs of emergency transportation</td>
<td>5</td>
<td>0</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Negotiation savings</td>
<td>5</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The use of warehouses</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sum</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

5. CONCLUSION

Thanks to the presented case study, the methodology of the proposed reward system has been verified. The reward system based on KPIs may have certain drawbacks but despite that, according to the authors’ opinion, it is the best choice for rewarding in the area of logistics process management. The important aspects do not include only a sophisticated design and proper initial setup of the reward system, but also its continuous reviewing and updating responding to the current turbulent development of the business environment. Along with the application of such a system, the top management of manufacturing companies should also develop other elements strengthening the motivation and loyalty of all managers with respect the performance and results of the company. The proposed methodology can also be used for non-production companies (e.g. wholesalers, logistics providers) or for other processes of the company.

ACKNOWLEDGEMENTS

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REFERENCES


SOLUTIONS IN THE FIELD OF CITY LOGISTICS AND THE INFLUX OF NEW INVESTORS BASED ON THE EXAMPLE OF THE LUBUSKIE PROVINCE

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Abstract
Urban development and the influx of people causes new problems posed in front of city authorities. Good solutions are those used in the area of logistics. Thus, the new direction of development of logistics that is dedicated to metropolitan area - city logistics. The management of cities, and especially practices in the field of city logistics have an impact not only on the quality of life of residents, but also on the influx of new investors. It could be for example road infrastructure, technical infrastructure, accessibility to the most important routes, the focus of other entities and partners in the area of supply chains have an impact on location of businesses. It becomes important to manage effectively logistics in cities and in creating good conditions for the creation of new enterprises, which stand to benefit metropolitan areas themselves, as well as residents. The aim of the article is to present solutions for city logistics, which favour the influx of new investors. This analysis will be presented on the basis of the Lubuskie Province. The article is literature - empirical, it is based on the analysis of literature, reports and research carried out for the authorities of the Lubuskie Province.

Keywords: City logistics, infrastructure, new investors

1. INTRODUCTION
The changes in the economy force the evolution of management. New tendencies of development necessitate new solutions or using the existing ones to new areas. One such example is the use of logistics aspects in the field of metropolitan area management. Logistics ultimately is dedicated to businesses. However, many aspects are not only related to the businesses but also the processes in the entire economy. The problems that arise due to the growth of cities, population growth, means of transport etc. create a new field of management. The increase of the awareness of the urban population, their preferences and requirements are also factors affecting the exploitation of new areas of management. Thus, for the efficient and effective management, including towns, solutions used in logistics are applied. Hence, a new concept of city logistics has emerged. It supports a number of management processes in the metropolitan area, and also puts a lot of emphasis on areas which have not been treated as relevant or have been ignored so far. One of the benefits that entails city logistics is the ability to create attractive conditions that contribute to the influx of new investors. The aim of the article is to present the relationship between the use of the concept of city logistics and the influx of new investors based on the example of the Lubuskie Province. The article was developed on the basis of the literature as well as the research and report created for the analysis and the state of development of the Lubuskie Province.

2. THE NATURE AND CHARACTERISTICS OF CITY LOGISTICS
The changes emerging in the economy determine new processes and the transfer of management concept to new areas, which are metropolitan areas. With regard to the changes taking place in the economy, at the turn of XX and XXI century a new research area emerged - city logistics. The occurring urban sprawl, and the associated population growth, organizations, enterprises and institutions, the density of road and municipal networks, waste growth, population flows and changes in preferences and awareness of the society, create
significant problems in management. Due to the fact that one of the features of logistics is universalism, the principles of logistics management, which are used in the management of enterprises, can also be transferable to cities’ economy [2]. To understand the idea of changes in the management of metropolitan areas in the first place it is necessary to define and characterize the very concept of "city logistics". [2].

M. Szymczak presented the definition of city logistics based on the definition of logistics developed by the Council of Logistics Management. He states that "city logistics can be defined as the process of planning, implementing and controlling the flows of:

- initiated outside and addressed to the city,
- initiated in the city and directed outwards,
- passing through the city,
- internal in the city

and accompanying information flows, designed to meet the needs of the city in the field of quality management, quality of life and development [6]. "An attempt to define city logistics has been also taken by J. Szoltyszek. He claims that "city logistics is the processes to manage flows of people, goods and information within the logistics system of the city, according to the needs and objectives of the development of the city, with respect for the environment, taken into account that the city is a social organization whose primary goal is to meet the needs of its users [5]." The research of city logistics are the issues of deliberately structured and integrated flow of materials, people and information in the urban area. These problems include, among the others: the problem of transport accessibility of cities, the supply chains of goods, the supply of metropolitan area in water and energy, waste water management, disposal and waste treatment, construction and maintenance of telecommunication networks and care for the environment of urban area and its surroundings [9]. Moreover, one of the main tasks of the city logistics is to create urban transport system that will optimize travel time [1].

The development of flows in the city has a significant impact on the functioning of the residents and life satisfaction in the city. So, it seems important to meet the expectations of citizens by ensuring an optimal urban transport, eliminating traffic congestion, minimizing the environmental impact, ensuring adequate public utilities etc. Aesthetic, cultural aspects and attractiveness of a particular place perception seem also important. This directly affects the number of people living in a given metropolitan area, as well as the increase or decrease in the population of the area. Thus, it is significant to undertake activities in the field of city logistics and optimizing processes in its area.

City logistics includes essentially the same processes that constitute the content of logistics in every dimension. It is possible to mention here transport, warehousing, customer service [6]. The main difference, however, is the recipient of these processes and added value, which in this perspective is a non-financial benefit in the form of the population living in the area, residents' satisfaction, attractiveness of the region, perception of the area by tourists, the region's image. Only an indirect impact of these elements can in some degree help to increase the profitability of the region.

The area of metropolitan area includes, however, the economic and social potential of the country, and its smooth functioning determines both the development of the country and the region [9]. From the point of view of the individual, as individual urban residents, two phenomena are crucial - meeting their needs in favourable conditions and the need to overcome space to implement these needs [4]. These phenomena also affect businesses. The location of the entity is determined now by a number of factors, which among other things, affect the authorities of the state administration. Attracting potential investors should be one of the objectives of the effective management of city logistics. It should be noted that in addition to economic benefits, for particular metropolitan areas remain social aspects.
3. CITY LOGISTICS AND INFLOW OF NEW INVESTORS BASED ON THE EXAMPLE OF THE LUBUSKIE PROVINCE - SELECTED ASPECTS AND RELATIONSHIPS

The development of cities depends on the efficiency of logistics systems, so their development is inextricably linked to the expansion of the logistics on their territories [7]. City logistics involves many concepts relating to the development and efficiency of transport systems [8]. It represents one of the key challenges for the authorities of the metropolitan areas, where the goal is to attract new investments. The location of production plants, companies in urban areas creates new areas of development for these entities. Moreover, the cities have large benefits from the influx of new investors.

The article tries to analyse the factors in the field of city logistics that affect the influx of new investors and the location of businesses. This analysis was based on a case study of the Lubuskie Province. The province is located in the western part of Poland and borders with Germany. The surface covers almost 14 thousand km², and the area is inhabited by over 1 million inhabitants.

The influx of new investment depends largely on the policy followed by the authorities of the administrative units, but also on the actions undertaken in the field of city logistics. It is possible to highlight the factors influencing the decision to locate enterprises, which relate to aspects of city logistics. The following describes the most important conditions affecting the influx of new investors on the example of the Lubuskie Province.

The factors influencing the attraction of new investors in the Lubuskie Province in the field of city logistics (Developed on the basis on: Potencjał inwestycyjny i eksportowy województwa lubuskiego w aspekcie rozwoju gospodarczego gmin i przedsiębiorstw z terenu województwa lubuskiego, Final report, Warszawa 2015, pp. 180-185.):

- Expansion of road infrastructure - preparation of S3 road and ring-roads in order to improve the flow of transport and relieve cities and nuisance to residents. City authorities in a particular way should strive to create conditions that will result in reducing the harmful effects of new investments within cities. Moreover, an important aspect is to improve local roads (municipal, county), which serve as vehicular routes between localizable investments and other co-operators in supply chains. The optimization of road infrastructure is also building new facilities and improving the flow of transport. An example of this province is the construction of a bridge in Kostrzyń, which would improve access to the German border. It is estimated that such an investment, only for one company located in this area, could save 340 thousand km (for 22 thousand of trucks leaving a year with the organization).

- Restoration of inland transport - of navigation on the river Oder, the transport has been in a low degree in the described area so far. According to the estimates, it is possible to achieve the fourth, namely international shipping class on the Oder, which would allow for the connection to an international network of waterways and transport up to 50 million tons of cargo annually.

- Use small airports to transport - Babimost Airport could be used to transport commodities (cargo-type operations).

- Accessibility to the border, and good connections with the main transport routes, including access to the A2, A6, A4 highways.

- Economic activity zones created in Gorzów Wielkopolski, Międzyrzecz, Świebodzin, Sulechów, Zielona Góra, Nowa Sól and Special Economic Zones (Walbrzych Special Economic Zone and Słubice - Kostrzyń Special Economic Zone) - they attract investors because of the tax allowances, grants from local government units and infrastructure of these areas constituting a convenience for the operation of enterprises.

- Improvements in the field of public transport - the problem in connection with the location of new investments and jobs generated there is a need to create new routes for public transport, so that employees can easily reach out to companies.
Access to the media - it is essential in the operation of businesses to have access to both water and electricity, gas, but also the Internet. It is pointed out, however, that in the Lubuskie Province not all areas are sufficiently adapted to the adoption of large investors.

Construction of new halls in the share of local government units - the construction of halls supports the influx of investors, who are not required to prepare the related procedures. An example of such an investment in the Lubuskie is to have built four modern halls by the Wałbrzych Special Economic Zone in 2015, all of which found buyers / tenants. It is also stated that many of the buildings (approximately 300 assets held by municipalities and private owners) situated in the area do not meet modern standards / requirements of the investors.

Qualified staff and adequate labour force - new investments mean new jobs. An important aspect becomes then labour force, but also mid-level managers having competence in particular functional areas. Unemployment in the Lubuskie Province at the end of September 2016 is 8.4%. Additionally, in this region there is a large influx of labour from Ukraine (according to the estimates in the region work 50 thousand of citizens of Ukraine), which affects the development potential of the area.

Social aspects - awareness and attitudes of the local community, which will favour the location of new investments in urban areas. It is now a key aspect, which is associated with the attitudes of citizens and their acceptance of the investments.

Attitudes of the authorities towards new investments emerging in the areas of particular metropolitan areas - it is the way of management, especially in the field of city logistics and the creation of favourable conditions for investments that the desire to create new branches or the location of the new organization in the area depends on.

Shaping space by land use plans and modernization of technical infrastructure.

Research and development - the creation of research units in urban areas, which promotes the development of new technology and eliminates barriers to access them.

Above there were presented the most important factors that affect the influx of new investors in the areas concerned. They refer to the city logistics, as it represents a new challenge placed before the authorities of the metropolitan area in terms of its effective management. Only active actions bringing tangible benefits and improvements in logistics management in cities can affect the development of the areas due to the influx of new investments. There are many benefits that can be achieved be a particular metropolitan area and its inhabitants in the social, economic, organizational, technological terms. Only efficient management of cities, especially in logistics can translate to achieve these effects.

4. CONCLUSION

City development is a very broad topic addressed in the literature and economic practice. One of the concepts that has been implemented for the needs of city management is logistics. The article presents the theme of city logistics in relation to the influx of investors, as a result, and a condition for efficient management of cities. There were presented the factors in the field of city logistics, which affect the influx of new investors. This description was based on the case study of the Lubuskie Province. The Lubuskie has been gradually developing. One of the goals the local authorities set is to create attractive conditions for the development of the industry. The conditions for development of the industry necessitate action in the field of logistics management in urban precincts. Only efficient and effective action can help to build new, attractive locations of businesses for potential investors. Therefore, efficient management in the field of city logistics can bring tangible benefits. The influx of people and new investments can be seen as a benefit, but it is combined with the conditions that must be met in order for a metropolitan area to still remain attractive for both residents and investors. These aspects are included in the topic of city logistics. It is an important management area, which contributes to increasing the attractiveness of regions for potential investments.
REFERENCES


ANALYSIS OF INVENTORY MANAGEMENT IN COMPANIES FORMING BRANCH PURCHASING GROUPS

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Abstract

The aim of this article is to assess and analyze inventory management in commercial companies forming branch purchasing groups. In the article the functioning principles of the purchasing groups and organizations of logistics in this type of groups were discussed. The strengths of the purchasing groups as well as the disadvantages of this type of organizations were shown. The role of the central unit in the organization of supply was discussed. The strategies and methods of inventory management in companies operating within the studied purchasing group were featured. In the article one assessed the impact of each strategy on the financial situation of companies. For the research there were used selected financial ratios and a preliminary financial analysis. The companies analyzed are Polish business units operating in the construction industry. The analysis was made on the basis of the financial statements for the years 2011-2015.

Keywords: Logistics, inventory, purchasing group

1. INTRODUCTION

Commercial companies deal with the purchase and sales of goods. The main objective of the company managers is to buy goods as cheaply as possible and then sell it with the highest possible margin. The organization of work is very important in this type of companies so that the goods do not stack up in the warehouse. Goods should not wait long for a purchaser and it should always be available when the contractor arrives. Too much time deviation in the purchase of goods, warehousing and sales may lead to unjustified costs, which negatively affects the financial results of the company and its safety. Therefore, warehousing and inventory management have a significant impact on the functioning of the company. Inventory optimization directly affects the liquidity and profitability. Errors made in the area of inventory management may lead to lower profitability and may reduce liquidity. The functioning of companies within the purchasing groups is an opportunity for companies to optimize inventory levels, which positively affects the finances of companies.

2. PURCHASING GROUPS

The first Group Purchasing Organizations - GPOs appeared in the US in 1950. Their maximum development was in the 80s and 90s [1]. In Poland, the strong growth of purchasing groups in the retail sector can be observed in the 90s. There are many definitions of purchasing groups. But, to define them properly one should distinguish two concepts of group purchasing and a purchasing group. Very often we can encounter a situation when several companies work together and make a one-time or a several-time common purchase. This type of action should be defined as group purchasing, i.e. a common action in order to purchase merchandise, products, materials or services without creating a special supervising body and without additional restrictions imposed on individual participants of the transaction. It is very popular now to get lower prices. However, a purchasing group should be understood in a different way. It can be described as a group of companies from the same or another industry which combine to make joint purchases [2]. This is a very simplified definition of this type of organization. Another definition defines the purchasing group as a group of cooperating companies. They are managed by a specially created central unit (this is a company which is often referred to as the
purchasing group). One can see the similarity to the organization network by which is meant the economic entity formed by or composed of a group strongly linked units, highlighting the strategic which controls unit all the activities of the organization [3]. The central unit is to execute the tasks commissioned by the companies making up the purchasing group. Performing these tasks is to ensure better financial performance and safety for the companies creating the purchasing group [4]. Another more extended definition of the purchasing group is based upon the definitions of logistics and supply chain by Martin Christopher and it is as follows - a purchasing group is a group of cooperating companies which jointly control and improve the flow property, information and cash from suppliers to end customers. The participants of this system create a separate central unit whose main task is to achieve the objectives set out by the companies in the system. It will take definite attitude towards suppliers in order to force them to meet the necessary requirements [5]. The most important task of the central unit is the realization of the objectives set by the companies in the system.

![An organization chart of a purchasing group](image)

**Figure 1** An organization chart of a purchasing group

Source: own study

The purpose of purchasing groups is to protect the individual companies against strong competition and to increase bargaining power [6]. The purchasing group can be described as powerful purchasers. They meet important criteria characteristic for powerful purchasers [7]: they buy large quantities of products, the goods purchased in the sector are standardized, the products purchased in a given sector by a group of purchasers are an important part of its costs. It is the integration of the companies within the supply chain. It is essential to fight the competition, to take joint actions and not continuous rivalry to avoid self-destruction [8]. The partnership is the basic condition of the supply chain development [9].

Another important division in terms of efficiency analysis of purchasing groups is the division due to the selection of participants into the branch and multi-branch groups. This division is important because of the intensity of the most important features for the assumed purchase groups, i.e. the economies of scale.

In the branch purchasing groups there are companies operating within only a single branch. This is very significant to increase the "power buy" economies of scale. Companies operating in this type of group order the same type of goods. This limits the range of suppliers to the minimum number. Limitation of suppliers makes that the scale of the order is large. The central unit negotiating conditions of the purchase for a branch purchasing group has a strong advantage which is an order size. This type of organization the supplier (producer) must reckon with.

In the case of the multi-branch purchasing groups the effect of scale is less visible as the entrepreneurs in this case divided into smaller groups and the purchasing power for individual goods, products is lower. The most important goal the companies operating within the purchasing groups want to achieve is a low purchase price. The effective functioning of companies in purchasing groups should reduce costs, increase revenue, improve the efficiency of working capital management [10]. The biggest flaw of operating within the purchasing groups is a difficulty to make a decision. Representatives of companies have a different vision of the development and a purchasing group needs to performed jointly the determined course of action.
3. ORGANIZATION OF LOGISTICS IN A COMPANY OPERATING IN THE BRANCH PURCHASING GROUP

In commercial companies logistics can be divided due to the function into the distribution logistics and procurement logistics. Logistics distribution allows enterprises to achieve a better position in the market. It is associated with the client and significant impact on sales by raising the level of customer service [11]. Joint action groups can purchase emergency excursions to take advantage of central storage unit or the help of the purchasing group. This is important because it allows to maintain the client. Distribution is the area that each company separately regulates itself. The commercial enterprise procurement logistics is the process of ordering, delivery of goods, and in certain parts of their storage. Supply consists of all the activities that are necessary for the acquisition of goods and services consistent with the requirements of the user [12]. The most important issues related to the purchase of logistics processes are the completeness, quality, timeliness of delivery, because they condition the efficient service processes [13]. Most of the tasks related to the logistics supply supervises the central unit.

Looking at the distribution level and logistics costs due to the cost centers, a very important role in the case of commercial companies performs a warehouse and the key used for the settlement of its costs. The functioning and organization of procurement and distribution logistics in the commercial company operating in the branch purchasing group are shown in Figure 2.

![Figure 2 Organization of logistics in a company operating in the branch purchasing group.](source: own study)

In case of the supplies organization the majority of purchases are carried out by the central unit. The company reports the demand and the order process is performed by the central unit. The delivery of goods for the company are directed directly from the manufacturer or are carried from the warehouse of the central unit. The central warehouse serves as the point of separation. It expands the supply chain the companies should pay attention to [14]. Companies operating in marketing and purchasing groups can organize delivery in several ways [15]:

a) direct deliveries from the manufacturer to the company,

This delivery system is possible only if one orders the right size of range set by the central unit. If one orders a small quantity of a given product the companies are forced to use other delivery systems.
The direct delivery system means low costs. Another positive feature is its speed of delivery. The speed and virtually no transport costs are the advantages of this solution. However, this type of supply of goods is possible in case of large supplies. Direct delivery is also maintaining the quality of incoming goods [16].

b) deliveries with the use of the central unit

Supply system with the use of the central unit is a solution for companies that at the time of the offer on the given range did not join the joint purchase, or if they ordered a small quantity of goods which was delivered to the warehouse of the central unit.

c) combined deliveries

This model supplies occurs in situations where a batch of goods goes into an area where there are several companies in the purchasing group. Combined deliveries are based on the principles of the concept of Milk-Run and occur when loads are too small to justify the direct deliveries [17].

d) deliveries bypassing the producer

The last system is the most expensive one that can be described as an aggressive supply management strategy.
These companies use only the warehouse of the central unit. If the goods are in the central unit then the companies may make an order. The cost of goods in this case is high, the central unit adds the costs of storage to the price of goods.

However, orders over the state of safety stock is contrary to the main tasks facing warehouse managers such as reducing inventory levels and cost management [18]. Functioning in the framework of purchasing groups often forces managers to this type of orders, thanks to this they gain a very low price of purchased goods.

4. ANALYSIS OF INVENTORY MANAGEMENT IN THE PURCHASING GROUP

In the surveyed companies about 70% of supplies go to companies directly from the manufacturer. Others are fulfilled from the storage of the central unit, which is related with the higher price of purchased goods. Companies operating in a purchasing group situated e.g. in the same province, or the city can also help one another reselling a missing or superfluous goods. This is an opportunity to supplement emergency-stocks. In this way the individual negotiations with the manufacturer are skipped and one can use previously purchased goods by other entities operating in the purchasing group, and the most importantly, one gains time.

Inventory management in the company consists of three basic strategies:

- **defensive or conservative strategy**, which is considered safe. Its main aim is to provide safety. Companies that use this type of management have high inventories. This type of management means high liquidity.
- **offensive or aggressive strategy** which involves minimizing inventory levels. Companies try to optimize inventory levels to that which will not result in downtime in sales. It is a risky model of inventory management.
- **moderate strategy** is intermediate between aggressive and conservative strategies.

In order to determine the strategies of inventory management an analysis of financial data for the years 2011-2015 of units operating in the branch purchasing groups was done. Table 1 shows the share of inventories in current assets.

<table>
<thead>
<tr>
<th>Company</th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
<th>2012</th>
<th>2011</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company 1</td>
<td>0.55</td>
<td>0.44</td>
<td>0.43</td>
<td>0.44</td>
<td>0.40</td>
<td>0.45</td>
</tr>
<tr>
<td>Company 2</td>
<td>0.43</td>
<td>0.42</td>
<td>0.45</td>
<td>0.43</td>
<td>0.41</td>
<td>0.43</td>
</tr>
<tr>
<td>Company 3</td>
<td>0.35</td>
<td>0.49</td>
<td>0.51</td>
<td>0.40</td>
<td>0.36</td>
<td>0.42</td>
</tr>
<tr>
<td>Company 4</td>
<td>0.25</td>
<td>0.23</td>
<td>0.25</td>
<td>0.27</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Company 5</td>
<td>0.45</td>
<td>0.39</td>
<td>0.42</td>
<td>0.33</td>
<td>0.36</td>
<td>0.39</td>
</tr>
<tr>
<td>Company 6</td>
<td>0.50</td>
<td>0.50</td>
<td>0.47</td>
<td>0.45</td>
<td>0.41</td>
<td>0.47</td>
</tr>
<tr>
<td>Company 7</td>
<td>0.54</td>
<td>0.52</td>
<td>0.56</td>
<td>0.54</td>
<td>0.50</td>
<td>0.53</td>
</tr>
<tr>
<td>Company 8</td>
<td>0.70</td>
<td>0.61</td>
<td>0.69</td>
<td>0.58</td>
<td>0.53</td>
<td>0.62</td>
</tr>
<tr>
<td>Company 9</td>
<td>0.53</td>
<td>0.47</td>
<td>0.48</td>
<td>0.53</td>
<td>0.45</td>
<td>0.49</td>
</tr>
<tr>
<td>Company 10</td>
<td>0.45</td>
<td>0.57</td>
<td>0.52</td>
<td>0.47</td>
<td>0.48</td>
<td>0.50</td>
</tr>
<tr>
<td>Company 11</td>
<td>0.82</td>
<td>0.85</td>
<td>0.71</td>
<td>0.79</td>
<td>0.59</td>
<td>0.75</td>
</tr>
<tr>
<td>Company 12</td>
<td>0.38</td>
<td>0.39</td>
<td>0.49</td>
<td>0.42</td>
<td>0.53</td>
<td>0.44</td>
</tr>
<tr>
<td>Company 13</td>
<td>0.42</td>
<td>0.38</td>
<td>0.42</td>
<td>0.42</td>
<td>0.36</td>
<td>0.40</td>
</tr>
<tr>
<td>Company 14</td>
<td>0.41</td>
<td>0.35</td>
<td>0.43</td>
<td>0.43</td>
<td>0.46</td>
<td>0.42</td>
</tr>
<tr>
<td>Company 15</td>
<td>0.61</td>
<td>0.52</td>
<td>0.59</td>
<td>0.57</td>
<td>0.63</td>
<td>0.58</td>
</tr>
</tbody>
</table>
The conducted analysis showed that the average level of inventories in current assets in case of 15 companies did not exceed 50%. It was in the range of 30-45%. This is positive information which indicates that in the studied companies managers try to limit the level of inventories. They do not conduct the defensive, safe inventory management policy. They implement simple methods that facilitate the process of inventory management. e.g. the method of classification ABC, XYZ. However, one should see a gradual increase in the level from year to year.

Table 2 Statistics for the inventory share ratio for 2011-2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Share of inventories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>𝜇</td>
</tr>
<tr>
<td>2011</td>
<td>0.43</td>
</tr>
<tr>
<td>2012</td>
<td>0.44</td>
</tr>
<tr>
<td>2013</td>
<td>0.47</td>
</tr>
<tr>
<td>2014</td>
<td>0.45</td>
</tr>
<tr>
<td>2015</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Changes between 2011 and 2015 were not accidental - the carried out an analysis of average values for both years and the location of points in a scatterplot allow to conclude that we are dealing with an increase in ratios for most companies. Table 3 shows the results for the inventory turnover in days.

Table 3 Inventory turnover ratios in days.

<table>
<thead>
<tr>
<th>Company</th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
<th>2012</th>
<th>2011</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company 1</td>
<td>70.00</td>
<td>70.00</td>
<td>62.00</td>
<td>75.00</td>
<td>52.00</td>
<td>66</td>
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<tr>
<td>Company 2</td>
<td>58.00</td>
<td>60.00</td>
<td>65.00</td>
<td>63.00</td>
<td>69.00</td>
<td>63</td>
</tr>
<tr>
<td>Company 3</td>
<td>50.00</td>
<td>64.00</td>
<td>71.00</td>
<td>52.00</td>
<td>46.00</td>
<td>57</td>
</tr>
<tr>
<td>Company 4</td>
<td>43.00</td>
<td>38.00</td>
<td>44.00</td>
<td>46.00</td>
<td>41.00</td>
<td>42</td>
</tr>
<tr>
<td>Company 5</td>
<td>75.00</td>
<td>68.00</td>
<td>79.00</td>
<td>57.00</td>
<td>64.00</td>
<td>69</td>
</tr>
<tr>
<td>Company 6</td>
<td>59.00</td>
<td>55.00</td>
<td>57.00</td>
<td>46.00</td>
<td>47.00</td>
<td>52</td>
</tr>
<tr>
<td>Company 7</td>
<td>100.00</td>
<td>92.00</td>
<td>87.00</td>
<td>71.00</td>
<td>53.00</td>
<td>81</td>
</tr>
<tr>
<td>Company 8</td>
<td>72.00</td>
<td>61.00</td>
<td>71.00</td>
<td>71.00</td>
<td>66.00</td>
<td>68</td>
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<tr>
<td>Company 9</td>
<td>76.00</td>
<td>63.00</td>
<td>67.00</td>
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<td>61</td>
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<td>82.00</td>
<td>85.00</td>
<td>73.00</td>
<td>70.00</td>
<td>80</td>
</tr>
<tr>
<td>Company 12</td>
<td>52.00</td>
<td>49.00</td>
<td>65.00</td>
<td>64.00</td>
<td>82.00</td>
<td>62</td>
</tr>
</tbody>
</table>
An analysis showed that in most companies this ratio increases and goods hang in warehouses. This is an unfavorable phenomenon. The positive information is that only two companies have an average inventories at the level of over 80 days. These companies are the entities that in the last three years joined the purchasing group. and yet do not use the mechanisms and benefits of the operation together. The last table shows the liquidity ratios.

Table 4 Financial liquidity ratio for the years 2011 to 2015

<table>
<thead>
<tr>
<th>Company</th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
<th>2012</th>
<th>2011</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company 13</td>
<td>61.00</td>
<td>58.00</td>
<td>77.00</td>
<td>76.00</td>
<td>69.00</td>
<td>68</td>
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<td>Company 14</td>
<td>42.00</td>
<td>36.00</td>
<td>44.00</td>
<td>42.00</td>
<td>50.00</td>
<td>42</td>
</tr>
<tr>
<td>Company 15</td>
<td>89.00</td>
<td>81.00</td>
<td>82.00</td>
<td>79.00</td>
<td>78.00</td>
<td>81</td>
</tr>
<tr>
<td>Company 16</td>
<td>59.00</td>
<td>59.00</td>
<td>58.00</td>
<td>62.00</td>
<td>54.00</td>
<td>58</td>
</tr>
<tr>
<td>Company 17</td>
<td>81.00</td>
<td>69.00</td>
<td>62.00</td>
<td>63.00</td>
<td>71.00</td>
<td>69</td>
</tr>
<tr>
<td>Company 18</td>
<td>48.00</td>
<td>47.00</td>
<td>58.00</td>
<td>56.00</td>
<td>46.00</td>
<td>51</td>
</tr>
<tr>
<td>Company 19</td>
<td>61.00</td>
<td>45.00</td>
<td>50.00</td>
<td>66.00</td>
<td>52.00</td>
<td>55</td>
</tr>
<tr>
<td>Company 20</td>
<td>49.62</td>
<td>46.33</td>
<td>48.94</td>
<td>46.08</td>
<td>46.20</td>
<td>47</td>
</tr>
<tr>
<td>Company 21</td>
<td>76.00</td>
<td>67.00</td>
<td>61.00</td>
<td>63.00</td>
<td>67.00</td>
<td>67</td>
</tr>
<tr>
<td>Company 22</td>
<td>78</td>
<td>71</td>
<td>65</td>
<td>65</td>
<td>55</td>
<td>67</td>
</tr>
</tbody>
</table>

Source: own study
Only one of the surveyed companies have the low level of financial liquidity. The rest of the analyzed companies have high liquidity. In the analyzed companies despite the fact that their level of inventories is moderate, it does not inventories disturb them to get high liquidity. It is caused by high levels of debt and low short-term liabilities. which is typical in the branch purchasing groups.

5. CONCLUSION

The studies conducted do not allow uniquely to assign a classic strategy for the surveyed companies. High liquidity, average inventory, a satisfactory level of inventory turnover - all this points to the conservative and moderate strategies. Therefore, for the companies operating in the branch purchasing groups the conservative-moderate strategy should be as an additional strategy to provide inventory management. This strategy in companies operating in branch purchasing groups is based on the guidance information from the central unit. The determination of orders limit. prices. trade credit. discounts and the suppliers is already a central role of the central unit (a specially created company. which can be determined as a purchasing group).
The companies which realize conservative-moderate strategy to keep inventories at optimum levels ranging from 30-45% of current assets. They often order more than they need. but to the extent that guarantees them to obtain a high discount. This is how the optimization works. Minimum limits which guarantee attractive prices are determined by the central unit. In this type of organization the methods based on the Just in Time principles cannot be used effectively. The companies which use this method often apply the one which is based on the principles of economic size - EOQ (Economic Order Quantity) and make the inventories classification based upon ABC or XYZ methods. This model of functioning. supported by mutual cooperation of the companies allows to maintain optimal inventory levels and significantly reduce unnecessary costs

REFERENCES


CUSTOMER ORIENTATION IN LOGISTICS AS A FACTOR INFLUENCING BUSINESS COMPETITIVE ADVANTAGE CREATION

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rmatwiejczuk@uni.opole.pl

Abstract

Firms are constantly looking for the ways and solutions leading to business competitive advantage creation. One of the most effective and efficient solutions of getting and maintaining sustained, long-term competitive advantage by a firm is to implement customer orientation in business management. First of all, customer orientation - perceived as a key component of market orientation - facilitates identification and fulfilment of a customer's needs and wants. In the recent years, apart from important place and role within the marketing concept, customer orientation has been more and more frequently taken into consideration in the logistics concept. The implementation of customer orientation in business management includes in particular: (1) the identification of customers' goals, needs and problems, as well as (2) the adjustment of a firm's offer (products and services) to the unique customer requirements and expectations. The effective and efficient customer orientation implementation in logistics and business management may significantly contribute to market (customer satisfaction, customer loyalty, market share) and economic (profit, profitability, ROI) outcomes achievement by a firm. These outcomes are not only the most significant symptoms of business success, but the basis for business competitive advantage creation as well. The article attempts to identify: (1) the most important dimensions of customer orientation, (2) the most significant possibilities of “embedding” customer orientation in logistics as well as (3) the significance of the logistics service in customer orientation development in the context of business competitive advantage creation.

Keywords: Customer orientation, logistics, competitive advantage

1. INTRODUCTION

Firms are constantly looking for ways leading to gaining and maintaining a sustainable, long-term competitive advantage. Competitive advantage may be embedded, among others, on focusing on customers' needs and wants by the firm. One of the most important conditions for effective and efficient customers' needs and wants fulfilment is the implementation of the customer orientation within business management. The implementation of the customer orientation concerns, in particular, the identification of customers’ purposes, needs and problems as well as the adjustment of a firm’s market offer (products and services) to the individual customer preferences and requirements [2].

The implementation of the customer orientation may also contribute to the achievement of the expected market outcomes (customer satisfaction, customer loyalty, market share) and economic outcomes (profit, profitability, ROI) by the firm. Such outcomes are not only the most significant symptoms of business success but may also be perceived as the basis for business competitive advantage creation [11].

The purpose of this article is to identify the most important dimensions of customer orientation, the most significant possibilities of “embedding” customer orientation in logistics as well as to identify the significance of the logistics service in customer orientation development in the context of business competitive advantage creation.
2. THE NATURE OF CUSTOMER ORIENTATION AND ITS BASIC DIMENSIONS

Customer orientation requires - first of all - the perception of the customer needs and wants as “guideposts” in the business management. The implementation of the customer orientation also requires the proper definition of the firm mission as well as strategic directions of its development conditioning the customer value creation. Furthermore, it is necessary to design and implement the organizational solutions focused on customer service as well as meeting the customers’ needs and wants [12]. An important role is also assigned to the integration of the goals related to the customer orientation with the corporate and business goals, as well as the integration of customer service strategies with the corporate and business strategies.

Customer orientation is often associated with the marketing concept. Ph. Kotler among the key dimensions of the customer orientation enumerates [10]:

- The identification and selection of a firm’s target market,
- The selection of ways and methods enabling customers’ needs and wants identification and fulfilment,
- The development of the integrated composition of marketing tools (marketing-mix),
- The determination of the expected profitability of a firm’s markets and products.

The adoption of the customer orientation by the firm enables building and maintaining long-term relationships with customers. However, maintaining such relationships requires a systematic measurement of the customer satisfaction as well as the design and implementation of solutions leading to the customer loyalty increase [10].

3. CUSTOMER ORIENTATION AS A COMPONENT OF THE FIRM’S MARKET ORIENTATION

In the literature there is often pointed out that customer orientation is an important part of another, much broader orientation, referred to as the market orientation. Firms perceiving market orientation as the basis of their business model, strategy and routine activities, are taking into account not only the needs and wants of customers (customer orientation), but also the monitoring of the strategies and operational programs and projects of their competitors as well as the reaction to the competitors’ behaviour on the market (competition orientation) [4].

The market orientation comprises in particular [9]:

- The collection (at the level of the whole firm) of the market knowledge concerning the firm’s present and future customers,
- Sharing this knowledge within the firm and its distribution across the firm,
- The firm’s responses to the so-called market signals.

Taking the above remarks into consideration, one may notice that the market orientation is characterized by two basic dimensions: (1) the customer dimension, also referred to as the demand dimension, which is related to the “customer sub-orientation” and (2) the competitive dimension, which is related to the “competitor sub-orientation”. In general, that means that the firms on the way to the market orientation implementation should take into account not only the customer needs, wants and preferences, but the competitors’ strategies, operational programs, projects and routines as well.

4. CUSTOMER ORIENTATION IN LOGISTICS

In recent years one may notice an increasing role of the customer orientation within logistics and supply chain management (SCM) areas [6]. The implementation of the customer orientation in logistics is mainly related to such trends as: increasing customer expectations, progressive “customization” of products and services, the
need for providing fast and reliable deliveries of goods as well as the need for providing a high level of customer service. Customer orientation in logistics is a basis for effective and efficient value delivery according to customer preferences.

A. Harrison and R. van Hoek suggested four basic dimensions of the customer orientation in logistics: (1) marketing perspective, (2) market segmentation, (3) service quality, and (4) logistics strategies related to customer preferences [5].

For the firm which treats the customer orientation as a key criterion for effective and efficient business management, the primary aim is to offer values and benefits that solve the customer’s problems. Adaptation of the marketing perspective means that the firm perceives customers as a “subjective starting point” of its activities. Meeting their needs and wants requires adequate methods and instruments related to the creation of value for the customer and, consequently, for the firm.

In fulfilment of the customers’ needs and wants an important role is played by market segmentation. The results of the segmentation can be very useful in the identification of the differences within the preferences of individual customers or customer groups. Market segmentation comes from the marketing concept. Within the marketing area different criteria for market segmentation are used: demographic, economic, geographical, social, etc. Within the logistics area there is one dominant criterion for segmentation: the level of logistics service offered to customers. The precise determination of the level of this service plays a very important role in the process of meeting the requirements of customers, ensuring the required quality of the customer service as well as in the formulation of logistics strategy by the firm.

From the perspective of the logistics concept a key dimension of the customer orientation is the logistics service, including service quality. Logistics service is a basic instrument for customers acquisition and retention, related to continuity, speed and reliability of the supplies meeting customers’ needs. By providing the appropriate level of the logistics service, it is possible not only to offer values corresponding to the customers’ needs and wants, but also to realize the value for the firm.

5. THE ROLE OF LOGISTICS SERVICE WITHIN THE CUSTOMER ORIENTATION IN LOGISTICS

Among the logistics strategies and processes implemented in order to meet the ever changing customers’ needs and wants, a key role is assigned to the logistics service. The customer service in logistics plays a distinctive role and - because of this - is often called “the logistics of the customer” [7]. It should be also noted that effective and efficient solutions within the field of logistics customer service, enabling the fulfilment of the customers’ requirements, can contribute to achieving several benefits by the firm.

Contemporary logistics concept offers different ways leading to the customer benefits increase. In particular, these ways are related to expanding the range and increasing the level of logistics services. Permanently rising customers’ expectations mean that firms are increasingly focusing their efforts on the development of the intangible “parts” of their market offer, among which an important place occupies the logistics customer service.

Customer service can be defined as the ability of the firm’s logistics system to meet the customer’s needs in terms of time, reliability, communication and convenience [1]. These elements could form the basis for defining standards, measures and indicators of service in relation to the customers’ requirements and the firm’s capabilities to meet them. Within the logistics area there is very widely used “formula of logistics customer service” referred to as “7R”, including: right product, right time, right place, right quantity, right quality, right cost, right information [2]. This formula is the basis for the detailed standards, measures and indicators development.
J. J. Coyle, E. J. Bardi and C. J. Langley Jr. enumerate three basic dimensions of customer service [3]:

- processes and activities enabling customers’ needs and wants fulfilment,
- level of service offered to customers, related to standards and solutions required by the customers,
- a firm’s orientation concerning the key importance of the customers and their preferences in the development of the business model as well as a firm’s strategy and operational programs.

The evolution concerning customer service in logistics is presented by D. Kempny [7] [8]. The author indicates two points of view in the customer service definitions: (1) classic and (2) contemporary.

Within the classic point of view, the customer service is the firm’s ability to satisfy the requirements and expectations of customers, mainly as to the time and place of the ordered supplies, using all available forms of logistics activities, including transportation, warehousing, inventory management, information and packaging [7].

Within the contemporary point of view, the terms “logistics customer service” or “customer service in logistics” are more and more often replaced by the term “logistics service”, which is both broader and more adequate term. Contemporary logistics service is related not only to the final customer (consumer), but also to all firms perceived as “customers” in the supply chain (suppliers, manufacturers, distributors, etc.) [8].

Logistics service in its broader view is defined as bringing significant benefits (i.e. fast, flexible, reliable and cost saving) services performance, including warehousing, transportation, handling, compilation, packaging, palletizing, labelling, marking, and many others (information, legal, customs and financial), concerning the supply of the ordered products to the customer [8]. This means that there is a need for the adaptation of the logistics systems as well as the business management systems to the market changes, associated first of all with customers’ satisfaction and solving their problems.

6. THE SYMPTOMS OF THE CUSTOMER ORIENTATION IN LOGISTICS INFLUENCE ON BUSINESS COMPETITIVE ADVANTAGE CREATION

The implementation of the customer orientation may not only contribute to strengthening the widely perceived firm’s competitiveness capacity, but also be a very important source of business competitive advantage as well as a significant premise of business success achievement [2]. Selected aspects concerning the implementation of the customer orientation in logistics in the context of its impact on changes in business management as well as business competitive advantage creation have been the subject of the research conducted by the Chair of Logistics and Marketing at the Faculty of Economics, Opole University, Poland, EU. (The research carried out by the Chair of Logistics and Marketing has included a sample of 111 companies operating in Poland, representing five lines of business: (1) Mining and extraction mining - 5.4%, (2) Industrial processing - 27.9%, (3) Media production and delivery: energy, gas, etc. - 1.8%, (4) Building engineering - 11.7%, and (5) Commerce - 53.2%. See more [13] [14] [15]).

The basis for the evaluation of the implementation of the customer orientation in logistics in the surveyed firms were business practices oriented on the required level of effectiveness and efficiency achievement, concerning key products supplies as well as key markets service (Figure 1).

Key “nature” of the firm’s products and markets means that such products and such markets play a significant role in - respectively - a comprehensive “portfolio” of products offered by the firm as well as a “set” of market segments served by the firm. Key products and key markets stand out against the “other” firm’s products and markets, first of all, by means of a significant contribution to the sales revenues achieved by the firm. Customers representing key markets deserve distinctive treatment by the firm, especially in the context of the level of logistics service offered by the firm.
7. CONCLUSION

Customer orientation plays an important role not only in business logistics, but in overall business management as well. The effective and efficient implementation of this orientation creates the possibilities for successful fulfilment of customer’s needs, wants and expectations.

Among the practices focused on the effectiveness and efficiency of products supplies and markets service, the firms which took part in the study conducted by the Chair of Logistics and Marketing at the Opole University, Poland, EU, the highest significance assigned to logistics processes improvement (64% of responses) and to order management processes (62%). These results may suggest that the firms which implement customer orientation in logistics and business management, focus on processes and activities directly related to the operational, often routine tasks in the field of logistics customer service.

In the process of the achievement of the required level of effectiveness and efficiency of products supplies and markets service an important role is also played by the practices concerning the use of electronic data interchange (EDI), total costs / earnings management systems as well as MRP/DRP/ERP systems. The solutions conditioning continuity, effectiveness, efficiency and reliability of the information flows within the firm as well as within the relations between firms also play an important role in ensuring the service level required by the customers.
REFERENCES


ASSESSING THE INTENSITY OF INSTABILITY IN CONSUMPTION OF STOCKS

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²University of Entrepreneurship and Law, Ostrava, Czech Republic, EU, petr.besta@vspp.cz

Abstract
Fluctuations in consumption of stocks (inventory consumption) can significantly influence comprehensive strategies for warehouse management. Stocks (inventory items) always mean the emergence of secondary costs arising from their possession. High fluctuations in consumption of stocks may then cause higher levels of safety stock and thus higher maintenance costs. The current extremely competitive environment is forcing all businesses to constantly look for potential sources of savings. An interesting option is the precise identification of the amount of variability in inventory consumption and subsequent optimization of the amount of warehouse stocks. The article deals with the analysis of the possibility of classifying stocks and experimental analysis of variability in inventory consumption. The analysis of the variability in inventory consumption was carried out within a selected company in the Czech Republic. Conclusions of the research performed are presented in the article content.

Keywords: Stocks, methods, costs, price, calculation

1. INTRODUCTION
Stocks can be assessed according to various criteria. The most common procedures are based on an assessment of their structure in terms of volume and variability. These methods are considered elementary for any logistic analysis [1, 2]. Other possibilities for the analysis of stocks relate to their potential availability, the consequences arising from their scarcity, seasonality, maintenance and storage requirements as well as other factors. In order to choose an appropriate strategy for inventory management, we must first divide the stocks into groups according to certain characteristics [3, 4]. For these groups of stocks, we can then define a targeted comprehensive strategy. This article focuses on an experimental analysis of the variability in inventory consumption and definition of follow-up recommendations. The article is based on a long-term research carried out in cooperation with industrial companies in the Czech Republic [5].

2. CLASSIFICATION OF STOCKS ACCORDING TO THEIR AMOUNT IN STORAGE
This method uses the principle of Pareto analysis and is often abbreviated as ABC (according to the title of classification groups). ABC analysis is based on the idea that some consumers and products bring greater benefits to the company than other customers or products. In this case, the benefit is assessed in terms of profitability, sales volume, market share and other parameters which are considered as key indicators by the respective business management. When using profitability as an example, then the most profitable customers and products should receive the greatest attention and thus the highest level of customer services. The area of profitability must then be perceived as the share of the given product revenue with regard to fixed costs and profit [6].

In his famous study, Vilfredo Federiko Damaso Pareto, Italian sociologist and economist, addressed the distribution of assets in Milan. Within this study, he also found that 20% of citizens owned 80% of all assets (today and globally, this number is about 5% / 95%). The assumption that significant attributes such as wealth
or importance are concentrated in a relatively small number (of people, factors) is thence called the Pareto principle. The same principle can also be applied in the context of inventory management where we can identify small groups of stocks that make up the majority of the total volume. We can then define three basic groups (ABC) and classify stocks into them according to their volumes (importance).

Therefore, the ABC analysis can be understood as a differentiated approach to inventory management. It is necessary to realize that manufacturing companies often work with hundreds of different types (items) of stocks. In this system, it is then considerably laborious to devote equal attention to all the items or use uniform methods for their management [7]. The ABC analysis is therefore used; it allows managers to divide inventory items into several groups and manage them subsequently in individual ways. Relative to the volume of various stocks, the individual groups can generally be defined as follows:

A - approximately 20% of the items involved in 80% of the total consumption,
B - approximately 10% of the items involved in 15% of the total consumption,
C - approximately 70% of the items involved in 5% of the total consumption.

It should be noted, however, that this structure of stocks will never be observed in real practice. Pareto principle is particularly important in terms of its idea that the items must be divided according to their importance and then managed adequately. The procedure for implementing the ABC analysis can be summarized into the following steps:

1) Accurate determination of annual consumption values for all inventory items.
2) Determination of the total annual inventory value for all items.
3) Determination of the percentage share.
4) Arrangement of items by descending order from most to less significant.
5) Determination of cumulative totals.
6) Classification of items into groups A, B, C or further groups - groups A, B and C should contain items participating approximately in 80%, 15% and 5% of the total consumption, respectively. Items in each group should be simultaneously volume-similar. It is not desirable that one group contains items that differ in volume by more than 10%.
7) Assembly of graphical visualization of computed values.

3. ASSESSING THE VARIABILITY IN INVENTORY CONSUMPTION

Variability analysis is also often called as XYZ analysis (according to the title of classification groups). Compared to the ABC analysis, the essential difference lies in the fact that the variability analysis evaluates the regularity of consumption. Inventory management for materials whose consumption is regular differs from that for materials which are used sporadically. Stocks are generally classified into three basic categories. Group X contains items with highly regular consumption, with no significant fluctuations in consumption. Group Y includes stocks which show deviations in consumption or certain trends throughout the year. Group Z comprises items whose consumption is maximally irregular and the possibilities of predicting their consumption are limited. The items are categorized into XYZ groups according to the values of variation coefficient:

X - variation coefficient - up to 50 %,
Y - variation coefficient 50 - 90 %,
Z - variation coefficient greater than 90 %.

The variation coefficient defines the degree of fluctuations in the statistical data set. It is calculated as a quotient of the standard deviation and simple arithmetic average; this quotient is then multiplied by a constant of 100 (formula no. 1).
The procedure for analyzing the variability in consumption of stock items can be summarized into the following steps:

1. Determining consumption values for monitored inventories within the given period.
2. Calculation of average values for each item.
3. Determining the standard deviation.
4. Calculation of the variation coefficient.
5. Classification of items into categories of variability (XYZ).

In logistic practice, both methods for the classification of stocks are often used simultaneously. Stocks are then classified into groups AX, AY, BX. This classification then provides an overview of the volume structure of individual items as well as the regularity of their consumption.

4. ANALYSIS OF THE VARIABILITY IN INVENTORY CONSUMPTION

Evaluation of the variability in inventory consumption related to a total of 11 selected stock items. Regarding these manufacturing stock items, we exactly knew their consumption per year as well as the consumption of each calendar month. Table 1 lists all the recorded data. For each item of inventory, the table also presents its unit price and the quantity in pieces. This set of stock items was subject to the analysis of consumption variability. Evaluation of variability was performed using the variation coefficient (formula 1). For the calculation of this relationship, we determined all the relevant variables. Table 1 then shows the determined values of arithmetic mean, standard deviation and variation coefficient. At the same time, the table presents the division of stock items into various groups of variability. For assessment into individual groups, we did not use the traditional division into XYZ groups but more detailed classification as shown in Table 2.

Table 1 Analysis of variability for key stock items

<table>
<thead>
<tr>
<th>No.</th>
<th>Consumption (Kg)</th>
<th>Price per piece (Kč)</th>
<th>No. (piece)</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>Average</th>
<th>Sk</th>
<th>Wc (%)</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1386000</td>
<td>69300</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.7</td>
<td>Z2</td>
</tr>
<tr>
<td>2.</td>
<td>1382000</td>
<td>13820</td>
<td>100</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>8.3</td>
<td>5.5</td>
<td>66.3</td>
</tr>
<tr>
<td>3.</td>
<td>1025000</td>
<td>4100</td>
<td>250</td>
<td>120</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>20.8</td>
<td>40.9</td>
<td>196.4</td>
<td>Z2</td>
</tr>
<tr>
<td>4.</td>
<td>590000</td>
<td>590</td>
<td>1000</td>
<td>200</td>
<td>200</td>
<td>0</td>
<td>140</td>
<td>140</td>
<td>120</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>83.3</td>
<td>86.7</td>
<td>104.1</td>
<td>Z1</td>
</tr>
<tr>
<td>5.</td>
<td>575000</td>
<td>11500</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4.2</td>
<td>4.9</td>
<td>118.3</td>
<td>Z1</td>
</tr>
<tr>
<td>6.</td>
<td>1125000</td>
<td>2500</td>
<td>450</td>
<td>50</td>
<td>70</td>
<td>40</td>
<td>20</td>
<td>0</td>
<td>30</td>
<td>40</td>
<td>20</td>
<td>60</td>
<td>60</td>
<td>20</td>
<td>40</td>
<td>37.5</td>
<td>17.4</td>
<td>52.3</td>
<td>Z1</td>
</tr>
<tr>
<td>7.</td>
<td>670000</td>
<td>670</td>
<td>1000</td>
<td>90</td>
<td>100</td>
<td>70</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>110</td>
<td>70</td>
<td>60</td>
<td>80</td>
<td>80</td>
<td>70</td>
<td>83.3</td>
<td>13.7</td>
<td>16.4</td>
<td>X3</td>
</tr>
<tr>
<td>8.</td>
<td>630000</td>
<td>504</td>
<td>1250</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>110</td>
<td>110</td>
<td>80</td>
<td>120</td>
<td>110</td>
<td>90</td>
<td>80</td>
<td>100</td>
<td>90</td>
<td>104.2</td>
<td>15.0</td>
<td>14.3</td>
<td>X1</td>
</tr>
<tr>
<td>9.</td>
<td>470000</td>
<td>376</td>
<td>1250</td>
<td>90</td>
<td>90</td>
<td>120</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>90</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>104.2</td>
<td>17.1</td>
<td>16.3</td>
<td>X3</td>
</tr>
<tr>
<td>10.</td>
<td>420000</td>
<td>280</td>
<td>1500</td>
<td>140</td>
<td>170</td>
<td>110</td>
<td>110</td>
<td>120</td>
<td>120</td>
<td>110</td>
<td>110</td>
<td>140</td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>125.0</td>
<td>18.0</td>
<td>14.4</td>
<td>X3</td>
</tr>
<tr>
<td>11.</td>
<td>510000</td>
<td>255</td>
<td>2000</td>
<td>190</td>
<td>200</td>
<td>170</td>
<td>170</td>
<td>140</td>
<td>180</td>
<td>160</td>
<td>170</td>
<td>150</td>
<td>170</td>
<td>100</td>
<td>200</td>
<td>166.7</td>
<td>26.6</td>
<td>15.9</td>
<td>X1</td>
</tr>
</tbody>
</table>

Conventional division assumes, e.g. in case of variability group X, the range of variation coefficient in the interval of 0 - 50%. However, this is a relatively broad range of variability that may include items with very different variability in consumption. With regard to this fact, a more detailed classification of the variability rate
was proposed (Table 2). The results presented in Table 1 show that most of the items were located in group X1 - X2. These are stock items with minimal variability in consumption, which exhibit very little variation. In planning the consumption (purchase) of these inventory items, it is possible to use the arithmetic mean value for the respective time series.

In the case of items with such low variability in consumption, just the given measure of middle position can be used. Stock items no. 2, 6 were classified into variability group Y1 - Y2. These stock items already show a higher degree of variability. It is necessary to consider the necessity of their presence in stock or the possibility of ensuring some form of consignment stock. In the case of items included in group Z1 - Z2, we can talk about stocks with high variability in consumption. Regarding these stock items, it is already very difficult to make forecasts of consumption.

Possible level of consumption can certainly be predicted but probably with a high degree of uncertainty. For these inventory items, it is necessary to assess the damage which can be potentially incurred if the stock is inadequate and the production is interrupted. At the same time, the minimum delivery time for these inventory items must be analyzed.

**Table 2 Modified groups of variability**

<table>
<thead>
<tr>
<th>Group</th>
<th>Variability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X1 0-25</td>
</tr>
<tr>
<td></td>
<td>X2 26-49</td>
</tr>
<tr>
<td>Y</td>
<td>Y1 50-70</td>
</tr>
<tr>
<td></td>
<td>Y2 71-90</td>
</tr>
<tr>
<td>Z</td>
<td>Z1 91-140</td>
</tr>
<tr>
<td></td>
<td>Z2 141 and more</td>
</tr>
</tbody>
</table>

Categories of stocks with high variability in consumption must also be analyzed with regard to their share in the total consumption. Stock items being less important in terms of Pareto analysis while the risk of their shortage is small can be ordered at the time of consumption. However, it is always necessary to consider all appropriate aspects that influence inventory management.

5. **CONCLUSION**

Stocks may substantially affect the competitiveness of manufacturing companies. It is therefore necessary to maximally optimize their amounts. This can be significantly supported by the applied tools for analyzing fluctuations in consumption. Nevertheless, it will always be necessary to assess all the key attributes of stocks. Ultimately, it is decisive whether the lack of inventory can significantly influence the course of the continuous production process. Interruptions in production can generate significantly higher costs than holding of excess amount of inventory. At the same time, it is very difficult to predict all potential threats and market risks under the current dynamic conditions.

**ACKNOWLEDGEMENTS**

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REFERENCES


BUSINESS MODEL OF TRANSPORTATION AND SPEDITION COMPANY

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Abstract
Proceeding globalization, increase of competition influence, increasing crisis symptoms, but also new cooperation possibilities are challenging for the companies. They are often related to changes in the strategic and operational management. New business models oriented at creation of value are the manifestation of implemented changes. They allow a company to get a competitive edge and generate income. Purpose of the paper was to present concept of business model of transportation and forwarding company. Business model of this company was treated as a unique architecture of tangible and intangible resources able to generate value. Object of the studies concerned theoretically and practically important scientific problem in the field of logistics, in particular this applies to business modelling of logistic companies. Within the last decade, the issue of constructing business models was very interesting as regards both science and research among foreign and domestic researchers and practical users. Subject of the studies was transportation and forwarding company belonging to a capital group of fuel and power sector. The paper presents business model structure of such company and together with assessment of generated value. Balanced Scorecard was used for the measurement purposes.

Keywords: Business model, transportation and spedition company, customer value

1. INTRODUCTION
Increasing global competition and threats resulting from the phenomena of recession, cause modern management to be affected by the value paradigm. It is an indicator and condition of understanding the operations of companies’ in the market and opportunity for their development. The ability of an organization to create value is perceived as one of many important conditions required to attain and maintain a competitive advantage. Thus, companies search for such methods and instruments that provide for the creation of value. One of them is designing and applying new business models, a component and attribute of which is the concept of creating value, which at the moment is strongly related to and based on innovative processes and resources. Business architecture represents the structure of such a model and should allow for the creation of value for a client and affect the growth of the company’s value allowing for its sustainability in the longer term. Achieved values decide whether such a business model is effective to achieve assumed goals and economic, market and social effects. It underlines its ability to implement innovations, which currently are perceived as the basis for creating a company’s value. Purpose of the paper was to present concept of business model of transportation and forwarding company. Business model of this company was treated as a unique architecture of tangible and intangible resources able to generate value. The paper presents and analyses the structure of business model of such a company in the aspect of changes caused by the necessity of restructuring the capital group to which the investigated company belongs. Value generated before the business model architecture change and after implementation of the changes was assessed and compared. Balanced Scorecard was used as a measurement tool. Application of this method allowed for multi-dimensional capture of value represented by results attained by the investigated company in the following perspectives: financial, process and mineral resources as well as human resources development.
2. BUSINESS MODELS - FOCUS ON VALUE CREATION

Interest in business modelling results from the search for effective methods of competing and using widely understood cooperation. Modern business models enable the creation of value based on innovations and coopetition effects believe Chesbrough [1] and Teece [2]. In particular, development of the theory and the application of work-related business models results from the following reasons:

- applying business models as a clear concept of creating value, both for the client and for the owners of the company,
- in case of the logistic company, the value is related to the type of logistic service and used resources.
- In the logistic companies, improving transportation, forwarding and warehousing processes is especially important
- treating the business model as a system of interrelated operations, strongly focused on creating value,
- the search for the instruments and methods of achieving a competitive edge by implementing innovations,
- treating the business model as an architecture of business operations, which is able to provide the organization with effectiveness by generating profit,
- treating the business model as a carrier of various innovations,
- the business model represents a valuable tool for strategic management, which is also useful in the company's operational activities,
- using the business model as a vision of an idea for a business, representing a proposal for potential investors.

Business models can be applied both as an instrument for the management of existing companies and represent the grounds for planning the operations of new organization. Development of research into business models bore fruit in the form of many definitions and concepts. References concerning business modelling (2001-2015) enable the identification of more than 150 different definitions and concepts of business models. A lot of them emphasize the relationship between business models and creating, delivering and capturing value. In the context of the performed studies, some of the business model definitions are worth a mention. The approach to a business model presented by Afuah [3], Amit and Zott [4] is fundamental. The first of the mentioned researchers defined a business model as a set of activities which a company implements, how it implements them and when it implements them and it uses the resources to perform the activities to create superior client value (low-cost or differentiated products) and puts itself in a position to appropriate the value. In turn, Amit and Zott [4] identify it as a “content, structure and governance of transactions designed to create value through the exploitation of business opportunities”. It is worth quoting Shafer, Smith, and Linder [5] who examined 12 definitions by assigning 42 different and unique attributes. These researchers concluded that definitions fit into 4 general categories: strategic choices, value creation, value capture value network. An extended definition of a business model presented by Teece [2] is often quoted. In his opinion “the essence of a business model is in defining the manner by which the business delivers value to the customer, entices them to pay that value and converts the payment to profit. It thus reflects management’s hypothesis about what customers want, how they want it and how businesses can organize themselves to best meet those needs, get paid for doing so and make a profit.” Focus on creating value is also manifested by a very compact definition of a business model, presented by B. Demil, X. Lecocq, which says that this is a “notation of dependence between elements of company, cooperation of which allows creating and delivering value for client” [6]. The importance of scientific potential for innovation transfer point Koszembar - Wiklick and Krannich [7] and Szmal [8]. However, Brzóska [9], [10], Hamel [11], Szmal [12], Knop and Olko [13] describe the role of innovations in creating value in business. In particular, this might also comprise eco-innovations [14] and network value configurations [15]. Frequently, business consultancy uses the business model concept developed by Ostrwalder and Piguer [16]. They say that a business model describes the rationale of how an organization creates, delivers, and captures value. Proposal of F. Newth [17] can also be included in the mainstream of business model concept based on value, and categorizes it into six elements: value proposal, dynamic abilities
and processes, strategic resources, streams of income, formula of profit, structure of costs. Business models themselves can also provide organizational innovativeness, important for competitive strategy. Overcoming these threats necessitates continuous improvement of business models. To sum up, one may say that value is the focal point of business model.

3. METHODOLOGY OF RESEARCH

Three perspectives predominate in theoretical considerations and methodical approach:

- perspective of selection (a set concerning selection, e.g. market service policy, selection of assets, method of value creation). These studies are of strategic character.
- perspective of activity (focusing on operation and processes creating value and deciding about competitive edge). Studies at the organization level.
- normative perspective (characterizing business models using descriptive and graphic method, building and systematics of business model ontology, verbal characteristics of value). Operative nature of studies.

The presented studies have been performed at the level of organization which is a forwarding and transporting company, thus related to the second perspective. Research methodology based on three basic components (stages), as given in the Figure 1, was used to assess the business model change of the forwarding and transporting company and the value created by it.

![Figure 1](image.png)

Figure 1 Scheme research methods. Source: own study

The first of them strategic analysis and literature studies. In particular, they include: elements of modelling theory, innovation ecosystems, business surrounding (including competitive forces analysis), relationships with partners and macro-economy situation evaluated in the aspect of logistics as well as fuel and power sector development. The strategic analysis results in a special area of significant meaning for the investigated company. This means policy and strategy of the capital group (corporation) to which the company belongs. The important thing is evaluation of development directions of the corporation, its logistic services portfolio, changes induced by innovations and relationships with daughter companies. The third element and a stage of studies is structural and comparative analysis of the business model. It consists of two areas of research. The first one focuses on evaluation of qualitative changes of the business model. In particular, changes of its structure were analysed, related to implementation of innovation and resulting from the policy and strategy of the capital group to which the investigated company belongs. Business model concepts were used, so called new era of innovation (3) and resource approach. The following business model elements must be
emphasized: social architecture (intangible resources), technical architecture (tangible resources) and business processes. Sources of creating value and type of competitive edges are included in the structural characteristics of business model. The second area of the comparative analysis is this part which allows for quantitative measurement of value. Elements of Balanced Scorecard (BSC) were used for quantitative measurement of value obtained through the application of a given business model type. Value created by business models was represented by the results obtained in four perspectives:

- financial,
- market,
- business processes and technical resources,
- development of human capital.

Such methodical approach allows for multi-aspect evaluation of value created by business models as well as changes within the models.

4. **EMPIRICAL RESEARCH - CASE STUDY**

The investigated forwarding and transporting company (called hereinafter the Company) is one of 16 companies owned by a strategic Company managing fuel and power capital group (Concern) operating in Poland. Concern (Capital Group) is a manufacturer of solid fuels, electrical energy and thermal energy. The forwarding and transporting company operates within the group since 1997. At the moment, its business operations cover three areas: complex manoeuvring maintenance of railway sidings, transport services within the scope of railway transport and repair of railway vehicles. In 2015, the Company employed 282 employees and generated income on sales at the level of 18 million EUR and Earnings before Deducting Interests and Taxes (EBIT) amounted 1.2 million EUR. The business model of this company was affected by two important factors. The first one is dynamic development of logistic services market in Poland, which can be characterized by increase of potential, innovativeness and amount of logistic companies leading to competitiveness growth (report). The other important consideration affecting the Company's business model is ownership relationships within the Capital Group as is well reflected by the company's mission, i.e. performing services related to railway transportation of goods and forwarding services, maintenance of sidings and rolling stock technical condition, applying high level, guaranteed service through employment of qualified personnel and maintenance of railway traffic safety. The Company's operations are oriented at implementation of mission and strategy of the Capital Group which determine the interest of the leading entity. Within the investigated period 2008 - 2015 one can say about two business models. The first one functioned within 2008 - 2012. The other one was implemented at the beginning of 2013 and is the current business model of the Company. Business model and strategy of the Company applied within the first period were based on transport operations (railway transport of goods), meaning a set of operations related to moving tangible goods (solid fuels) using suitable logistic means. Forwarding services were provided to a limited scope. Clients of the Company mostly belong to the Capital Group (solid fuels producers). The model consisted of a relatively simple combination of assets providing value for the Capital Group, expressed by reliable and relatively inexpensive transport service of solid fuels. Technical architecture of the model was represented by own and leased means of transportation (mostly locomotives, train sets) as well as loading and unloading devices. Social architecture is mostly transport qualifications of employees and transport licenses. The basic process is railway transport of solid fuels. Managing processes were within that time at basic level (planning, financial analysis, human capital management, ICT). Within 2008 - 2012, level of capital engagement was relatively low and oscillated at the level ca. 6 million EUR. Within 2013 - 2015, the Company received significant financial support (to the level of 35 million EUR), there was an increase in technical assets and employment, railway sidings were transferred in the form of a lease. This allowed for significant extension of Company's operations. Beside current operations, it preforms full-range forwarding services (organization of cargo transport, activities related to handling transport documentation, cargo insurance, preparation for transport by acquiring and combining
cargo in order to optimize cargo space, selection and management of transportation means based on cargo features, cost, distance and time, etc.). The Company is an operator of leased railway sidings, and performs:

- technical and maintenance activities (technical and traction audit of transportation means, maintenance of technical condition of railway rolling stock, shunting operations, optimization of sets, logistic combination of the sets).
- organization and legal operations, keeping the railway vehicles records, activities related to obtaining type certificates for railway vehicles, keeping records related to operation and maintenance of railway vehicles, development and supervision over Railway Vehicles Maintenance Systems, periodical trainings as well as qualification and verification exams, advisory related to railway transport.

The investigated company performs also servicing of railway transportation means and specializes in shunting locomotives. New, currently applied business model necessitated significant changes both in technical and social architecture. Changes in technical architecture were related to taking over railway sidings, acquiring innovative means of transportation and modern service workshop equipment. Significant changes took place in the social architecture. New products (forwarding, railway siding operations, transportation means servicing) required new strategic competences in the management of railway sidings, optimization of transport services, mastering railway vehicles maintenance. Competences and skills in servicing railway transport means and operation of modern locomotives were also important. The map of business processes also changed. Next to transportation processes, the Company implements such basic processes as: forwarding, management and operation of railway sidings, servicing of railway transport means as well as marketing and CRM (implementation phase). The two latter ones, are related to the change of clients portfolio. Within new business model, except the entities from the Capital Group, other Polish and foreign production companies are clients also. Management processes were also changed. The Company introduced controlling, new development and employees motivation systems, it supports employees innovativeness, applies developed ICT systems, allowing for optimization of business processes. Current business model represents complex configuration of tangible assets and knowledge resources creating multi-aspect value for a client and affects company value for its owners. Differences between the structure of previous and current business model are given in Table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Changes in the structure of business model (synthesis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social architecture - elements of the model</td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>Stable employment at the level ca. 100 employees.</td>
</tr>
<tr>
<td>Strategic competences</td>
<td>Competences within the scope of railway transport. Knowledge of transport needs within the Capital Group.</td>
</tr>
<tr>
<td>Technical elements of the model</td>
<td></td>
</tr>
<tr>
<td>Material resources</td>
<td>Transport infrastructure, modern rolling stock. Low level of equity</td>
</tr>
<tr>
<td>ICT resources</td>
<td>Basic IT of accountancy and sales.</td>
</tr>
</tbody>
</table>
When analysing information given in the table, one can find significant changes in the social architecture of the model. They were related to the increase of employees number and improvement of employment structure. Number of employees with university education increased significantly (Table 2). There were more trainings and the Company implemented motivation system related to effects of work. Significant widening of competences occurred, which was related to new type of products (services). The Company used formalized knowledge resources to even bigger extent. The most important changes in the technical infrastructure is modern transport means and equipment of repair workshops as well as new ICT systems used in controlling and customer service. This is related to the additional funds the Company received. The map of processes changed significantly. The Company implemented three new basic processes: forwarding, railway sidings and rolling stock repair. New resources and processes significantly changed the nature of value and competitive edge. Quantitative capture of the generated value is presented in Table 2.

Analysis of financial perspective results shows that new business model allowed for significant increase of EBIT and profitability. Major increase in capital affected the limitation of growth of economic value added and return on capital. However, it was necessary to start new business activities. Market results of the Company must be positively assessed. Change of the business model allowed for dynamic increase of income, winning new clients and reaching beyond the transport services of the Capital Group. Clients satisfaction from the Company’s services is growing, though slowly. Within the logistics and processes perspective, growth of transport assets and equipment is noticeable, in particular of active railway rolling stock (locomotives). New business processes were implemented, however promptness of services could not have been improved significantly. Within the human capital development perspective, one must positively assess the growth of employees efficiency as well as very favourable changes in the employment structure. The level of employees satisfaction is stable and can be considered as satisfactory. Structure of employment improved, number of engineers and economists - lawyers increased, whose competences are necessary in implementing new processes and services.

Significant increase of productivity is a major achievement for the company. So far, changes of the business model did not affect innovativeness of employees which means that the Company uses open innovation and their main carrier is investments.
Table 2 Quantitative capture of the generated value in four perspectives

<table>
<thead>
<tr>
<th>Result</th>
<th>Measure</th>
<th>2008</th>
<th>2012</th>
<th>2013</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic value added (EVA)</td>
<td>Thousand EURO</td>
<td>260</td>
<td>320</td>
<td>230</td>
<td>310</td>
</tr>
<tr>
<td>Return on sales</td>
<td>Net profit / sales (%)</td>
<td>7.3</td>
<td>8.7</td>
<td>10.1</td>
<td>11.2</td>
</tr>
<tr>
<td>Return on assets</td>
<td>Net profit / assets (%)</td>
<td>4.7</td>
<td>4.9</td>
<td>5.9</td>
<td>6.2</td>
</tr>
<tr>
<td>EBIT dynamics</td>
<td>Previous period = 100</td>
<td>100</td>
<td>123</td>
<td>243</td>
<td>131</td>
</tr>
<tr>
<td>Sales dynamics</td>
<td>Previous period = 100</td>
<td>100</td>
<td>112</td>
<td>207</td>
<td>137</td>
</tr>
<tr>
<td>Share of clients outside the capital group</td>
<td>Percentage</td>
<td>4.1</td>
<td>6.4</td>
<td>18.3</td>
<td>23.4</td>
</tr>
<tr>
<td>Level of customer satisfaction</td>
<td>Percentage</td>
<td>No data</td>
<td>82.3</td>
<td>80.5</td>
<td>84.0</td>
</tr>
<tr>
<td>Number of new customers</td>
<td>quantity</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Value of active transport means.</td>
<td>Million EURO</td>
<td>6.3</td>
<td>5.2</td>
<td>21.4</td>
<td>24.2</td>
</tr>
<tr>
<td>Increase in quality of services</td>
<td>Claims number / number of transport services(%)</td>
<td>2.3</td>
<td>3.1</td>
<td>4.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Number of new processes</td>
<td>quantity</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Value of logistic means and equipment</td>
<td>Million EURO</td>
<td>9.2</td>
<td>8.8</td>
<td>28.1</td>
<td>30.3</td>
</tr>
<tr>
<td>Innovativeness of employees</td>
<td>Number of registered innovative solutions</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Increase in employees’ productivity</td>
<td>Value of sales per 1 employee (thousand EURO)</td>
<td>32.7</td>
<td>37.3</td>
<td>50.3</td>
<td>55.9</td>
</tr>
<tr>
<td>Personnel qualifications</td>
<td>Number of engineers and economists</td>
<td>17</td>
<td>19</td>
<td>37</td>
<td>44</td>
</tr>
<tr>
<td>Employee satisfaction</td>
<td>Percentage</td>
<td>No data</td>
<td>74.6</td>
<td>75.8</td>
<td>74.9</td>
</tr>
</tbody>
</table>

Source: own study

5. CONCLUSION

Changes of business models are mostly affected by the dynamic or even turbulent surrounding. Directions of changes and improvement of business model are related to ability to create value by such model. This is the ground for competing, especially when based on innovations. The performed studies have shown that change of the Company's business model leads to the increase of generated value. In the investigated Company, significant changes took place within business model structure, and they covered human capital and innovations within tangible logistic resources. In the applied model, one designed and implemented new business processes that allow for rendering new services, representing carrier of value for a client. Balanced Scorecard used to measure and quantitatively assess value points to multi-dimensionality of value which is a category so important for management processes. Results obtained by application of new business model show the necessity of its improvement within the area of improvement of services quality, better utilization of capital and activation of employees innovativeness.
REFERENCES


Abstract

Logistics presents vast potential for effective acting of all companies, orientated to cost decreasing and by this way to profit maximizing. Logistic principles can be used in management of various sectors of national economy, while important part of economy in present time is area of transport. Development of transport is influenced by economical severity and speed of roads infrastructure construction. Slovakia has advantageous position in the frame of middle Europe and it is also important European transport joint in the frame of international business. Therefore there is necessary to know cost of transport with aim to determine effective and productive price. Through cost calculation in transport company there was determined possibilities for decreasing of transport cost and optimal solution of transport.

Keywords: Transport, cost calculation, driving fuel, road traffic, company

1. INTRODUCTION

Transport presents individual branch of national economy. Its development is dependent on geographic conditions and construction of roads infrastructure. There is necessary to know costs of transport with aim to determine proper price, where transport firm must have sufficient information and tools for evaluation of costs. In present condition companies must strengthen their position in competitive environment. One of the ways how to strengthen position of the companies is saving of costs by proper cost calculation, which could create space of development of the companies and increasing of their competitiveness. Transport plays irreplaceable role in social and economic development of the society. The role of the public transport in the development of villages and cities or regions is also apparent and not only as a counterbalance to the individual transport. There are many reasons why the state is interested in the capability to specify and distinguish particular sorts of transport costs and consequently the necessity of the unified method of costs calculation which this article deals with (Říha and Tichý, 2015). Lada et. al (2016) applied statistical analysis to calculate the cost of transport and to receive a general assessment of the profitability / unprofitability of transport trip. They found factors influencing the transportation costs, as a basic set of parameters for the cost calculation. Their findings make it possible to get a proper assessment of profitability or unprofitability of a transportation direction taking into account the accumulated traffic statistics regarding a particular transport company. To support costing improvements in transport, Bokor (2011) aims to identify the shortcomings of currently used techniques and give a guideline on how to overcome them. The theoretical basics of a new transport costing model are developed while some experiences of early pilot applications are also considered, providing reliable cost information for decision makers on transport services.

2. PRESENT STATE OF TRANSPORT COSTS IN SLOVAKIA AND EU COUNTRIES

Transport belongs to the tertiary sector of the economy. Transport development is influenced mainly by overcoming these obstacles, economic demands and the speed of construction of road infrastructure. Slovakia is due to its favorable location in the center of Europe an important European transport point able to take
advantage of its location in international trade. Slovakia is transitive country in the frame of EU with diverse geographical structure, which influences development of transport together with economical severity and speed of roads infrastructure construction. Road transport in Slovakia has very important rate on whole transport volume, till 77% of total transport. In 27 member states of EU this type of transport present approximately 48% from total transport, since geographical conditions of these countries are yet more diverse than in Slovakia. Rate of road transport is still increasing. Road transport in EU represents almost 600 000 SMEs with average 4 employees. In 2011 road transport employed approximately 3 million people (Gnap, 2005). In comparing with Czech Republic that is considered as country with most stable economy of former socialistic countries, Slovakia has the similar development. Czech Republic uses privileges, resulting from membership in EU through adaptation of rules, regulating economy and still extending export. Czech Republic is very favorable country from the view of transport, which provides big number of offers of free consignments and vehicles in the frame of Transport database. Transport is realized similarly as in whole EU through simplified legal principles. In the frame of Transport database there is possible to realize transactions in Germany, Slovakia, Great Britain, France, Poland, Austria and China (logintrans.sk). In Hungary small and medium sized road freight transport companies are facing strong competition on the logistics market. An advanced cost management system supporting decisions on capacity allocations or pricing may be a competitive advantage for them and indirectly for the whole economy as well. Still, they generally apply simple, traditional cost calculation regimes, potentially sufficient in case of a homogeneous service portfolio. Nevertheless, road haulage companies with heterogeneous service structures may witness information distortions when using traditional costing methods. So it might be recommended for them to introduce better costing principles. Bokor and Markovits-Somogyi (2015) introduced therefore a multi-level full cost allocation model. Volume of cost is one of the important facts that determine disposition of competitiveness in road transport. Some costs are connected with seat of member state - for example costs for registration and service of vehicle, taxes, and capital costs. Variable costs, for example fees for using of roads or taxes of driving fuel are connected also with seat of service in given member state. Due to the certain balancing of wages with minimal norms in seat of service in member state cost of wages become partially variable. Therefore wages and driving fuel become most important costs in area of transport. Wages present approximately 20-40% of costs, driving fuels 24-38% of total costs (Figure 1) (Gnap, 2005).

Figure 1 Description of transport costs in chosen member states
(own processing according Gnap, 2005)

Costs of driving fuels belong among highest transport companies and there must be given proper attention. For example in Germany price of driving fuels can be changed by day in week, region or daily hour (Christofakis, 2014). Figure 2 illustrates review of driving fuels prices during 2009-2013 in Slovakia, Czech Republic, Hungary and Germany, given in value added tax.
Average monthly wage in transport in chosen EU states are developed as illustrated by Table 1. Wages present gross income in area of transport in EU countries. Wages are calculated according available exchange rate of the National Bank of Slovakia in 2013.

Table 1 Average monthly wage in SR and EU

<table>
<thead>
<tr>
<th>State</th>
<th>Currency</th>
<th>Gross income</th>
<th>Exchange rate</th>
<th>Calculation to €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovakia</td>
<td>EUR</td>
<td>803</td>
<td>1</td>
<td>803.00</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>CZK</td>
<td>22191</td>
<td>27.427</td>
<td>809.09</td>
</tr>
<tr>
<td>Hungary</td>
<td>HUF</td>
<td>223351</td>
<td>297.04</td>
<td>751.92</td>
</tr>
<tr>
<td>Germany</td>
<td>EUR</td>
<td>2894</td>
<td>1</td>
<td>2894.00</td>
</tr>
</tbody>
</table>

From the table we see that Slovakia, Czech Republic and Hungary have almost the same wages, since they went through similar development of economy.

2.1. Costs calculation and price creation in transport

Due to the cost calculation there is necessary to know logistics indexes for transport (Table 2).

Table 2 Structure of logistics indexes in transport

<table>
<thead>
<tr>
<th>Number of clients</th>
<th>Active</th>
<th>Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>dispatched consignments per unit</td>
<td>Total number of dispatched consignments / time period (consignments / month/year)</td>
<td></td>
</tr>
<tr>
<td>Number of stocking levels</td>
<td>Central stocks</td>
<td>Regional stocks</td>
</tr>
<tr>
<td>Number of stocking places</td>
<td>Total turnover / number of clients</td>
<td>Euro / client</td>
</tr>
<tr>
<td>Average volume of order</td>
<td>Number of products / number of orders</td>
<td></td>
</tr>
<tr>
<td>Average distance between stocking levels</td>
<td>km</td>
<td></td>
</tr>
<tr>
<td>Rate of distribution workers</td>
<td>Rate of workers in distribution / total number of clients x 100 (%)</td>
<td></td>
</tr>
<tr>
<td>Number of stocking places</td>
<td>Number (min)</td>
<td></td>
</tr>
</tbody>
</table>

Source: own processing, according Rosová, 2010
Cost calculation present activity with aim to calculate and express costs of transport performance in road transport. By this way company is able to obtain information about volume, structure and subject of calculation [7]. Own costs in transport are created by work and financial means consumption, produced for transport during certain period. Price of transport presents agreement among transport and consignor. It consists from several items, for example transit rate, taxes of driving fuels, road toll, parking charge, vehicle evidence, insurance etc. (Teplická, 2009). Price of transport should be determined by transport experts. Such price must be determined properly with aim to cover costs and bring profit, but also with aim to be competitive and saleable (Gnap, 2006). Whole logistic process of transport in the company is realized according Figure 3.

![Figure 3](image)

**Figure 3** Logistics process of transport company  
(own elaboration, according internal data of the company)

The main goal of Transport Company is to achieve satisfaction of the clients in every direction: price, quality, service, etc., in case company is single supplier or provider of transport.

In the frame of cost calculation determination of minimal costs rate per 1 passed kilometer, 1 loaded kilometer and 1 hour of stand time can be calculated as follows:

I. **Total time of service in hour / month**
   
   Total time of service \( T_S \)
   
   \[
   T_S = T_{sd} \times WD \tag{1}
   \]
   
   \( T_S = \) total time of service  
   \( T_{sd} = \) service time per day  
   \( WD = \) working days per month

II. **Consumption of driving fuel**

   Consumption of driving fuel \( (DF) \)
   
   \[
   DF = P_f \times C \tag{2}
   \]
   
   \( DF = \) Consumption of driving fuel  
   \( P_f = \) Price of fuel per litter  
   \( C = \) consumption per 100 km, per month

III. **Cost of tires**

   Cost of tires \( (C_t) \)
   
   \[
   C_t = N_t \times P_t \tag{3}
   \]
   
   \( C_t = \) cost of tires  
   \( N_t = \) number of tires  
   \( P_t = \) price per 1 tire / durability of tire

IV. **Price of transport**

   Result price \( (R_T) \)
   
   \[
   R_T = L \times P_u + N_{st} \times P_{st} \tag{4}
   \]

\( L = \) length of transport  
\( P_u = \) price per unit  
\( N_{st} = \) number of stand time  
\( P_{st} = \) price per stand time
During costs and price calculation there is necessary to consider:

- price per 1 km (in case there is bulk goods)
- price per 1 t, when there is possible to know if maximal weight of consignment could be 25 t
- price per whole vehicle
- length of transport,
- costs, connected with whole process,
- profit.

3. COSTS CALCULATION IN CHOSEN SLOVAKIAN TRANSPORT COMPANY

Costs of transport had been analyzed in company PESCH TRANS, ltd. Company is orientated to dispatch and transport activities and it is registered in international database of dispatch companies RAAL TRANS and TIMOCOM. While in last year prices of transport reflected transport cost properly and in Slovakia there was not existing fee for using of highway, in present period profits of the company enabled extension of wagon stocks. On the other hand legislative conditions and increasing crisis caused decline of transporters, as well as decline of demand on transport. Prices of transport had been decreasing, but driving fuel costs and highway charges decreased, therefore number of transport companies terminated their activity. Neither less of competition on the market did not stop decreased profits from transport. Also PESCH Trans, ltd had been forced to evaluate and actualize its strategy and minimize its costs. It reflected for example in limitation of periodicity of repairs of vehicles and decreasing of wages. One of the good alternatives was moving to partially own spaces and by this way decreasing of costs of stock and administration space. Situation at the market forced also employer and employees to access their work responsibly, to save costs. At the same time company made strategy for operative adaptation to the real demands on the market. Sometimes company rejected transport, since offered price did not cover all costs. Company had been forced to increase its activity also in area of sale and purchase of transported commodities. At the same time profit from business with such commodities became tool how to overcome crisis in transport. From the obtained data we analyzed development of costs of service and maintenance, overhead material and work clothing for drivers, stocking of administrative necessities, leasing interests, costs of purchase, repair and change of tires and finally road fee. Costs of service and maintenance increased every year, overhead had varying development. Cost of tires development was not explicit; it could be caused by using of protector tires. Also cost of leasing credit increased. Road fee had been marked as item, significantly disadvantaged transporters and increasing their costs. But unfortunately quality of Slovakian road infrastructure is still not proper, which has influence also to the wearing of tires and increasing of their costs. In the frame of calculation according data from transport firm we constructed entry configuration and calculation form with determination of minimal costs rate per 1 passed kilometer, 1 loaded kilometer and 1 hour of stand time.
Table 3  Entry configuration (Caplová, 2011)

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Value in € / Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving performance</td>
<td>7000 / km/ month</td>
</tr>
<tr>
<td>Daily service time</td>
<td>9/ hour</td>
</tr>
<tr>
<td>Total service time</td>
<td>153/ hour / month</td>
</tr>
<tr>
<td>Technical speed</td>
<td>64 km / hour</td>
</tr>
<tr>
<td>Coefficient of driving using</td>
<td>0.81</td>
</tr>
<tr>
<td>Driving fuels</td>
<td>3573.57 / month</td>
</tr>
<tr>
<td>Tires</td>
<td>159.642</td>
</tr>
<tr>
<td>Wages</td>
<td>560</td>
</tr>
<tr>
<td>Fund of repair</td>
<td>142</td>
</tr>
<tr>
<td>Travelling replacement</td>
<td>72</td>
</tr>
<tr>
<td>Road tax</td>
<td>211.7775</td>
</tr>
<tr>
<td>Insurance</td>
<td>163</td>
</tr>
<tr>
<td>Overhead</td>
<td>63</td>
</tr>
<tr>
<td>Highway charges</td>
<td>90</td>
</tr>
<tr>
<td>Depreciation</td>
<td>1678.64</td>
</tr>
</tbody>
</table>

Through data from entry configuration we made calculation, necessary for calculation form, which is presented in Table 4.

By the way of cost calculation we determined price of transport. Results of calculation had been proved also by calculation per concrete transport. We followed up cost of transport for vehicle DAF XF 105. Vehicle transported material with volume 24.5 tones, 384 km with load, total distance 553 km. Invoiced amount was 427.96 EUR without VAT, and 513.552 EUR with VAT. According previous results we applied our values for this transport at 437, 3906 EUR.

Table 4  Calculation form

<table>
<thead>
<tr>
<th>Entries of costs</th>
<th>Costs in € / km</th>
<th>Costs € / hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving fuel</td>
<td>0.51051</td>
<td></td>
</tr>
<tr>
<td>Oil to engine</td>
<td>0.003483</td>
<td></td>
</tr>
<tr>
<td>Oil to gear box</td>
<td>0.0003077</td>
<td></td>
</tr>
<tr>
<td>Tires</td>
<td>0.022806</td>
<td></td>
</tr>
<tr>
<td>Maintenance, repairs</td>
<td>0.02028</td>
<td></td>
</tr>
<tr>
<td>∑ variable costs</td>
<td>0.5573867</td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>0.08</td>
<td>5.12</td>
</tr>
<tr>
<td>Insurance</td>
<td>0.0232857</td>
<td>1.4902857</td>
</tr>
<tr>
<td>Depreciation</td>
<td>0.2398057</td>
<td>12.27804952</td>
</tr>
<tr>
<td>Highway charges</td>
<td>0.012857</td>
<td>0.82285</td>
</tr>
<tr>
<td>Overhead</td>
<td>0.009</td>
<td>0.576</td>
</tr>
<tr>
<td>Travelling replacement</td>
<td>0.0002857</td>
<td>0.0182857</td>
</tr>
<tr>
<td>∑ unit fixed costs</td>
<td>0.3652341</td>
<td>20.30547092</td>
</tr>
<tr>
<td>∑ total individual costs</td>
<td>0.9226208</td>
<td>20.30547092</td>
</tr>
</tbody>
</table>
ADDITIONAL INFORMATION FOR PRICE CALCULATION:

Route: Čierna nad Tisou (Slovakia) - Žatec (Slovenia) = 702 km mainly 7 hour 31min.

Since company makes international transport, there is necessary to consider also main overhead and all risks that can influence final price due to the possible time of vehicle stop, for example 1-3 days, since stationary vehicle is not bringing profit.

Costs per vehicle: company calculates costs per minimally 0.73 Euro/km, where there are included:

- leasing payments per 1 km
- diesel oil, fuel,
- amortization
- purchase of accessories, etc.

Further there is necessary to include also other costs, mainly:

- job of driver,
- toll fees (Slovakian territory)
- highways fees (Hungary and Slovenia territory)

\[ P = 1.21 \times 702 \]
\[ P = 850 \] €

Profit: is dependable on concrete market situation and on the regularity of transport. Due to the all costs and possible risks company determined price of transport (P) per 1 km = 1.21 Euro, from which results that total price of transport of free loaded goods according planned tour presents 850 Euro for client of shipment.

4. DISCUSSION

From results there is obvious that invoiced amount did not cover variable and fixed cost and by this way there was no recorded profit from this transport. But transporter could cover this loss by better using of vehicle or better price per loading during reverse vehicle loading or during next transport in given month. For calculation of cost there is necessary to use actual table for cost calculation of every transport, as well as to have proper software, which could calculate total costs per concrete transport more rapidly and to suggest optimal solution of transport. By this way capacity of vehicles can be used maximally, and number of stand time and not loaded kilometer can be decreased (Malindžáková, 2011 and Straka, 2010). Following possibility is to decrease costs of driving fuels, which belongs among most costly items. Since company cannot influence consumption tax, there is necessary to find out possibilities for driving fuel purchase at lower prices. One of the possibilities is to find out cheaper supplier or to purchase in greater volumes for better prices. But this possibility demands to prove proper stocking of greater volume of driving fuel. By this way company could record not only saving of driving fuel costs, but also saving of consumption, since riders of vehicles should approach fueling more responsibly (Gnap, 2006). General possible cost decreasing can be proper price - goal of transport firm is to make transport at most convenient price, which could bring profit and full using of vehicle capacity. Fuel cards can provide for transporters information about driving fuel with best price. In case company disposes modern wagon stock, it saves not only living environment, but also its costs of driving fuel, service or maintenance of vehicles. Present trend of driving fuel prices in Slovakia and EU countries forces transporters to follow up the prices, since there is no preferable fuelling in abroad. Except price per ordered transport we can calculate also price of whole logistic process that begins at the order from the view of efficiency in the seat of the company. The information can be obtained from daily report of vehicle performance, from which whole process of transport from the beginning to the end together with time data can be determined. Granichin et.al (2013) discuss the different organizational models of cargo transportation for truck companies have influence on transport costs, mainly in situation, where trucks return back to their garage after each trip, and more flexible, where trucks wait for new orders at the unloading positions, where trucks can be late but pay a penalty for this, and finally where orders can be adaptively rescheduled. One of the main difficulties in transportation
companies is to determine and evaluate true cost of their operations and services. ABC method can be very helpful for transportation companies to determine cost of their operations with higher correctness. ABC method is quite effective in costing in transportation company, in comparing with existing traditional costing systems (Baykasoğlu, and Kaplanoğlu, 2008). Activity-Based Cost is widely used in enterprises in the United States, Japan and European Union. Indirect cost accounts for a comparatively higher percentage in logistic enterprise’s total cost, whose greatest feature is that it is without inventory cost. Ma et.al (2011) considers the characteristics of cost structure for logistic enterprise and derives a practical logistic enterprise activity cost accounting model from basic activity cost model.

5. CONCLUSION

Business in road transport is not simple and to penetrate at transport market is also difficult. Transport firm must regard during its activity number of factors that influence its existence and at the same time it must evaluate and actualize them regularly. Skills of company management in area of transport and logistics become basic pillars of future development, achieving of business aims and effective using of market possibilities in given area. Proper regional conditions and not used transport capacity present also positive assumption for development of transport area. Company has clear vision and goals. It wants to be still leader at transport market and to satisfy needs and claims of its consumers. But it must therefore to find out tools and ways for transport costs decreasing. Since in near surroundings there are several transporters, offering similar transport services, one of the possibility is to create association of transporters, which could stand against existing costs of transport and to obtain orders, adequately evaluated. Next possibility is to exclude from the market through natural serious completion not serious transporters. Important part in present economic situation plays also tax and education charge of businessmen, heavy business environment and various legislative obstacles. Further possibility how to decrease transport cost is to eliminate state of wagon stocks, decreasing of number of employees, which means also decreasing of service and wage costs, since they present biggest rate of company costs. There is number of possibilities for costs decreasing, it depends on management of the company how to face such actual problem solving.

ACKNOWLEDGEMENT

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THE INFLUENCE OF SUPPLY CHAIN CONFIGURATION ON A CUSTOMER SERVICE LEVEL
IN A MINING MACHINE-BUILDING ENTERPRISE

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Abstract
The authors discussed issues concerning the supply chain configuration of metallurgical products and its influence on the level of logistics customer service. The study was undertaken in a selected machine-building enterprise, a manufacturer of machinery and equipment for companies in a hard coal mining sector, to analyse factors determining logistics customer service. The study proved a magnificent importance of a supply chain configuration for the effective execution of logistics processes in make-to-order contracts realised by a selected company. The study indicates that in a competitive environment, further changes in a supply chain structure are crucial for the future of effective activity of an analysed company.

Keywords: Machine-building company, supply chain configuration, logistics customer service

1. INTRODUCTION
Supply chain configuration is one of decisive indirect factors affecting the level of a customer service. Currently, logistics processes are highly sophisticated, and they are crucial in a contract realization. It derives from significant changes in a market environment. Finally, the high level of a customer service creates the value for an end customer, and determines the competitiveness level of a company [6]. Contracts, developed in a machine-building sector, are concentrated on better and better adjusting to individual requirements of a customer. Satisfied clients make it possible to develop a machine-building enterprise in a mid- and a long-term perspective.

In the face of an economic downturn on domestic and international coal markets, and the related necessary technical and technological changes to improve the productivity of a technical system in coal mines in Poland, the key investments will be modern longwall complexes. In this context, knowledge and experience of Kopex Machinery allow to adjust appropriate solutions in the field of machinery and equipment for coal producers, and other recipients. A good example is a Polish copper producer, KGHM, in which it is being considered the implementation, on a large scale, longwall exploitation systems. Developing individual solutions, as an order by Kopex Machinery, needs to ensure adequate storing of technological knowledge, as well as further improving a logistics customer service, including designing, manufacturing, delivering and after-sales servicing, mainly of high-tech solutions in the field of mechanized longwall complexes.

The article is focused on determinants affecting a customer service in accordance with the configuration of a supply chain. The study concerns Kopex Machinery, the supplier of machines and equipment for hard coal mining. The study was based on the analysis of source materials and direct interviews with engineering and technical staff of a selected company. The study results have indicated the influence of the configuration of a supply chain on a customer service, and necessary actions to improve the economic situation of a given company.
2. DETERMINANTS OF SUPPLY CHAIN CONFIGURATION AFFECTING A CUSTOMER SERVICE LEVEL IN A MAKE-TO-ORDER SECTOR

Present supply chains have to take into account many factors, both external and internal ones due to dynamic changes in a market environment and changing recipients’ needs [8]. The point is that companies have to compete on rapidly changing markets and it needs searching for reorientation of enterprises’ strategies [1]. The new situation requires more versatile and innovative business models as a contemporary form of model capture of concept of the strategy and organization system [2].

To make a supply chain work effectively and efficiently in order to satisfy a customer, it is necessary to undertake actions due to general strategic objectives. Main decisions, related to the supply chain configuration, concern problems as follows [4]:

- What is the current supply chain performance?
- “What if” analysis?
- How to improve customer service?
- How to improve supply chain robustness and delivery reliability?
- Could supply chain be made more profitable?
- Is supply chain sufficiently flexible?
- How to improve cooperation?
- How to comply with local requirements?
- Whether to pursue outsourcing?
- Which partners to choose?
- Where to locate supply chain facilities?

Answering these questions leads to formulation of general supply chain configuration decision-making objectives. These objectives can be formulated on the basis of performance attributes identified in the Supply Chain Operations Reference (SCOR) model [9]:

- Objective 1: To improve supply chain delivery reliability. The performance of the supply chain delivering the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.
- Objective 2: To increase supply chain responsiveness. The velocity at which a supply chain provides products to the customer.
- Objective 3: To increase supply chain flexibility. The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.
- Objective 4: To optimize supply chain costs. The costs associated with operating the supply chain.
- Objective 5: To improve supply chain asset management efficiency. The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all fixed assets and working capital.

Objectives can similarly be identified on the basis of discussion provided by Beamon, such as [1]:

- Objective 1: To improve customer satisfaction and customer responsiveness.
- Objective 2: To improve flexibility and risk aversion.
- Objective 3: To improve information and material flow integration.
- Objective 4: To optimize costs (other related performance measures are total cost, sales value, profit, inventory holding cost, return on investment, and others).
- Objective 5: To optimize suppliers’ performance.
In many cases, it is necessary to identify disruptions determining the level of a logistics customer service. It can be worked out in line with the indication of different logistics service elements. In the process of disruptions identification, it is also possible to point to an order realization [7]:

- pre-transaction elements (customer service policy, flexible service system, service procedure),
- transaction elements (order information, expedition of goods and services, the availability of substitutes),
- post-transaction elements (guarantee, instalment, complaint, returns and replacement of products and spare parts).

3. THE INFLUENCE OF SUPPLY CHAIN CONFIGURATION ON A CUSTOMER SERVICE LEVEL IN AN ANALYZED MACHINE-BUILDING ENTERPRISE

Machine-building industry in Poland is of significant importance in accordance with its role as the supplier of machinery and equipment for other industrial branches and sectors. The effective and efficient activity of machine-building industry affects the general level of production and products’ quality. Machine-building enterprises’ activity is determined by, inter alia, the access to qualified engineering and technical staff, research facilities, the resource base (mainly steel products) and markets [6]. One of the key aspects in the activity of make-to-order enterprises is knowledge management including implementing new technology, dealing with knowledge deficits in logistic processes, applying changes in infrastructure, optimizing human resources, and making use of up-to-date methods and tools [5].

Kopex Machinery is the largest manufacturer of machine-building industry in Poland. Kopex Machinery offers machinery and equipment dedicated to different industrial branches, especially complete solutions for coal companies, for all longwalls’ heights and the power adjusted to customers’ requirements. The company’s activity is aimed at meeting all customers’ demand, mainly to execute make-to-order contracts for coal mining (longwall shearsers, heading machines, haulage longwall complexes, transport equipment, equipment for mechanical processing of minerals). The key issue is to meet customers’ needs implementing innovative techniques and technology. Highly qualified and experienced specialists are able to provide adjusted individual solutions of the highest quality. Kopex Machinery makes use of modern design systems based on 3D software (e.g. 3D Autodesk Inventor). The quality of manufactured machinery and equipment is confirmed by the most technologically advanced measuring machines.

Generally, the level of a logistics customer service is determined by many factors deriving from a supply chain. For a machine building enterprise, the level of a customer service strongly depends, among others, on three main groups of logistics determinants. It could be given as a following dependency:

\[
CSL = f (A, B, C, X)
\]

CSL - customer service level
A - factors concerning supply logistics,
B - factors concerning production logistics,
C - factors concerning distribution logistics,
X - other factors.

Restructuring changes in the capital group of Kopex Ltd., mainly in the field of employment and organization, led to the changes in the structure of a supply chain from a distracted structure into a compact one, based on subsidiaries [6]. In Figure 1 the structure of a supply chain in Kopex Machinery is presented. The structure is adjusted to logistics processes realised in the analysed enterprise.
3.1. Supply logistics in Kopex Machinery affecting a customer service level

Based on deliveries of its subsidiaries, Kopex Machinery manufactures basic products i.e. longwall shearsers, heading machines, conveyors and scraper conveyors and machines for coal enrichment and classification. Above-mentioned products are of high technical and technological advancement consisting of a great number of components. It is not possible for Kopex Machinery to produce all necessary components on their own. And therefore, it uses hundreds of suppliers of specialized materials, e.g. electronics, hydraulics, electrical motors, bearings and seals, castings etc. Steel products are also of great importance for a final product. Their share in total purchases is about 30%. Supplies of steel products, up to 55% are realized as internal supplies by subsidiaries. Other deliveries are supplied by external contractors which are not connected with Kopex Machinery. The largest subsidiaries of Machinery Kopex are: Mililux Poland Ltd., Tagor, Poland Investments 7 Ltd. and HSW Odlewnia Ltd. Mililux Poland Ltd. is a major supplier of hard wearing steel sheet used in the production of longwall scraper conveyors. Tagor is a supplier of sheet metal and alloy construction, which are components of shearsers. Poland Investments 7 provides processed steel structures and the complex of heading machines, and products designed for vertical transport of excavated material and people, horizontal transport (conveyors), machines for enrichment and classification of coal. HSW Odlewnia Ltd. is the main supplier of steel and iron castings. Deliveries of HSW Odlewnia Ltd. cover almost the entire demand for castings in Kopex Machinery [6]. The internal supplies in Kopex Machinery have a significant impact on the quality of supplies, their timelines and pricing. The creation of consignment warehouses resulted in a significant decrease in inventories in the assortment of metallurgical products.

The reconfiguration of the supply chain, which took place in Kopex Machinery is a good example that shows how essential are flexible supply chains in machine-building enterprise for the effective implementation of products for individual customers' order. They bring benefits in reducing the number of defective materials in the process of completing a product, and on the other hand they enable to obtain the improvement of the
quality of a product for a final consumer. Kopex Machinery is going to continue solutions in the range of consolidation and optimization of an internal supply chain mainly by the development of existing assets and by the improvement of internal logistics systems.

3.2. Production logistics in Kopex Machinery affecting a customer service level

The activity of Kopex Machinery is focused on a unitary make-to-order production. Parameters of final products complies with customers' requirements. In case it is necessary, consultations are held with the producers of materials for the optimum selection of input components. The production cycle, in Kopex Machinery, includes building a prototype. On the other hand, product's construction is modular and it enables the use of components for different recipients. Due to a modular construction of products, the part of assortment can be classified as series production. It concerns mainly the elements of scraper conveyors, belt conveyors, and components used in longwall shearers and heading machines.

In relation to all products, any commercial order is independent and meets individual needs of a customer. Due to the international nature, the activity form of Kopex Machinery corresponds to conditions and circumstances of a country. For instance, in Poland, firm's activity is in line with the Public Procurement Law. Based on market research, the firm schedules production and maintains the minimum level of standard modules for all products. Depending on a product type, standard production is from 60% to 80%. Such an approach is aimed at optimizing production costs and providing the possibility of response to shortening delivery time of manufactured devices. Despite this approach, due to the individual nature of a final product and environment volatility, in which devices work, client's intervention is possible to change the form of a delivered product. These changes are most often associated with so-called accessories (cutting heads, driving elements), and constitute from 5% to 15% of delivery.

3.3. Distribution logistics in Kopex Machinery affecting a customer service level

The configuration of a supply chain enables more efficient after-sales service. The customer service, including maintenance services and the supply of spare parts, is a strategic activity of the company which makes it more competitive. Her character is dependent on the activity of a given market and covers all activities through their own subsidiaries. The company participates in both the selection of equipment, their implementation, supervision, and maintenance management.

In a mid-term horizon, the future of Kopex Machinery, given in the development strategy of the company, will focus on the diversification of final products due to a difficult situation on the domestic and international hard coal market, and the further reconfiguration of the business model, mainly in response to external circumstances.

4. CONCLUSIONS

The undertaken analysis in a selected mining machine-building enterprise, operating in a make-to-order sector, enables the following conclusions:

1) The factors determining a customer service level in an analysed machine-building enterprise indicate growing significance of supply chain configuration. Further changes are necessary in this area i.e. its flexible reconfiguration depending on a portfolio dedicated to end-customers (concerning products sold on domestic and international markets).

2) The changes which took place during last years in the organisational structure of Kopex Machinery group, and in ownership's relations suggest better and better adjustment of subsidiaries to realize logistics processes in the area of supply, production and distribution.
3) Kopex Machinery has to implement solutions for further optimization of supply chain configuration, as a key aspect, to improve logistics customer service, and as a result to create the value for an end customer.

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THE CONCEPT OF COMPUTER APPLICATION SUPPORTING THE WORK OF THE ORGANIZERS OF RAILWAY TRANSPORT AND RAILWAY UNDERTAKINGS IN THE CONSTRUCTION OF TRAINS TIMETABLE

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Abstract

Every year a new annual timetable is being prepared. Under the work on its preparation the organizers of transport together with railway undertakings determine the shape of the transport offer, which will be best suited to the needs of passengers. A multitude of factors which should be taken into account can cause some mistakes. The article presents the concept of computer application supporting the work of the rail transport offer construction and its visualization on the graphic trains timetable. The paper presents the mathematical model of transport offer and its display on the graphic timetable. The article also shows example of using the application to construct the timetable for the selected railway line.

Keywords: Computer application, construction of trains timetable, organizers of railway transport

1. INTRODUCTION

Organization of railway traffic is a very important issue, because it allows for arranging of trains displacement in time and space on the railway network. Its introduction guarantee movement in a timely, fast, safe and secure manner. Expression of the correct method of its preparation is the timetable, which should meet the needs of different groups of stakeholders. On the development of timetable consists shaping the transport offer and its visualization on a graphic train timetable [6]. Shaping the transport offer consists of properly determination of customer expectations and capabilities of service providers in terms to meet the needs [13]. Process in detail was presented in paragraph 3 of this article. For the preparation of rail transport offer are responsible railway undertakings and organizers of the transport. At present, this process is supported by text editors, spreadsheets and commercial software: packages for the analysis of traffic flow distribution in the communication network (e.g. PTV VISUM) or information systems for railway undertakings (e.g. DPK Railways or city Line Designer). There is a lack of tools to support the shaping of the offer and its visualization on a graphic timetable.

In Polish literature the issues of shaping the transport offer relates generally to public transport [13]. It was also pointed to one of the most important elements of shaping which is timetable [12]. In the field of railway transport offer were discussed factors influencing the shape of the offer [15]. In addition, presented approach to the mathematical modelling of the transport offer [6], [18] together with the characteristics of the application used to this [7]. An important part of problems of shaping the offer is also distribution of traffic flow in the transport network [1], [10], [11]. It should be also ensure that that the offer allowed for the implementation of services in a reliable and effective way [9].

In world literature a lot of space devoted to mathematical modelling of the transport offer, where the problem is referred to as the "Line Planning Problem" [3]. Mathematical formulation of various researchers is as close to each other. The differences are mainly in terms of indicators to assess the quality of solutions and methods of solving the problem. Used, among others, branch-and-bound method [5], [14], tools of integer linear programming (ILP) [2], nonlinear mixed integer model [4], branch-and-cut method [8] or Lagrangian relaxation
and heuristic methods [16]. As an objective functions assumed among others number of transported passengers [2], [5], the cost of implementation of transport tasks [4], [8], [14] and the number of transfers between train sets [16].

The article presents the concept of application BEERJ supporting the work of transport offer designers: railway undertakings and transport organizers. We introduced the concept of the application and the mathematical model being the basis of its action. At the initial version of the computer application we conducted the trial of methods works - we prepared the transport offer and it illustration on a graphic timetable for the railway line 285: Wrocław Główny - Świdnica Przedmieście.

2. CONCEPT OF APPLICATION SUPPORTING TRANSPORT OFFER CONSTRUCTORS

As mentioned above, the application [7] is designed to support the designers of railway transport offer: transport organizers and the railway undertakings. Through the utilization of this application, responsible for the preparation of the offer, after the introduction of input data will be able to shape it and illustrate using graphic train timetable. Display the transport offer in graphical form allow for its more accurate development and eliminating of potential errors. Comprehensive preparation of the transport offer will also facilitate the work of the constructors of graphic timetable (who are the representatives of the infrastructure manager), who receive input data much more accurate.

BEERJ application will allow for a solution of three problems. The first is allocating of the volume of traffic flow to transport on previously designated communication lines. The second problem is to assign for each communication line, on the basis of the specified volume of the traffic flow, the type of train set to support and frequency of running. The third problem is to develop graphic timetable for the previously prepared transport offer. Problems have been characterized in detail at point 3 of this article. Figure 1 shows the main BEERJ application window and Figure 2 an example screen shot.

The BEERJ application is prepared in the programming language C# (C Sharp) [17] in a free Microsoft Visual Studio 2015. This environment supports the designing in visually manner - objects and elements are at first placed on the form and then are programmed their behaviour. Editor on an ongoing basis indicates errors in the code and suggests how to fix them. BEERJ application will be available for Windows. The application is prepared in the technology Windows Forms Application.

Figure 1 Main application window
Figure 2 Example screen shot
3. MATHEMATICAL MODEL OF TRAIN TIMETABLE CONSTRUCTION WHICH IS THE BASIS OF THE APPLICATION

BEERJ application will allow for solution of three problems. The first one is allocating to the designated communication lines appropriate volume of the traffic flow which will be transported over them. We look for the volume of traffic flow \( d(t_{\text{kat okrdob}}, \text{kat okrdob}) \) which should be transported in a direct relations along the route \( t_{\text{kat okrdob}} \in T_{\text{kat okrdob}} \) by the trains category \( \text{kat} \in \text{KAT} \), in a specified period of the day \( \text{okrdob} \in \text{OKRDOB} \) record as a vector \( D \):

\[
D = \left[ d \left( t_{\text{kat okrdob}}, \text{kat okrdob} \right) \right]
\]  

(1)

The set \( T_{\text{kat okrdob}} \) is developed separately for the specific periods of day \( \text{okrdob} \) and for each category of trains \( \text{kat} \). To this set are classified all train routes \( t_{\text{kat okrdob}} \in T_{\text{kat okrdob}} \) - these are the routes, which beginning and / or end is not included in operating offices where it is possible to begin and terminate of trains run.

To solve the first problem is also needed to define additional input data. The railway network should be presented using graph \( \text{GK} = <\text{WK}, \text{LK}> \) consisting of a set of operating offices \( \text{WK} \) \( (\text{wk} \in \text{WK}) \) and a set of connections between these operating offices \( \text{LK} \) \((\text{lk} \in \text{LK})\). In addition, for each period of the day \( \text{okrdob} \) and each category of train \( \text{kat} \) should be defined matrices \( P_{\text{kat okrdob}} \) determining the demand for transport between all operating offices.

As an indicator of assessing the quality of solution \( f_1(D) \) we used the demand for transport, which was transported in direct relations:

\[
f_1(D) = \sum_{t_{\text{kat okrdob}} \in T_{\text{kat okrdob}}} \sum_{\text{kat} \in \text{KAT}} \sum_{\text{okrdob} \in \text{OKRDOB}} d \left( t_{\text{kat okrdob}}, \text{kat okrdob} \right) \rightarrow \text{max}
\]  

(2)

In the model should be apply the boundary conditions as: the volume of the traffic flow transported in direct relations should not be negative, should not exceed the flow to transport on the given route, and be less than the supply of seats on the route.

The second problem is the allocation to the routes \( t_{\text{kat okrdob}} \), the type of train set \( \text{po}(t_{\text{kat okrdob}}) \in \text{PO}(t_{\text{kat okrdob}}) \), which can handle the trains for this category in a given part of the day, and the frequency of running \( f(t_{\text{kat okrdob}}) \) for a specific period of the day \( \text{okrdob} \) and specific category \( \text{kat} \), so we need to determine the values of the elements of vector \( X \):

\[
X = \left[ x \left( \text{okrdob}, \text{kat} \right), \text{po}(t_{\text{kat okrdob}}), f(t_{\text{kat okrdob}}, \text{kat okrdob}) \right]
\]  

(3)

The frequency of running \( f(t_{\text{kat okrdob}}) \) should be selected from the interval \( <f(t_{\text{kat okrdob}}), \text{po}(t_{\text{kat okrdob}})> \) specified for given category \( \text{kat} \) and the day period \( \text{okrdob} \). In addition, to solve the problem, it is neccesary to define a parameter indicating the train capacity \( c(\text{po}(t_{\text{kat okrdob}})) \), their numbers \( k(\text{po}(t_{\text{kat okrdob}})) \), number of running hours on the route \( l(t_{\text{kat okrdob}}) \), travel time of the vehicle type \( \text{po}(t_{\text{kat okrdob}}) \) along the route \( t_{\text{kat okrdob}} \), the average stop time at a operating offices \( \text{wk} \) of the train category \( \text{kat} \) - \( \Delta(\text{wk}, \text{kat}) \) and the amount of operational costs of ride the trainkm by train type \( \text{po}(t_{\text{kat okrdob}}) \) - \( k_0(t_{\text{kat okrdob}}) \).

To assess this problem we used two indicators for assessing the quality of solutions. Indicator first \( f_1(X) \) describes the operational costs associated with running of all trains:

\[
f_1(X) = \sum_{t_{\text{kat okrdob}} \in T_{\text{kat okrdob}}} \sum_{\text{kat} \in \text{KAT}} \sum_{\text{okrdob} \in \text{OKRDOB}} k_0 \left( t_{\text{kat okrdob}} \right) \cdot x \left( \text{okrdob}, \text{kat} \right) \cdot \text{po}(t_{\text{kat okrdob}}) \cdot f(t_{\text{kat okrdob}}, \text{kat okrdob}) \rightarrow \text{min}
\]  

(4)
The second indicator $f_2(X)$ describes the number of train sets required to operate trains in all periods of day:

$$f_2(X) = \sum_{t_{kat} \in t_{kat}, \kat, okrdob, okrdob} \sum_{poc \in poc(t_{kat}, \kat, okrdob)} \sum_{X \in X(t_{kat}, \kat, okrdob)} \sum_{Y \in Y(t_{kat}, \kat, okrdob)} 2 \left[ lb(t_{kat}, \kat, okrdob) \right] \left[ \frac{60}{f(t_{kat}, \kat, okrdob)} \right] \left[ qp(t_{kat}, \kat, okrdob) \right] + \Delta(wk, \kat) \rightarrow \min$$

In the model should be apply the boundary conditions: each line should be handled by only one train set, and that the assigned number of train sets should not be greater than at the disposal. An important issue is also the fact that we need to determine the number of train of each category $kat$ to run $poc(t_{kat}, \kat, okrdob) \in POC(t_{kat}, \kat, okrdob)$ on specific routes $t_{kat, okrdob}$ and leading hours for them $gw(poc(t_{kat}, \kat, okrdob))$.

The third problem is to develop graphic timetable for prepared transport offer. We look for relative positioning of train paths $poc(t_{kat}, \kat, okrdob, \kat)$ in time and space $lr(lk, poc(t_{kat}, \kat, okrdob, \kat))$, which can be presented as vector $Y$:

$$Y = \left[ y(lr(lk, poc(t_{kat}, \kat, okrdob, \kat))) \right]$$

For the preparation of a graphic timetable it should be presented in the form of a graph $GR = <WR, LR>$ consists of a set of time moments $WR$ ($wr(lk, poc(t_{kat}, \kat, \kat) \in WR)$) and a set of states $LR$ ($lr(lk, poc(t_{kat}, \kat, \kat)) \in LR$). In addition, it is necessary to define the parameters: length of station time spacing $lrsk(wk)$, length of open line time spacing $szl \in SZL$, length of time needed for transport connections $lrsk(wk)$.

To assess this problem we used indicator for assessing the quality of solution $f_1(Y)$ describing the volume of differences between time taking into account and not taking into account the principles of proper conducting the railway traffic $p(lr(lk, poc(t_{kat}, \kat, \kat))$):

$$f_1(Y) = \sum_{lr(lk, poc(t_{kat}, \kat, \kat)) \in LR} p(lr(lk, poc(t_{kat}, \kat, \kat))) \cdot y(lr(lk, poc(t_{kat}, \kat, \kat))) \rightarrow \min$$

In the model should be apply the technical and security boundary conditions. To technical boundary conditions we can include, among others, that the train should have one moment of appearance and leave on a chart, and the intermediate nodes only one predecessor and one successor. To security boundary conditions we include the need to maintain station and track spacing and time needed for transport connections.

4. CASE STUDY OF TRAIN TIMETABLE CONSTRUCTION FOR SELECT RAILWAY LINE

We prepared in application BEERJ transport offer and its presentation on the graphic train timetable for a railway line 285: Wrocław Gł. - Świdnica Przedmieście. As part of the testing procedure, we assumed that will be launched the agglomeration trains in relation Wrocław Gł. - Wrocław Klecina, regional trains in relation Wrocław Gł. - Sobótka Zachodnia and freight trains in relation Wrocław Brochów - Świdnica Przedmieście (on line 285 from junction signal box Tarnogaj).

Presenting the line 285 as a graph we identified 22 operating offices (vertices) and 21 edges. Timetable will be prepared for the one period of day (whole day) for three segments of demand (agglomeration, passenger and freight trains). For each segment we prepared demand matrices.

After collecting the data for each trains category and for each period of the day we searched the communication lines (e.g. for the first category - six routes). Then we conducted aggregation of lines to those that are between points where it is possible to begin and terminate of trains run (for all categories are two routes) and assigned to them volume of traffic flow to transport. Then we assigned the type of train to service from pre-defined (we adopted to use rolling stock owned by the Lower Silesia Province) and the frequency.
The effects of the work are as follows: to handle the 12 pairs of agglomeration trains we assigned rail-bus SA106 and frequency 120 min., to handle the 6 pairs of regional trains in relation we assigned rail-bus SA135 and frequency 240 min., to handle the 2 pairs of freight trains in relation we assigned locomotive SM42 and frequency 720 min.

For prepared transport offer we developed a model graphic train timetable (Figure 4)

![Figure 4 Model graphic train timetable for railway line 285 Wrocław Główny - Świdnica Przedmieście](image)

On model graphic timetable there are many collisions between trains. There are not preserved times spacing. Included are only leading hours for trains. It should be removed all problems threatening safety of traffic. Removal of the conflict should be carried out under the supervision of the constructor. Through experience of the researcher timetable becomes more adapted to the needs of customers. After removal of collisions and application of experience of constructor it is preparing a real graphic timetable (Figure 5).

![Figure 5 Real graphic train timetable for railway line 285 Wrocław Główny - Świdnica Przedmieście](image)

5. **SUMMARY AND CONCLUSIONS**

A well-constructed timetable allows for conducting of movement smoothly and safely. In prepared timetable should be taken into account the time associated with any determinants - e.g. adequate time to change of the passengers, the time required to realize train announcing by train dispatchers, time of non-simultaneous arrival etc. Timetable should take into account satisfying the needs of all participants of movement - mostly passengers, so capacity of train sets and frequency of running should be adjusted accordingly.
The aim should be to develop applications to support the work of timetable constructors (both transport offer and graphic timetable). Use of application will reduce the risk of error, which can have more or less serious consequences. Article presents the author's assumptions about the computer application BEERJ, which is intended to support railway undertakings and transport organizers in preparing the transport offer, together with its presentation on the graphic train timetable. Graphic form of presentation of the transport offer will allow the constructor for a holistic look and possible correction of plan in places generating problems and ensure accurate implementation of transport needs.

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THE APPLICATION OF ENVIRONMENTAL LIFE CYCLE COSTING TO THE ECO-EFFICIENCY ANALYSIS OF TRANSPORT MODES

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Abstract

This paper presents an analysis of the applicability of environmental life cycle cost to the eco-efficiency analysis of transport modes. For calculating such costs, the method based on LCA results converted into monetary values was proposed. It allows taking into account all externalities generated by transport in the life cycle. The proposed solution complements earlier research work undertaken in this area, because the existing methods often focus on valuation of damages generated only during usage of transport modes and often take into account only the valuation of the damages resulting from the emission of substances contained in exhaust gases. It all makes, that the value of the environmental effects determined in this way is undervalued and relatively small compared with financial costs incurred throughout the life cycle of a transport modes. Thus, it has a little importance in the decision-making process. For that reason it is very important to develop the solutions which allow assessing impact of the transport mode in entire life cycle and which allow expressing the externalities in monetary terms.

Keywords: Environmental life cycle costing, eco-efficiency, transport modes

1. INTRODUCTION

Transport underpins modern economy and society. Its role is important not only in transfers of goods and services, but also in ensuring the mobility of people. It has, however, a negative impact on the environment causing air pollution, natural resource depletion and other damages in the environment and in human health.

The volume of transport modes is still growing, which undoubtedly will result in further deterioration of the environment quality. Therefore, to prevent this situation, the European Union proposes solutions aiming at „greening” the transport modes. The White Paper on Transport [1] is an example of document, which indicates possibilities of transition of transport system to a more environmentally friendly. It includes the Roadmap towards a competitive and resource efficient transport system significantly reducing greenhouse gas emissions. The implementation of actions indicated in the White Paper should allow such organization of the transport system to reach maximum economic efficiency with the least environmental impact. For this reason when the transport modes are chosen, it is essential to take into account the financial aspects, as well as the environmental aspects and assess the eco-efficiency of each of them.

There are some methods described in the literature, which can be used to assess the eco-efficiency of transport modes. A lot of them take into account only the most important environmental impact factors caused by the transport modes during the phase of their usage like: global warming (mainly through emission of CO2), air pollution (e.g., particulates and nitrogen oxides) and noise nuisance. Only few of them include also impacts generated in the fuel production phase. These methods generally express damages in various units of measurement making difficult the assessment of the eco-efficiency. It seems therefore that seeking for solutions which allow assessing impact of the transport mode in entire life cycle and which allow expressing the externalities in monetary terms is required.

This paper presents an analysis of the applicability of environmental life cycle costing to the eco-efficiency analysis of transport modes. For calculating such costs, the method based on LCA results converted into
monetary values was proposed. Such a solution allows taking into account all externalities generated by transport in the life cycle and allows to express the eco-efficiency ratio in monetary terms.

2. THE CONCEPT OF THE ECO-EFFICIENCY

Eco-efficiency is an instrument for sustainability analysis, which shows an impact of economic activities on the environment and human health. The concept of eco-efficiency was popularized by the World Business Council for Sustainable Development (WBCSD) as a key concept, which can help companies, individuals, governments or other organizations to become more sustainable. According to WBCSD, eco-efficiency can be achieved through the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while at the same time reducing ecological impacts and resource intensity throughout the life cycle [2]. The European Environmental Agency (EEA) defines the eco-efficiency as “a concept and strategy enabling sufficient linking of the use of nature from economic activity, needed to meet human needs, to keep it within carrying capacities and to allow equitable access to, and use of the environment, by current and future generations” [3]. OECD assumes that eco-efficiency is “the efficiency with which ecological resources are used to meet human needs” and defines it as a ratio of an output (the value of products and services produced by a firm, sector or economy as a whole) divided by the input (the sum of environmental pressures generated by the firm, the sector or the economy) [4]. The term of eco-efficiency is also defined in ISO 14045 as an aspect of sustainability relating the environmental performance of a product system to its product system value [5].

As appears from the definitions presented above, the measure of eco-efficiency is a function determining the relation between two types of indicators: economic and environmental. Economic indicators are related to the value of product system for a stakeholder. According to ISO 14045 the value of the product system may be chosen to reflect its resource, production, delivery or use efficiency, or a combination of these. This value may be expressed in monetary terms or other value aspects [5]. Generally applicable indicators for value of product system can be divided in three group: (1) describing a quantitative value of product system - units of goods or services produced, mass of goods or services sold, (2) describing a monetary value of product system - net sales, gross margin, value added, income, net present value (NPV), conventional Life Cycle Costing (LCC), the Dynamic Generation Cost (DGC), (3) describing the functional value of a product system to the end-user - transport capacity (e.g. ton-kilometers, passenger-kilometers), product performance (e.g. laundry loads washed), product durability / lifetime.

The impact of system product on the environment might be determined by environmental indicators. These indicators are expressed as single indicator describing the influence on the individual elements of environment (e.g. emission of VOC, SO₂, NOₓ, emission of wastewater, amount of packaging waste) or identifying the volume of energy, water, natural resources or materials consumed. They can also be expressed in aggregated form as a sum of the indicators for different pollutant contributing to the same environmental burden (e.g. Global Warming Potential, eutrophication, human toxicity). Most indicators describe the influence generated in a selected phase of life cycle (e.g. product creation or product use) but some of them cover the entire product life cycle. It should be stated, that in accordance with ISO 14045, the environmental impacts should be evaluated using Life Cycle Assessment (LCA) [6]).

The measurement of eco-efficiency requires the determination of the relation between economic and environmental indicators applied by the organization. Depending on the aim of eco-efficiency measurement, this relation is described as:

- the ratio of economic indicator to environmental indicator, if the organization wants to know, what is its environmental productivity or what is the cost of environmental improvements,
- the ratio of the environmental indicator to the economic indicator, if the organization wants to know, what is its environmental intensity or environmental cost-effectiveness.
Due to the desire to determine which transport mode is the most efficient in terms of both aspects economic and ecological, in this article the first formula was chosen as appropriate for eco-efficiency assessment of transport modes.

3. THE TOOLS USED TO THE ECO-EFFICIENCY ASSESSMENT OF TRANSPORT MODES

There are few examples of eco-efficiency assessment of transport modes in the literature. Most of them use commonly applicable methods to assess the efficiency adapting them to the needs of assessment of transport modes [e.g. 7, 8]. There are also several tools, which are dedicated specially for eco-efficiency assessment of transport modes. Their short description was presented in Table 1.

Table 1 Selected examples of tools used for eco-efficiency assessment of transport modes [9, 10, 11, 12]

<table>
<thead>
<tr>
<th>Name of tool</th>
<th>Tool description</th>
</tr>
</thead>
</table>
| Intermodal Terminal Eco-Efficiency Calculator (ITEC) | • developed by HaCon, KombiConsult and Thinkstep within the scope of the EcoHubs project co-funded by the EU;  
  • can be used for calculation of environmental impact of intermodal terminal including impact of used transport modes;  
  • calculates: (1) the greenhouse gas (GHG) emission, (2) the fuel consumption, (3) the energy consumption of intermodal terminals including all relevant operations;  
  • identifies the terminal’s “hot spots”, i.e. the main energy consumers and processes;  
  • points out the impact of “greening measures” already implemented and anticipates effects of planned measures;  
  • does not take into account the economic indicators to calculate eco-efficiency;  
  • includes only the tank-to-wheels analysis, which takes into account the emission caused by use of transport modes. |
| EcoTransIT World | • developed by The Institute for Energy and Environmental Research (ifeu) Heidelberg, the Öko-Institut Berlin and the Rail Management Consultants GmbH (RMCon/IVE mbH) Hanover;  
  • can be used for assessing the environmental impact of transporting freight by various transport modes;  
  • calculates: (1) the primary energy consumption, (2) the greenhouse gas emissions, (3) NO\textsubscript{x} emission, (4) SO\textsubscript{2} emission, (5) NMHC emission (6) PM emission;  
  • does not take into account the economic indicators;  
  • includes the well-to-wheels analysis, which takes into account the emission from production and distribution of the fuel and from use of transport mode;  
  • excludes the emissions associated with the production of the vehicle and the recycling or after use-processing. |
| Ecoscore | • developed by the Vrije Universiteit Brussel (VUB), VITO and ULB;  
  • can be used for evaluation of the environmental performance of passenger vehicles;  
  • identifies the impact of environment taking into account: (1) emissions with impacts on global warming (CO\textsubscript{2}, CH\textsubscript{4}, N\textsubscript{2}O), (2) emissions with impacts on air pollution (NO\textsubscript{x}, SO\textsubscript{2}, CO, HC, PM) and (3) noise emission;  
  • expresses the different impacts on the environment in one single indicator - as a value between 0 and 100 (the higher the score, the more environmentally friendly vehicle);  
  • does not take into account the economic indicators;  
  • includes the well-to-wheels analysis, which takes into consideration the emission from production and distribution of the fuel (fuel cycle emission) and from use of transport mode (exhaust emissions);  
  • excludes the emissions associated with the production of the vehicle and the recycling or after use-processing. |
| Clean Fleets Life Cycle Cost (LCC) Calculator | • developed within the scope of the Project Clean Fleets funded by the EU;  
  • is an operational instrument under the European Commission Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles;  
  • can be used only for evaluation of eco-efficiency of different type of road vehicles (cars, vans and Heavy duty vehicles);  
  • calculates the Life Cycle Costs of vehicles, which include: (1) costs of acquisition, (2) operation costs (3) maintenance costs (4) tax and other cost (5) emission costs (Operational Lifetime Cost -OLC), (6) end-of-life costs;  
  • converts the impacts on the environment to monetary terms and calculates the Operational Life Costs, which are consist of: the lifetime costs for energy consumption, CO\textsubscript{2} and pollutant emissions (NO\textsubscript{x}, PM and NMHC);  
  • includes only the tank-to-wheels analysis. |
Analysing the tools shown in Table 1 it can be said that most of them focus on the assessment of selected environmental aspects generated by the transport modes ignoring the assessment of economic aspects. Therefore, these tools do not assess the eco-efficiency but indicate which transport modes is more environmentally friendly. The Clean Fleets LCC Calculator is the only tool which takes into account both economic and environmental effects thereby allowing the determination of eco-efficiency indicator.

A part of the tools listed in Table 1 takes into consideration only the impacts generated during use phase of transport modes applying the tank-to-wheels approach (ITEC and Clean Fleets LCC Calculator). Part of them extends the analysis and assess also the impacts generated in the phase of fuel production and distribution using the well-to-wheels approach (Ecoscore or EcoTransIT World). None of the presented tools takes into consideration damages caused in the phase of extraction and processing of raw materials needed for the production of transport modes, in the manufacturing phase and in the end-of-life phase. It means that neither of them assesses the eco-efficiency of the transport modes throughout the life cycle. In addition, most of these tools evaluate only the emissions of greenhouse gases, exhaust emissions and fuel consumption. The Ecoscore is the exception, because the emissions generated by transport mode are divided here into three impact categories: emissions with impacts on global warming, emissions with impacts on air quality (which are divided into impacts on human health and impacts on ecosystems) and noise emissions from engine.

In the most of eco-efficiency studies presented in literature the environmental impacts are expressed in incommensurable units. For that reason their aggregation is complicated because there usually are no unambiguous value-weights for these impacts. As a consequence, many eco-efficiency studies present each category of environmental impact separately or they apply ad hoc summation of different criteria, disregarding their relative importance. In the case of tools presented in Table 1, the different categories of environmental influence are aggregated in one indicator in Ecoscore and Clean Fleets LCC Calculator. In Ecoscore environmental effects are expressed in a single value between 0 to 100, while in Clean Fleets LCC Calculator are converted into monetary value on the basis of the value of external effects included in Directive 2009/33/EC [13]. Both of these methods could be therefore considered appropriate to calculate the eco-efficiency of transport modes, but none of them takes into account the impact on the environment throughout the life cycle, which is recommended by ISO 14045. In addition, Ecoscore allows to determine only the environmental impacts, without taking into account economic aspects. The advantage of Clean Fleets LCC Calculator is expressing economic and ecological indicator in the same unit, i.e. in monetary values, which undoubtedly makes it easier to understand the results of the analysis. Unfortunately, despite that an economic indicator is expressed as Life Cycle Costs (LCC), the environmental indicator focuses only on the value of effects generated during the use of the transport modes. Therefore, in order to identify the transport modes characterized by the highest eco-efficiency throughout the life cycle, all environmental effects generated throughout the life cycle should be monetised. It is possible by application of the Environmental Life Cycle Costing.

4. THE ROLE OF ENVIRONMENTAL LIFE CYCLE COSTING IN THE ECO-EFFICIENCY ASSESSMENT OF TRANSPORT MODES

Life cycle costing (LCC) is a methodology for the systematic economic evaluation of life cycle costs over a period of analysis. Environmental life cycle costs are one of the type of life cycle costs. They include monetary value of externalities resulting in different phases of the product life cycle, which can be internalized in the account of polluters. The concept of environmental LCC was developed for combining the results of Life Cycle Assessment (LCA) with conventional LCC, which includes all financial costs (acquisition costs, ownership costs and end-of-life disposal costs) directly covered by the main producer or user in the product life cycle. Accordance with SETAC, environmental LCC contains conventional LCC and the monetary value of externalities (positive or negative) generated in life cycle [14].

Calculating the value of environmental LCC is not easy, because it requests to express in monetary terms environmental effects which don’t have a market value in most cases. Nevertheless, there are non-market
methods valuing this kind of effects. These methods include stated preference methods (e.g. contingent valuation method and choice experience) and revealed preference methods (e.g. hedonic price method, travel cost methods, opportunity costs or restitution costs method). These methods are used to determine the value of different types of environmental effects. There are examples of studies in literature, where the results of LCA (expressed in midpoints or endpoints) have been converted into monetary value \[15\]. There are also some examples, in which the valuation of externalities generated by the transport mode was done. \[16\].

The calculation of the environmental life cycle costs allows to express the environmental indicator in monetary values and thus allows the calculation of eco-efficiency indicator for transport modes. It is therefore proposed to accept conventional LCC as an economic indicator and LCA results converted into monetary value as an environmental indicator. Determining the eco-efficiency indicator would be based on the following formula:

\[
\text{eco-efficiency indicator} = \frac{\text{Conventional LCC}}{\text{Economic value of LCA results}}
\]

On the basis of the earlier studies \[17\], it can be stated that the calculation of eco-efficiency indicator may be not sufficient for the determination of the eco-efficiency of transport modes. There may be a situation when two different transport modes have the same value of eco-efficiency indicator at different levels of conventional LCC and values of LCA. In such case, the mentioned above formula takes the following form:

\[
\text{eco-efficiency indicator} = \frac{\text{Conventional LCC}}{\text{Economic value of LCA results}} \wedge \text{Environmental LCC} \rightarrow \text{min}
\]

5. CONCLUSION

The solution proposed in this article allows the assessment of eco-efficiency of transport modes in life cycle through expressing the environmental indicator in monetary value. Undoubtedly, it facilitates interpretation of the results of such analysis. Although the execution of LCA requires the identification of all environmental influence generated in life cycle and for that reason it is not easy task, the availability of databases facilitating the execution of LCA (e.g. IDEMAT, Ecoivent, GaBi LCA Databases) increases with each year. Similarly there are more and more examples of environmental damage valuations that can be transferred to determine the economic values of environmental effects generated by transport modes.

The implementation of the ambitious targets set out in the White Paper on Transport requires the introduction of diverse eco-innovations and development of various forms of interorganizational cooperation \[18\] in the transport area. In practice, these activities must be supported by IT tools \[19\]. The proposed solution allows to extend the functionality of existing IT tools giving the opportunity to take into account the environmental effects generated throughout the life cycle.

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Abstract

Since each company can be considered only as a segment of the supply chain, cooperation among all the segments is inevitable. Through cooperation, supply chains can gain competitive advantage and achieve better performance. Competition has shifted to the level of the supply chain. Nowadays, buyers engage in specific types of processes at their suppliers in order to strengthen their cooperation and to improve their performance. It is especially noticeable in automotive industry.

Extant literature on types of cooperation among companies within supply chain provides the foundation for the study. The data collection was conducted through questionnaire. Questionnaire was sent to manufacturing and business companies of all sizes (small, medium and large enterprises) with the representation in the Czech Republic within following sectors: automotive, food, clothing industry, electronics and pharmaceutical industry.

The results show how the companies develop their cooperation with suppliers and what is significant in different sectors. Majority of the companies prefer close cooperation with suppliers, some of them participate on streamlining of the supplier’s processes and effective sharing of information via information technology systems.

Keywords: Cooperation, Czech Republic, supplier development

1. INTRODUCTION

In recent years, it is especially noticeable the short product life cycles, ever-increasing competition, individual customer requirements which change over the time and, last but not least, cost competitiveness. Today, companies must be able to mix this cocktail individually for each customer, otherwise they will quickly lose its competitiveness in the market.

For that reason, it is inevitable for the companies in the supply chain to cooperate closely otherwise the flows of products, information and payments would not be efficient [1], [2]. Through cooperation with suppliers, supply chains can gain competitive advantage and achieve better performance by gaining synergic effect. Therefore, supplier integration goes beyond the buying and selling activities and emphasize the importance to involve suppliers in different processes, for instance product development [3].

This paper outlines what types of cooperation and supplier development are important for the companies in the Czech Republic. Moreover, it focuses on companies that are directly involved in streamlining of supplier’s processes and show what the motivation for such involvement is. Authors define two research questions.

RQ1: Do the companies participate in supplier development? If yes, how?
RQ2: Are the companies directly involved in streamlining of supplier’s processes? If yes, how?

2. SUPPLIER DEVELOPMENT

2.1. Literature review

In sectors where manufacturing know-how is crucial for the final product such as automotive or electronics industry, companies are highly dependent on their own knowledge in order to produce innovative products.
Moreover they have to rely on know-how of their suppliers otherwise they would not be able to compete with other companies. [4], [5].

Since each company in the supply chain concentrates on the specific manufacturing process, companies can only produce innovative and competitive products using innovative parts from their suppliers. [6], [7] In order to be sure for the companies that they receive a competitive and innovative part for their final product, they tend to supervise the supplier’s processes.

In today’s global competitive environment, companies go further. They engage in supplier development as a reaction to competitive markets. Companies access to supplier development differently. It starts with an informal supplier evaluation and a request for improved performance. On the other hand companies invest in the training of the supplier’s personnel and in the supplier’s operations. [8], [9]

Carter emphasized that strong relationships built through collaboration may block competitors from accessing key sources of supply. It means that the buyer company can gain a technological exclusivity for a period of time until the supplier decides to cooperate with other companies. [10]

Supplier development is described as activities initiated by a buying company to strengthen the competitive capability of its suppliers. In practice, supplier development activities vary significantly, buying companies use different approaches to enhance their suppliers’ performance and capabilities.

Li classified these endeavours into four categories. Asset specificity represents transaction-specific investments in the supplier by the buying company. Joint action represents in-depth cooperation between buyers and suppliers on certain activities that are important for improving the performance of both parties. Performance expectation represents buyers’ expectation of suppliers’ performance improvement. Trust too is an important factor. [11]

2.2. Data collection

The data collection period was established to five months during the second half of 2015. Questionnaire was sent to approx. 800 selected manufacturing or business companies belonging to all sizes (small, medium and large enterprises). Target group are companies with the representation in the Czech Republic within following sectors: automotive, food, clothing industry, electronics and pharmaceutical industry.

Questionnaire was sent to the companies from described sectors, from different regions in Czech Republic electronically. Since the questionnaire encompasses the wide range of questions concerning the strategic decisions of the company, authors selected carefully the key informants. Thus, the recipient of the email is logistic or supply chain manager (if this role is not held within the company, it is sent directly to the CEO). Questionnaire response rate is around 5 %. Every company is contacted by email that includes cover letter, instruction sheet and the questionnaire. To increase the response rate as well as to send the questionnaire to the right person, pre-notification calls were made. Managers were invited to participate and authors offered them a copy of the questionnaire’s results.

However the response rate is low, we received enough questionnaires in order to make a conclusion, moreover some companies are willing to continue with the research and cooperate on semi-structured interviews. Although most companies understood well the questions, there were some discrepancies in a few questionnaires. Moreover some companies were not able to finish the questionnaire due to different reasons. Some of the questionnaires had to be discarded.

2.3. Results

Recipients were asked about the cooperation with suppliers. From 40 companies, only 7 companies stated that they do not participate on supplier development. The majority of them (4 out of 7) belong to the food industry. One of the companies belongs to the automotive industry.
Table 1 Participation on supplier development

<table>
<thead>
<tr>
<th>Yes</th>
<th>33</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>7</td>
</tr>
</tbody>
</table>

If the company confirmed the participation on supplier development, we asked about how they develop the cooperation with suppliers. Each company could mark more than one possibility. Table 2 shows the results. Regular meetings with suppliers, personal or online meeting are the most frequent across all studied industries. Employee training and effective sharing of information is other preferred way to cooperate. Less presented types of cooperation as efforts to involve suppliers on savings and vendor-managed inventory were confirmed across industries as well.

Table 2 How the companies develop relationship with suppliers

<table>
<thead>
<tr>
<th>Involvement in R&amp;D</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular online meetings</td>
<td>18</td>
</tr>
<tr>
<td>Regular visits at supplier</td>
<td>23</td>
</tr>
<tr>
<td>Employee training</td>
<td>12</td>
</tr>
<tr>
<td>Efforts to involve suppliers on savings</td>
<td>7</td>
</tr>
<tr>
<td>Capital investments</td>
<td>2</td>
</tr>
<tr>
<td>Effective sharing of information</td>
<td>10</td>
</tr>
<tr>
<td>Vendor-managed inventory</td>
<td>7</td>
</tr>
<tr>
<td>Other techniques</td>
<td>6</td>
</tr>
</tbody>
</table>

Some companies not only cooperate with suppliers but they are directly involved in streamlining of supplier’s processes. This trend is especially noticeable in automotive industry (3 out of 7 companies confirmed direct involvement) and pharmaceutical industry (2 out of 4 companies).

Table 3 Direct involvement in streamlining of supplier’s processes

<table>
<thead>
<tr>
<th>Yes</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>33</td>
</tr>
</tbody>
</table>

The companies that confirmed the involvement were asked how they are involved. Each company could mark more than one possibility. Most of them apply lean management principles, know-how sharing. Involvement of own employees or involvement of external consulting companies are frequently marked as well. All companies confirmed financial investment in their suppliers.

Table 4 How are the companies involved?

<table>
<thead>
<tr>
<th>Know-how sharing</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training and development of employees</td>
<td>1</td>
</tr>
<tr>
<td>Involvement of own employees</td>
<td>4</td>
</tr>
<tr>
<td>Involvement of external consulting companies</td>
<td>4</td>
</tr>
<tr>
<td>Financial investment</td>
<td>7</td>
</tr>
<tr>
<td>Lean management principles</td>
<td></td>
</tr>
<tr>
<td>• Total quality management</td>
<td>3</td>
</tr>
<tr>
<td>• Just in time</td>
<td>1</td>
</tr>
<tr>
<td>• Kaizen</td>
<td>3</td>
</tr>
<tr>
<td>• Radical change and redesign of processes</td>
<td>1</td>
</tr>
</tbody>
</table>
The motivation for involvement in streamlining of supplier processes is the long-term cooperation with the supplier or strategic partnership. The results of the motivation for cooperation shows Table 5. Each company could mark more than one possibility. There was not found any specific motivation that would be typical for concrete industry.

Table 5 What is the motivation for this involvement?

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of supplier with long-term cooperation</td>
<td>6</td>
</tr>
<tr>
<td>Strategic partnership</td>
<td>5</td>
</tr>
<tr>
<td>Insufficient financial capital of partner</td>
<td>0</td>
</tr>
<tr>
<td>Motivation of financial savings</td>
<td>4</td>
</tr>
<tr>
<td>Motivation of increased quality of supplied parts</td>
<td>4</td>
</tr>
<tr>
<td>Motivation for partner’s development and stabilization</td>
<td>4</td>
</tr>
</tbody>
</table>

The companies stated the benefits that bring such involvement. All of them confirmed increased on-time deliveries, majority of them claimed increased quality of deliveries and faster delivery cycle time. Another benefit of such involvement is supplier stabilization. The results are shown in Table 6.

Table 6 What are the benefits of such involvement?

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faster delivery cycle time</td>
<td>5</td>
</tr>
<tr>
<td>Increased quality of deliveries</td>
<td>6</td>
</tr>
<tr>
<td>Increased on-time deliveries</td>
<td>7</td>
</tr>
<tr>
<td>Decreased buying price</td>
<td>3</td>
</tr>
<tr>
<td>Decreased expenses on salaries at supplier</td>
<td>0</td>
</tr>
<tr>
<td>Supplier stabilization</td>
<td>5</td>
</tr>
</tbody>
</table>

3. **CONCLUSION**

This paper confirmed the importance of the cooperation in the supply chain. Supplier development is one of the ways how companies can strengthen their position on the market and bring innovative products. As a result of closer relationship with the suppliers, companies can improve their performance. Cooperation with suppliers allows them to provide their customers with shorter time of delivery since the supply chain becomes more flexible.

The results of the questionnaire sent to the companies from different sectors in the Czech Republic show that Czech companies constantly work on the relationship with their suppliers, more frequently they regularly visit their suppliers or meet them online, train supplier’s employees or share the information with them. The benefits of such cooperation are better quality of deliveries, lower costs of deliveries or more flexible supply chain.

Some of the Czech companies participate on streamlining of supplier’s processes with different methods and motivation. Most of them apply lean management principles, know-how sharing, involvement of own employees or involvement of external consulting companies. All companies confirmed financial investment in their suppliers. The benefits of such involvement are increased on-time deliveries, increased quality of deliveries, faster delivery cycle time or supplier stabilization.

Since the study confirmed the necessity of future research on cooperation with suppliers, the authors have already started in-depth interviews with participating companies from automotive industry to reveal how the involvement in streamlining of supplier’s processes influence the company’s performance.
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PLANNING OF DELIVERIES IN MODERN LOGISTICS SYSTEMS

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Abstract
A production company in the current demanding market situation has to optimize the process of planning deliveries in close cooperation with the production team and with the support of modern IT tools. The customer needs to have goods delivered at the promised time, in the ordered quantity and in the required quality. Ideally, the planning of production, tracking of production, planning of deliveries and the realization of deliveries are covered by one integrated IT solution. However, this process is usually split between MES that collects information from production, dedicated planning software and an ERP system where deliveries are finally made. This solution can be expanded by a customer portal where customers can see the information related to their orders and plan the delivery of orders that are ready in the stock of finished goods. This article will describe how such a process is designed and what the benefits are for the company and its customers.

Keywords: Delivery term, decoupling point, storage costs, logistics

1. INTRODUCTION

Today, manufacturing firms of traditional industries must - like their counterparts from the modern sectors - improve their delivery planning systems to meet the growing demands of their customers. The customers demand their products of the highest quality, in the shortest possible and exact delivery times and in the agreed amount. Businesses unable to keep pace with these growing demands are slowly but surely becoming uncompetitive.

The actual planning and delivery of products to the customer itself precedes the entire production logistics process, which must be capable of delivering the products in the required quality, quantity and within the required deadlines to the warehouse of finished goods. This cannot be achieved without feedback from the production information systems.

The most significant conditions of effective delivery planning are:

- Exact production planning.
- Reliable monitoring of the production process.
- Appropriate organization of warehouse management.
- Effective communication with the customer.

2. PRODUCTION PLANNING

If the company is unable to plan its production accurately and reliably, it then needs to count on a reserve, directly proportional to the lack of control of the manufacturing process, in confirming the delivery date to the customer. This condition will result in postponing the product delivery dates. In this case the customer of course prefers producers with shorter delivery periods because it enables him to respond to changes in demand more flexibly and he can also optimize his costs.
In practice, we encounter instances where the customer prefers a manufacturer with longer lead times if this is balanced by higher product quality or a lower price. This cannot alter the fact that longer delivery times are an obvious competitive disadvantage.

However, even more important for customers than delivery time is meeting the promised delivery date. The customer uses the delivery schedule to optimize his warehouse management or to plan his own production. Any deviation from the agreed deadline means additional costs for the customer who of course prefers suppliers who meet their delivery deadlines [1].

There are a number of auxiliary methods and tools for good quality planning including integrated IT solutions for advanced production planning (APS - Advanced Planning and Scheduling).

3. MONITORING OF THE PRODUCTION PROCESS

In order to effectively plan and manage the entire logistics process, the company must be able to obtain the necessary feedback from the manufacturing information systems (MES - Manufacturing Execution Systems). Information from MES must be provided at sufficiently short intervals in reliable quality and cover the largest possible part of the logistics process. Only then can this information be used to effectively assess and manage the ongoing production, storage and preparation of delivery.

MES then sends the information to the ERP system or to the APS tool, if the company implements it. The flow of information may look as you can see in Figure 1:

![Figure 1 Interfaces between MES-ERP-APS](image)

4. ORGANIZATION OF WAREHOUSE MANAGEMENT

Another condition for the effective planning of deliveries is the proper organization of the warehouse of finished products. The products must be stored so that the final preparation for loading and loading itself takes place in the shortest possible time and with minimum requirements on moving products before the delivery itself. The process of organization of warehouses is closely related to the type of product, type of transport, the quantity of target locations etc. [2].

Warehouse management is in most cases done primarily in MES and synchronized with the ERP system or with the customer portal which we will explore later.

The facilitating and streamlining of warehouse management is possible with the help of various technologies, mainly using solutions based on records of individual products / packages using bar-codes or QR codes. They carry the information about the type of product, production order and the customer both in the format required by the manufacturer and in the format used by the customer [3].
5. PLANNING OF DELIVERY

If the products are properly manufactured and stored in the warehouses of finished products, it is possible to start planning their delivery to the customer. In most cases the planning of delivery takes place in the ERP systems that draw data from MES and APS systems. Two approaches may exist:

- Delivery is planned without the assignment of specific products/packages. The completion of delivery itself takes place after the physical loading to the transport vehicle. In this case it is apparent that the company loses the ability to effectively prepare for the delivery because it does not know what will be loaded. In these cases the customer selects the goods during loading. This approach is mostly used by companies that do not have accurate information on storing products in warehouses of finished products and do not know which packages are ready for immediate dispatch and which are still to be handled. It requires the presence of workers handling the deliveries in the ERP system at all possible times of deliveries. The logistical documents can be prepared only after the completion of loading, which extends the time of realization of the delivery.

- The second approach is based on accurate records of stocks of finished products including individual storage locations, and plans the deliveries depending on which packages are ready and where these packages are. The employee then sees all packages that are ready for dispatch in the ERP system. He then creates individual deliveries based on the mode of transport and assigns the available packages to them, orders the transport and notifies the customer. This significantly decreases the time needed for the loading as such [4].

6. COMMUNICATION WITH THE CUSTOMER

Whether the transport is organized by the manufacturer or the customer, careful communication with the customer is always necessary. The customer must know that his goods are finished and ready for shipment and that the delivery can be scheduled. It is also necessary to inquire about the carrier (whether external or internal). Confirmation of the final scheduled delivery date is possible only after the transport is secured [5].

The above clearly indicates that the communication with the customer during scheduling of the delivery is very intense. The standard means of communication are phone or e-mail. This communication is mostly handled by a dedicated customer care department (Customer Service), because its nature is different from the ordinary mercantile activity and is therefore usually detached from it [6].

In an effort to optimize this process, businesses implement portals for customer communication. The customer portal activities fulfill these main tasks:

- Provide the customer with information about the ongoing production and readiness of his orders for delivery.

The customer can monitor the status of his orders online, also which of them are already ready for delivery. This eliminates or minimizes the communication with the Customer Service department and since all information is available online there are no typical time delays due to e-mail communication.

- Delivery scheduling tool.

The next step is to allow the customer to schedule the delivery itself based on the acquired information. The customer then can create delivery orders on packages that are ready in the warehouses of finished products. This order is then confirmed by the supplier. If the manufacturer organizes the transport of his products, he must also confirm the availability of transport and only then confirm the delivery date. The delivery is therefore created, ordered and confirmed without need for e-mail or telephone communication.
Providing documentation.

Another possible use of the customer portal is to print all the necessary logistical, financial and customs documents for the already delivered products. This eliminates the need to print them by the manufacturer or send them to the customer electronically by e-mail. Everything is in one place, transparent and ready to preview or print at any time.

Feedback, checks, reporting.

Because the customer portal contains all information about the warehouses of finished production and ongoing deliveries, the data should be used to obtain feedback on the quality of the provided service and the development of key logistics indicators. The managers can then monitor the development of delivery time, fulfillment of the promised deadlines or the length of time from the ordering of the delivery to its realization.

The customer portal can also be used to order products, or the customer can check the list of available products in supplier warehouses in case of production to stock.

7. CUSTOMER PORTAL AND ITS LINKS WITH OTHER ENTERPRISE SYSTEMS

The customer portal of course needs to draw data from other enterprise systems. It draws information regarding new orders entering into production from the ERP system, and the information on the delivery schedule goes back, if that is being created in the customer portal.

The planning APS system then provides data about the planned completion of orders, allowing customers to schedule deliveries in advance and to optimize their warehouse management or their own production.

The MES system then provides the current information on the state of production and finished products ready for delivery. In cases where the creation of an order and delivery takes place primarily in the MES system, the customer portal provides the delivery schedule (if one can be obtained from the ERP system).

The basic information flow then looks like in Figure 2:

![Figure 2 Interfaces with Customer Portal](image-url)

For the most up to date manufacturing companies such as in the automobile industry, where the Just In Time approach is being used for the management of logistics processes, this whole process is replaced by direct communication between the customer and supplier information systems (IS).

The production order is created in the end manufacturer's system based on demand on his side. It creates the need for the supply of specific materials or semi-finished products and the system itself sends these requests
to vendors' ISs and these return the exact date on which the material will be delivered. Based on this date, then the IS of the final manufacturers compiles a schedule of production and delivery to end customers. This approach is however very difficult to apply to traditional metallurgical sectors that are not able to achieve the accuracy of production in hours or days.

8. CONCLUSION

Modern management of the logistics and delivery process is not possible without close links to corporate MES, APS and ERP systems. Only by knowing the plan and production process and readiness of products in warehouses of finished products, can deliveries to customers be scheduled efficiently. Delivery scheduling takes place in close communication with the customer and it is therefore appropriate to also support this part of the process with an IT solution - in this case with the customer portal. Here the customer receives information about the readiness of his orders; he can schedule the deliveries and obtain logistics documents. The company management can then closely monitor the quality of customer service and the development of key logistics indicators.

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REFERENCE

OPTIMIZATION OF THE LOADING OF GOODS INTO THE CARGO COMPARTMENT OF A VEHICLE AS A DYNAMIC PROGRAMMING PROBLEM

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¹VSB - Technical University of Ostrava, Ostrava, Czech Republic, EU

Abstract

In managerial decision-making, we encounter situations that include simple or complex decisions. The company management often must take into account the sequence of decisions where each decision affects the next one. A tool used in solving these types of subsequent decision-making problems is called dynamic programming.

An integral part of logistics processes is also the loading of goods (products) into the cargo compartment of the vehicle and their shipment to the customer.

This article deals with optimizing the loading of goods into the limited cargo compartment of a vehicle in order to maximize the value of the cargo.

Keywords: Optimization, management, dynamic programming problem

1. INTRODUCTION

There is no simple model for solving dynamic programming problems. Therefore, these problems are classified into groups, each of which has a formulation and method of solution. However, the basic approach and the logic of solving all the problems of dynamic programming is the same. [1]

Dynamic programming can solve problems that can either be segmented into a sequence of decisions or that are composed of a series of small problems to start with. [2]

Analysis in dynamic programming is based on the Bellman's optimality principle, which says: “The optimal method has the property that whatever the initial state and initial decision are, any remaining decisions must create an optimal tactic given the state resulting from the decision.”

The understanding of the optimality principle is that if we start in a current stage, the optimal decision for the remaining stages depends only on the state in the current stage and not on the means that brought the system to this state (the optimal tactic is independent of decisions used in earlier stages). [3]

Unlike most other mathematical models for dynamic programming, there is no standard recursive relationship [4]. It is therefore not possible to use a generic calculation tool (e.g. the simplex method of linear programming). It is however possible to classify the problems of dynamic programming into "groups" and build a special calculation process for each of them [5]. Despite the fact that these groups differ in structure and calculation procedures, they use the general approach of dynamic programming. These groups are:

- Allocation problems - these problems are broken into smaller problems,
- Multi-periodic problems - are divided into two or more sections,
- Network problem - PERT and other networks may often be viewed as dynamic programming problems, and so resolved,
- Multiphase problems - these problems arise from situations in industrial production,
- Feedback problems - these problems typically occur in electronics, aerospace, automotive industry,
- Markov decision problems.

Keywords: Optimization, management, dynamic programming problem
2. **MATHEMATICAL DESCRIPTION OF DYNAMIC PROGRAMMING**

The relationship between the yield at each stage and optimal yield is the key to the process of dynamic programming. [6] The relationship of the individual yields is called a recursive relationship. For dynamic programming, it is important to write recursive relationships for each problem. When the equations are written down, we can perform the dynamic programming calculations. The recursive relationship tells us that the optimal yield in each stage for each of the states is determined as the value of the best option, with each option including the total immediate yield and optimal yield calculated in the previous stage [7].

**General description**

- \( n \) - index for the current stage indicates how many stages there are from the current state to the end of the problem,
- \( n-1 \) - previous stage,
- \( s_n \) - system state in the current stage to which the recursive relations relate,
- \( s_{n-1} \) - state in the previous stage,
- \( f_n(s_n) \) - total yield realized for each variation from state \( s_n \) in stage \( n \) to the end of the problem,
- \( f^*_n(s_n) \) - optimal total yield, best \( f_n(s_n) \) from state \( s_n \) in stage \( n \),
- \( f^*_{n-1}(s_{n-1}) \) - optimal yield obtained in the previous stage,
- \( r_n(s_n,d_n) \) - optimal yield realized in stage \( n \), when the decision \( d_n \) is made for the specific value \( s_n \) of the state variable,
- \( d_n \) - decision between variants made in stage \( n \) in the currently considered state.

The recursive relationship for state \( s \) in stage \( n \) is then:

\[
f_n(s_n) = \min d_n[r_n(s_n,d_n) + f^*_{n-1}(s_{n-1})]
\]  

Dynamic programming reduces a complex problem into a series of simpler problems. After the actual reduction, it is still necessary to solve the subproblems. The subproblems can be solved with methods such as:

- Calculation - in many cases very effective, because the number of possible solutions of subproblems is finite and small,
- Mathematical programming - in many cases the subproblems represent problems of linear or non-linear programming and can be solved as such,
- Sequential search - in some cases iterative procedures may be used in which the solution is improved step-wise.

3. **APPLICATION OF DYNAMIC PROGRAMMING TO THE PROBLEM OF STORING GOODS INTO A LIMITED SPACE**

We have 4 types of palettes of commodities with a limited delivery quantity for each of them. The weight and value of commodities are given in **Table 1**. Find which items and in what quantity they should be loaded into the compartment of a truck, if its maximum load is 11 tons and the goal is to maximize the value of the cargo.

**Table 1** Problem input data

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight [t]</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palette A</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Palette B</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Palette C</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Palette D</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>
3.1. Mathematical description

$n$ - stage under consideration,
$x_n$ - number of items of type $n$ to load,
$v_n$ - value of item of type $n$,
$w_n$ - weight of item of type $n$,
$K$ - maximum available capacity,
$s_n$ - state (remaining available weight) in stage $n$.

3.2. Formulation of dynamic programming

This problem belongs to the group of allocation problems.
Stage means any kind of item.
State is the remaining capacity available for allocation, i.e. states 0, 1, 2, 3 . . . 11.
At each stage, it is necessary to decide how many units of each item are to be incorporated into the optimal mix.
The following recursive relationship describes this problem:

$$f^*_n(s_n) = \min x_n[v_n x_n + f^*_{n-1}(s_n - w_n x_n)]$$

where,
$s_n$ - the remaining weight for allocation,
$v_n x_n$ - current yield,
$f^*_n(s_n)$ - optimal total yield in stage $n$ for state $s_n$,
$f^*_{n-1}(s_n - w_n x_n)$ - optimal yield in the previous stage.

Solutions will involve four stages, because there are 4 items.

Stage 1

Table 2 shows states on the left-hand side. On the top, there are the numbers of palette D that can be loaded.

<table>
<thead>
<tr>
<th>State $s_1$ tons suitable for allocation for palette D</th>
<th>$f^*_1(s_1) = v_1 x_1 = 20^*x_1$ (number of palette D to load - 3 tons each)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$x_1 = 0$</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>
Since the weight of palette D is 3 t, either 0, 1, 2 or 3 units may then be loaded. The table gives the yield calculated according to the formula specified in the table above.

Mathematical description of stage 1:
The yield function is given by the formula \( v_i x_i = 20^i x_i \), where \( x_i \) determines the number of units palette D. The column of optimal solution is expressed as \( f_1(s_i) = \text{maximum} (v_i x_i) \), where \( f_1(s_i) \) is the optimal yield starting from state \( s_i \) and using the optimal method from stage 1 to the end.

Stage 2
At this stage, palette C with the remaining weight are allocated based on the best procedure recommended in stage 1. Table 3 shows yields for different states. Total yields are \( f_2(s_3) = 30^i x^i + f_1(s_2 - 5x^i) \); and optimal yield is \( \text{max} f_1(s_2) \).

For instance in state 10, if 10 tons are available, the following 3 alternatives are possible:
- Zero to palette C, then 10 palette D. From Table 2 we can derive that the optimal allocation of 10 palette D gives a yield of 60,
- One to palette C leaves 5 tons. The best allocation of 5 (from state 1) gives 20 + 30 obtained from allocation 1 to palette C for a total yield of 50.
- One to palette D, two to palette C, takes 10 tons; that means, nothing is left. Therefore, the yield is 2*30 = 60.

Table 3 Stage 2. - palette C

<table>
<thead>
<tr>
<th>State ( s_i ) tons suitable for allocation of palette C and palette D</th>
<th>( f_2(s_2) = 30^i x^i + f_1(s_2 - 5x^i) ) (number of palette C, each 5 tons)</th>
<th>( f_2^*(s_2) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x_2 = 0 )</td>
<td>( x_2 = 1 )</td>
<td>( x_2 = 2 )</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>6</td>
<td>40</td>
<td>30</td>
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<tr>
<td>7</td>
<td>40</td>
<td>30</td>
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<tr>
<td>8</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>11</td>
<td>60</td>
<td>70</td>
</tr>
</tbody>
</table>

Stage 3
The results are listed in Table 4. The function of total yield is:

\[
f_3(s_3) = 25^i x^i + f_2^*(s_3 - 4x^i)
\]  

and \( f_3^*(s_3) = \text{max} f_3(s_3) \)
Table 4 Stage 3. - palette B

<table>
<thead>
<tr>
<th>State $s_3$ tons suitable for allocation of palette C, palette D and palette B</th>
<th>$f_{s_2} = 25x_3 + f^*_3(s_3 - 4x_3)$ (number of palette B, each 4 tons)</th>
<th>$f^*_3(s_3)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$x_3 = 0$</td>
<td>$x_3 = 1$</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>45</td>
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<tr>
<td>9</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>11</td>
<td>70</td>
<td>65</td>
</tr>
</tbody>
</table>

Stage 4

The results are listed in Table 5. The function of total yield is:

$$f_d(s_4) = 18x_4 + f^*_3(s_4 - 2x_4)$$

and $f_d(s_4) = \max f_d(s_4)$

Table 5 Stage 4. - palette A

<table>
<thead>
<tr>
<th>State $s_4$ tons suitable for allocation of palette C, palette D, palette B and palette A</th>
<th>$f_d(s_4) = 18x_4 + f^*_3(s_4 - 2x_4)$ (number of palette A, each 2 tons)</th>
<th>$f^*_d(s_4)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$x_4 = 0$</td>
<td>$x_4 = 1$</td>
</tr>
<tr>
<td>11</td>
<td>70</td>
<td>78</td>
</tr>
</tbody>
</table>

4. OPTIMAL SOLUTION

The initial state is $s_4 = 11$ and its solution is the solution of the whole problem. The optimal solution reads as $x_4 = 4$, i.e. 4 palettes A (weight 8 tons). The remaining $11 - 8 = 3$ tons are allocated in an optimum manner according to the 3rd stage (Table 4). Then $x_3 = 0$ and no palette B is loaded. The check then continues to stage 2 (Table 3). From table $x_2 = 0$, finally moving to stage 1. (Table 2). Optimal solution for 3 tons is $x_4 = 1$.

Therefore, the best solution is:

$x_4 = 4$ palettes A,

$x_1 = 1$ palette D.
Total yield is $18 \times 4 + 20 \times 1 = 92$.

5. CONCLUSION

The allocation problem has several variants. For instance, it may be required that at least one unit (or more than one unit) of each item shall be loaded. The goal may be to minimize costs. Additional restrictions can also be attached, such as limits of volume. Due to the special structure of dynamic programming it is difficult to design a standard computer program for it. Either a special program for every problem must be designed or an extremely large variety of options must be constructed.

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LOGISTICS MANAGEMENT AS A TOOL FOR OPTIMIZING LABOR COST

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Abstract

Permanent optimization of both process and also costs in all areas of activities is one of the fundamental goals of any company, whether it is in terms of competitiveness and achieving optimal results. Also, the management of logistics processes should lead to an increase in sustainable development and reducing costs of organization. This paper evaluates the interdependence of labour costs and logistics management. Specifically, the ratio of labour costs of warehouse employees and the number of manipulated volume of material and labour costs to the total volume of production. Evaluation of this interdependence is implemented for a period of five years, and during this time a new logistics tool Milk-run was implemented in terms of managing logistics processes.

Keywords: Logistics costs, labour costs, Milk-run

1. BINDING BETWEEN LOGISTICS AND COSTS

If the enterprise wants to be viable, it must also produce a profit, which they re-invest. Due to this fact it is possible to deduce a pattern of behaviour, it is the "\( \text{cost} = c + \text{profit} \)" which evaluates that costs are dependent parameter. From this it follows that for survival, organizations must reduce their costs so that they reach a maximum value of commodity prices. Group costs, which in this paper we deal with are those which relate to the logistics, thus labour costs and their dependence on the management of logistics processes.

1.1. Logistics

In the literature we can find a wide variety of definitions related to the concept of logistics. Briefly summarized, the logistics understands the movement of goods and materials from point of origin to point of consumption, sometimes to the point of disposal, and related information flow. The aim of such a flow is yet considered to satisfy customer requirements. Logistics covers all components of the circulatory process of transportation, inventory management, material handling, packaging, distribution and storage. It also includes communication, information and control systems. Logistics is a very broad field, which in many respects fundamentally affects the living standards of the company. In current, mature society we have become accustomed to the fact that logistics services operate flawlessly, and we perceive logistics at the moment of a problem. We can summarize that the main task of logistics is to ensure the right materials in the right place at the right time, in the required quality, with sufficient information and financial impact. Logistics is not only a part of the manufacturing sector, but also the service sector. [1]

1.2. Method Milk-run

During the development of logistics it gradually formed a logistics technology, which began to use in practice. Based on feedback occurs assessing the suitability of the technology for specific industries, because not all circumstances can be applied to the same logistics technology. Before application of certain technologies into practice the company must always be investigated a number of phenomena, such as the phenomena of production, economic etc. Currently the core logistics technologies are considered: Kanban, JIT, Milk-run, Quick Response, Efficient Consumer Response, Hub and Spoke Cross-docking, Concentration warehouse network, combined transportation, automatic identification, and computer integrated technology, training and management of production and circulation Communication technology [2].
That method Milk-run was for introduction into internal logistics, manufacturing companies of this case study assessed as optimum logistics technology. Origin methods Milk-run comes from England, where in essence consisted periodic collection of fresh milk from individual farmers to the dairy. Milk-run is a transportation concept with pre-established routes and regular waste collection intervals. This specific supply system is based on the circulation of packages. The consumer goods are transported filled packaging and from the consumer are collected emptied to refill. To trim material from the warehouse is under a prearranged schedule and plan routes. At precisely specified locations at the specified time of unloading the material and at the same time there is a loading empty transport boxes into the warehouse. [3]. When applying methods Milk-run is necessary to take into account several factors such as the location of the business in landscape, ordering materials warehouse, production hall layout, transport units, information system etc.

1.3. Optimisation of labour costs

If a company wants to be successful and competitive, it is essential to monitor the effectiveness and share their logistics costs to overall corporate performance. Cost management becomes very important task of each company. One of the most important business factors of production is a powerful work, i.e. Human energy and mental labour expended in the production of goods. Eligibility workforce to perform certain activities depends on physical constitution, talent, age, natural endowment, level of education and practical experience. Prices and this work are expressed by wage costs. [4]

Any change management, for which the organization chooses, it must precede the analysis useful for analysing the areas affected by the amendment. In our present study, which deals with the optimization of labour costs depending on the management of logistics processes organization, respectively optimization of wages after the introduction of Milk-run, it is necessary to identify and analyse the activities that are secured human resources. Optimization labour costs involve modifying these costs so that their spending has achieved the best effect as a contribution to the company. Costs are optimal when their spending is effective and is achieved through their highest potential returns and not as a waste of resources. If someone says optimizing labour costs, many people only think about mass redundancies. This of course is one of optimization methods, but not usually the right or appropriate. In organizations facing mass layoffs of employees created an unpleasant atmosphere, which is manifested by increased stress among employees. This fact certainly does not contribute to the proper functioning of an organization. For these reasons, this method is the least desirable and is approached with more cases of existential problems of the organization.

2. THE INTRODUCTION OF THE METHOD INTO PRACTICE AND ITS IMPLICATIONS

To evaluate outputs of the new system is needed to characterize the situation before the introduction of the system. Cost optimization is one of the key targets actions of each company. In here, the production company decided to locate and establish a system that leads to lower costs of internal logistics. One of the examples of inefficiency, thus wasting company resources, is the use of handling equipment and its subsequent optimization in context of wage costs compared with original state. Original condition, respectively the situation before the introduction of Milk-run company assessed through monitoring raids meter reading and distance travelled while ensuring transportation between warehouses and production halls causing futile invasions as well as repetitive driving routes and also inefficiencies in the utilization of material resources and manpower.

With applications of Milk-run system there is a need for a precise definition of the conditions in this case, the time and route. It is necessary to set exact times at which it is carried out regularly ride a course beforehand clearly defined and mapped out the route along which the transport of goods and materials carried on.
The production company has set itinerary of specifying the individual points of loading, where the ready goods and materials for production for the ride in Milk-run system, and the designation of places of distribution, i.e. individual points of factory buildings and production lines to which the material is distributed.

2.1. Monitored variables

In internal logistics, manufacturing companies are long-term monitoring the aggregate costs associated with primarily the use of forklifts. It is the cost of operation and maintenance, fuel costs, labour costs associated with operation of these trucks. Following the monitoring of all the company's values is also recorded and evaluated workload of each forklift and its operator, the need for warehouse management and manufacturing needs of the company. This way summary of Weights on values such as total fuel consumption, total labour costs, etc. is summarized. In order to ensure the long-term objective evaluation, there is a comparison of wage costs; it means total number of manipulations, i.e. number of intake and output in within warehouse management, and also to compare with the total volume of production of manufacturing companies.

2.2. Evaluation of the monitored values

The company decided to introduce a Milk-run system for internal logistics at the beginning of the year 2013. In 2013 began trial operation of production supply using the method of Milk-run. All the values before and after the introduction of Milk-run, during the reporting period from 2011 to 2015, are summarized in Table 1, where you can see how it develops the wage cost in comparison with the total number of operations (number of intake and exit), and total company production in weight measurement units. The organization monitors expenses in the full range of staffing warehouse management. The table shows a breakdown of handling workers, from the number of hours worked, wage costs and technical personnel and economic costs associated with their activities.

Table 1 Summary comparison of labor costs to the total number of operations and total production [own processing]

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of manipulates</td>
<td>12</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Number of hours [h]</td>
<td>17 882</td>
<td>17 002</td>
<td>17 113</td>
<td>17 614</td>
<td>15 772</td>
</tr>
<tr>
<td>Of the mandated overtime [pm]</td>
<td>1 602</td>
<td>1 665</td>
<td>1 011</td>
<td>814</td>
<td>819</td>
</tr>
<tr>
<td>The number of hours worked by temporary workers [pm]</td>
<td>572</td>
<td>1 810</td>
<td>1 495</td>
<td>1 060</td>
<td>358</td>
</tr>
<tr>
<td>The total number of hours [h]</td>
<td>18 454</td>
<td>18 812</td>
<td>18 608</td>
<td>18 674</td>
<td>18 172</td>
</tr>
<tr>
<td>The operator labour costs [CZK]</td>
<td>3 160</td>
<td>3 176 282</td>
<td>3 005 832</td>
<td>2 624 292</td>
<td>2 541 748</td>
</tr>
<tr>
<td>Wage costs of temporary workers [CZK]</td>
<td>42 900</td>
<td>135 731</td>
<td>127 075</td>
<td>73 920</td>
<td>53 661</td>
</tr>
<tr>
<td>Number of MET</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Number of working hours [h]</td>
<td>4812</td>
<td>4476</td>
<td>4212 . 75</td>
<td>4396</td>
<td>4134</td>
</tr>
<tr>
<td>Of the overtime [pm]</td>
<td>131.25</td>
<td>711</td>
<td>191</td>
<td>250</td>
<td>279</td>
</tr>
<tr>
<td>THP labour costs [CZK]</td>
<td>1 133</td>
<td>1 133</td>
<td>1 272 625</td>
<td>1 092 835</td>
<td>799 655</td>
</tr>
<tr>
<td>Total labour costs of the warehouse [CZK]</td>
<td>4 293</td>
<td>4 448 907</td>
<td>4 098 667</td>
<td>3 423 947</td>
<td>3 269 500</td>
</tr>
<tr>
<td>Total intake and output (number of manipulations)</td>
<td>N / A</td>
<td>65 269</td>
<td>58 492</td>
<td>60 335</td>
<td>55 923</td>
</tr>
<tr>
<td>Converted price for a handling [CZK / manipulation]</td>
<td>N / A</td>
<td>68.16</td>
<td>70.07</td>
<td>56.75</td>
<td>58.46</td>
</tr>
<tr>
<td>Company production [t]</td>
<td>N / A</td>
<td>29 455</td>
<td>25 661</td>
<td>25 969</td>
<td>25 086</td>
</tr>
<tr>
<td>Price per tonne produced to manipulate [CZK / t]</td>
<td>N / A</td>
<td>0.1510</td>
<td>0.1597</td>
<td>0.1318</td>
<td>0.1303</td>
</tr>
<tr>
<td>YoY difference [CZK]</td>
<td>N / A</td>
<td>155 091</td>
<td>-350 240</td>
<td>-674 720</td>
<td>-154 447</td>
</tr>
</tbody>
</table>
From the table above it is apparent some facts related to the introduction of the Milk-run organization. As the primary can be seen the long-term trend of decreasing total wage costs of running the store, as well as trend of lowered volumes mandated overtime. The table also captures the wage cost per transaction handling and also the wage cost per ton was produced by. In these cases we can also observe a positive trend of cost reduction. The last line of the table then shows the evolution of the annual total wage costs of running the store, therefore, since the introduction of logistics management methods Milk-run occurred, there are savings of more than 1 mil CZK.

To the total amount of the wage costs of maintaining a warehouse is to be noted that while downsizing, they also contain severance pay for employees with whom employment contracts have been terminated and despite this fact shows that the method implementation Milk-run is in this case, the step in the right and led to the actual financial savings organization.

3. CONCLUSION

The primary feature of the optimal management of logistic processes is to ensure the right materials in the right place at the right time, in the required quality, with sufficient information and financial impact. The financial impact is in this case meant optimal and higher costs associated with all activities of logistics. The aim of the investigation, which describes the article, was to evaluate the economic aspects of the introduction of Milk-run into internal logistics, manufacturing companies, and in the area of labour costs.

To evaluate the economic aspects of these occurred during the follow-up of wage costs to the total number of transactions executed in warehouse management and the total volume of production in manufacturing companies. With this monitoring, it was found that the application of the method Milk-run, in the long term is to reduce the reduction of the sum of wage costs of providing warehousing activities, reduction of mandated overtime, then being reduced annualized rates for handling both related to the number of manipulated items, and also the total volume of production organization. It can be assessed that the implementation of the Milk-run in this organization was a right move and lead to real cost savings.

ACKNOWLEDGEMENTS

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REFERENCES

MOTIVATION OF SALES REPRESENTATIVES

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Abstract

The paper focuses on one important human element of logistic chains - sales representatives. Their position does not enable instant control and leadership of their supervisors such as in office positions, nor is such supervision desirable for ambitious sales representatives who prefer a certain level of autonomy. For their managers, it is necessary to find goal-oriented but still strongly encouraging motivation tools. This paper presents the specifics of the work of sales representatives and based on these it recommends the most effective and up-to-date motivation techniques.

Keywords: Motivation tools, performance, sales representative

1. INTRODUCTION

Every business needs to attract and retain employees with the skills and experience that meet the requirements of specific jobs. The scopes of positions are different; so the competence demands on the people who fill them differ as well. While an accountant should be mainly careful and patient, a sales representative should excel in communication and persuasion skills.

The sales representative is an essential element of logistic flows, because he finds and negotiates new contracts. His abilities predetermine the amounts and conditions under which the company will supply its products or services to the customer. The performance of sales representatives is not determined only by his abilities. The extent to which he will use them can be influenced by the enterprise and, by extension the manager sets incentives.

The position of a sales representative has many specifics that require a targeted motivational strategy. Its aim must be to attract and retain experienced sales representatives in the enterprise.

The authors' own survey among managers of successful sales representatives and experiences from case studies [1] show that even if each enterprise has its own motivational tools, the most effective are the same, or new ones are added following new trends.

The article aims to present the specifics of the work of the sales force, and subsequently define the best current motivational techniques to promote the job performance of sales representatives.

2. MOTIVATION FOR WORK PERFORMANCE

For an enterprise to be successful, the managers must focus sufficient attention on the motivation of employees, which has a direct impact on their work performance [2]. The work performance can be defined as a result of work at a certain time and under certain conditions. The performance itself, i.e. achieving a certain level of completion of the assigned task, is influenced by many factors, in particular the management style of managers or working conditions, such as e.g. temperature, noise or the lighting of the workplace. Work motivation is the intensity of the relationship of the individual to his work based on the degree of satisfaction of his needs. There are two types of work motivation - internal and external. Internal motivational factors include the principles, ideals, attitudes, beliefs, values and value orientation and whether the work itself, its content, more or less satisfies the worker. External motivations represent the valuation of work by the enterprise,
whether financial or non-financial. The motivation to do most activities including work is a combination of both. [3]

Motivation for work performance should fall mostly within the competence of line managers, because they are in closer contact with their subordinates than the personnel department or senior management. Especially in the area of non-financial incentives, the individualized targeted approach can support the work performance of subordinates. Another reason is that thanks to their proximity to their subordinates they can create exactly the conditions for them that allow them to give their best work performance.

3. SPECIFICS OF SALES REPRESENTATIVES' WORK

Sales representatives are the essential link in the supply chains of most industrial enterprises. They actively seek out new customers and negotiate sales of the production for the enterprise. Simply put, they deliver information about what, to what extent and for whom the enterprise is required to produce. Their job is thus sales of enterprise products and services. Their main strengths must include confidence, communication skills, especially the ability to convince a broad spectrum of customers about the benefits of the product and negotiate mutually acceptable terms of sale with them. More than the level of education and acquired expertise, the success of the sales representative is determined by his approach to people, selling skills and experience. The knowledge that they must also possess is related to the company itself, its production, technological processes and in particular the characteristics of the product itself.

The main tasks of the sales representative include [4, 5]:

- Planning of personal visits to existing and potential customers.
- Maintaining personal or telephone contact with customers.
- Maximum responsiveness to customer needs.
- Preparation and implementation of presentations promoting new products or special sales events.
- Advising customers regarding the delivery and subsequent services.
- Negotiations and agreements with customers about orders, prices, delivery terms and forms of payments.
- Records of orders and communication with the sales and production department.
- Monitoring of competition and their conditions of sale.
- Visiting conferences and seminars on trends in the sphere of action.
- Reporting on utilization of trends to employer.
- Reporting on the fulfillment of sales targets to employer etc.

The sales representatives work relatively independently, they themselves organize their working time and meetings with clients. Supervision of their way of working with customers is not possible, as is usual with subordinates that work within the company. Therefore task assignments, the monitoring of their fulfillment and motivational measures have to be set in a specific manner.

4. MOTIVATION TOOLS FOR SALES REPRESENTATIVES

The most important prerequisite for top performance of sales representatives, that their employer can ensure, is their motivation. Their work is mentally challenging, even frustrating, and their efforts are often met with the dismissive reactions of potential clients; but they must always be ready to responsibly approach the next client again with a smile. To treat all clients equally assiduously or even adamantly can be ensured only through a vision of attractive rewards or other motivational measures that are important to them, as explained by the still valid Vroom's expectation theory [6].
These mostly individually operating employees need a strong internal motivation, which that is represented by meeting the goals and the related success rate. However, their superior should support them further by promoting measures that will motivate them also from the outside; otherwise they may choose another employer who is more attentive in this regard.

Based on the polling of sales representatives’ managers of five production and two sales enterprises, and based on case studies and expert advice from Internet sources, the following measures have been proposed which have the maximum effect on the motivation of sales representatives:

Leadership style

Some managers choose the approach "Do not interfere where everything works". This is a better approach than the micromangement style, where the frequent checking, questioning and constant advice and recommendations of the manager rather hamper the performance of the sales representative and de-motivate him. However, according to a study by Aberdeen [1] an adequate manager's interest about their work, accepted by the subordinates, is considered a contribution by both sides. A capable manager will learn the best sales techniques from his best sales representatives so that he can teach other, maybe less successful sales representatives. From less successful sales representatives, the manager will then systematically detect obstacles in performance, which he may help to remove by virtue of his position. [1]

The top managers should become an example for their subordinates, especially in activities that are essential for their performance and which are thus required from them. They should demonstrate and regularly support behavior such as an honest and open approach in front of them. For internally motivated sales representatives, the positive interest of the manager about their performance and work style is the prerequisite of effectiveness of other motivational techniques.

Transparent system of rewards

Sales representatives are motivated by performance based rewards, not only for the money itself, but also with regard to their rather ambitious nature. If the rewards are not directly proportional to the performance e.g. negotiated orders, perhaps because of hidden, unclear or even changing shared costs, (e.g. sales support), the sales representatives will not be nearly as motivated and will eventually move to competitors that can offer easily calculated, directly proportional to performance and therefore more motivating rewards for performance. Besides, an employer with a transparent system of rewards always appears more trustworthy. However, if it is necessary to include any costs or rank the orders by a certain difficulty factor, it pays if the companies invest in software which, after entering the potential sales performance, calculates the reward in advance so that they know why they should strive. [7]

Managers should not forget about different working conditions of their sales representatives for negotiations with potential clients, for example when it comes to various regions of their performance [8]. Previous researches confirmed that capital city is by far the most interesting place for the location of enterprise head offices and other regions host enterprise affiliates with mostly marginal or auxiliary functions [8]. Therefore it is usually easier to make a contract for representatives in richer regions than for their colleagues in poorer ones. Nevertheless, companies need to keep clients in those regions too not to give a competitor chance to grow and expand from there to other regions too. Managers need to motivate representatives to stay and negotiate in poorer regions, for example by some coefficients to standard remuneration otherwise they will move to regions with easier earnings.

Non-financial rewards

Financial motivation on its own may not be enough. For example, during a difficult sales period or with a very stressful contract (but of course even in periods with plenty of sales) the managers may support their
subordinates by recognition announced within the company, by regular citing the best sales representatives on public information panels or on the intranet, as important employees who contribute to the enterprise objectives. Just as no one wants to be on the bottom line of corporate boards of sales representatives’ productivity, all watch with the same intensity by how many points they are missing the top rungs, usually associated with some form of reward. Such activities further strengthen the cohesion and loyalty of employees with the company [9]. It is also necessary to continuously determine what the desirable and motivating offered prices and forms of rewards between different sales representatives and whether these are not just only inefficiently expended corporate means. Each member of the team is a unique personality, some are motivated by recognition by a senior manager, and others will appreciate a day off for time with family.

**Autonomy**

Capable sales representatives like to have a certain degree of autonomy, or room for choosing their own sales techniques, to ensure that they give their best performance. Their manager should define their objectives and generally applicable conditions of sale. He should provide support and advice only if explicitly requested by the sales representatives.

**Technological support of sales**

Administration is a part of almost every position, including sales representatives. In order to have more room for the negotiations with the clients themselves, sales representatives must spend less time filling out numerous forms and doing lengthy searches for new contacts and the necessary information about them. Today, every sales representative should have a notebook with a high-quality Internet connection, smart mobile devices and possibly a printer, if he needs to conclude written contracts. A well-structured online marketing platform for enterprise product or about the conditions of purchase and delivery, which the sales representative can refer to when getting a client, could provide significant support for the sales representative's work. The larger part of a laboriously organized appointment can then be used for persuasion about the sale itself. [7]

**Games**

Capable sales representatives are endowed with competitiveness. The managers' experience indicates that announcing contests improves their performance. According to a survey by the Aberdeen Group, companies that use employee competitions increase their commitment by up to 48% [1]. The market offers a plethora of proven online applications that aim to motivate and excite the sales representative to even higher performance [10]. To be able to use them, the sales representatives must be equipped with the necessary above-mentioned smart devices.

5. **CONCLUSION**

Sales representatives are an important part of logistical chains because the company's sales volumes largely depend directly on their job performance. Therefore special attention must be given to their motivation, because only properly motivated employees deliver maximum performance and do not look for employment elsewhere. The sales representatives are a very specific workforce in many aspects. Polling in companies that rely on selling skills of employees in the field, and experience from many surveys and case studies on the Internet confirm that extraordinary abilities require extraordinary incentives and support measures to support the work of sales representatives.

Effective and targeted coaching by managers is the basis for targeted financial and non-financial incentives. The experienced sales representatives deem modern sales support technology and the necessary level of independence the essential platform of an enthusiastic work performance. The congenital competitiveness of
sales representatives again invites to implement various forms of contests for both material and non-material prizes. Disclosure of the rank of performance which fuels the desire of sales representatives to get "in front" of their colleagues is highly recommended. This tool is also much cheaper than competitions for material prizes. In the Czech Republic, it is not used nearly as often as in the USA, which stems from our mentality that considers the American public "boasting" a negative trait. Nonetheless, foreign companies increasingly also publish the sales representatives' rank in their Czech branches. Their popularity and mostly positive influence on sales helps their gradual introduction in various forms (e.g. on the corporate intranet or at regular meetings of sales representative teams) also in the Czech businesses.

Above-average sales skills must be matched by a corresponding reward for their work and other incentives. A financial reward must be the same for all, clearly defined (i.e. easily calculated) and should not contain unclear items in which the sales representative does not know how to influence them with his performance.

The motivational tools mentioned in the article are currently among the most efficient, and therefore the managers of the sales teams use them extensively in different variations to strengthen the work performance of their sales representatives. However, trends due to changes in technology and the mentality of buyers cannot escape even this area, so new motivational techniques are still being discovered, with benefits replacing the original ones. Therefore, managers should not be "complacent", and should follow these trends constantly, evaluate them and, if they are in compliance with the company goals, should utilize them among their sales representatives to keep pace with the competition.

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INNOVATION ACTIVITIES OF INDUSTRIAL ENTERPRISES AND THEIR IMPACT ON COMPETITIVENESS

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Abstract
In today’s busy world, industrial enterprises are trying to innovate not to lose their competitive advantage and to match the competition. The global environment makes constant innovation an imperative. Industrial enterprises are trying to innovate their products, processes or business strategy, which entail high costs. This paper explores the innovative activities of industrial enterprises, the costs associated with the introduction of these innovations and looks at the brand new innovative direction of the German economy in the industry.

Keywords: Innovation, competitiveness, costs, industry

1. INTRODUCTION
Enterprises that are trying to maintain and consolidate their market position should implement an appropriate innovation policy that would allow them to achieve a more favorable position compared to the competition. This competitive advantage may have the character of an offer in the form of an array of improved products that better meet the needs and desires of customers or it may consist of cheaper production methods, i.e. innovations. Innovation is the culmination of a whole series of scientific, technical, organizational, financial and commercial activities, and together they make up the innovation process which consists of the inventive and the innovative phase. The innovations are preceded by certain activities, for example inventions, rationalization proposals, projects or industrial designs. These activities leading to changes in management structure are called inventions. Not all of these activities will also see realization. Some remain unfinished, others are meant to serve only the development of science and knowledge. We can call innovations only those results of scientific, research and development activities, which will also benefit realization. [1] The article analyzes the innovation activities in the Czech Republic in recent years, investments in technological and non-technological innovations, and demonstrates the growing importance of information and communication technologies.

2. INNOVATIONS
In the current globalized market, innovations from the aspect of an enterprise represent a core element for its further development and increased competitiveness. Innovation is closely associated with research and development (R&D), which provides the basis for the creation and implementation of innovations. The high costs and risks associated with the introduction of innovations mean that enterprises often invest less funding in innovation than is socially desirable. In this context, the Czech government has prepared a strategic document, "National Innovation Strategy of the Czech Republic 2012-2020", which focuses on innovation activities of enterprises in the country. [2]

The need for innovations occurs when the current medium-term or long-term plan does not achieve the desired enterprise objectives and sustain competitive advantage. Any innovation should contribute to the advantage of the strengths of the enterprise and to eliminate business risks. Innovations can be divided into four categories.
2.1. Innovations in production and services

Innovations in production and services represent the introduction of goods and services that are new or significantly improved with respect to the characteristics of their potentially intended use. This includes significant improvements in technical specifications, components and materials, software, user friendliness or other functional characteristics. [3, 4]

2.2. Innovations in the business processes

Innovations in business (technological) processes reflect the implementation of new or significantly improved methods of production or supply relationships, they may involve significant changes in techniques, equipment and software. [3]

2.3. Organizational innovations

Innovations of an organizational nature reflect the introduction of new organizational methods in business practices, including the design of the new arrangement of the workplace. [3]

2.4. Marketing innovations

Marketing innovation is the introduction of a new marketing method not previously used by the enterprise and which is part of a new marketing strategy. It could mean a significant change in the design of the product in its packaging, product placement on the market through new sales channels, essentially changed product promotion using tools of the communication mix, new pricing strategy, etc. [1]

Experience shows that it is possible to successfully innovate in the traditional way, where the business or marketing department prepares the task, the development drafts the concept, the designers draw drawings and the process bills of material, and technologists draw the technological procedures and write the NC programs. At the end of the chain the result full of compromises horrifies not only the production workers but also merchants and consumers. The entire process marketing - product development - training - production ramp up must take place in a common multi-profession team and in parallel. This approach allows creating output with much higher quality in less time, says Ján Košturiak of the company IPA.

3. INNOVATION ACTIVITIES

According to the broader concept of innovation as described in the Oslo manual (OECD, 2005), there are four main types of innovations: product, process, marketing and organizational. Product and process innovation are together called technological innovations because they are closely associated with technology. On the other hand, marketing and organizational innovations are among the non-technological innovations.

3.1. Enterprises with innovation activities

To collect data on innovation activities of enterprises, the Eurostat harmonized model questionnaire was used for a uniform survey on Innovation CIS 2014 (Community Innovation Survey 2014) for the reference period 2012 - 2014. The following text is based on a series of tables and charts, which are based on CSO statistical surveys from 2014.

The most Intensive innovators are large enterprises with more than 250 employees. During 2012 - 2014, up to 77.2 % were innovating. From the perspective of business ownership, more foreign owned companies innovated - 53.7% rather than domestic enterprises - 39%, see Figure 1. The most innovative sector of the manufacturing industry was the manufacture of other transport vehicles and equipment, with 74 4% of innovative enterprises. [2]
Figure 1 Share of innovative enterprises in the total number of companies in a group according to the type of innovation activities [2]

Within their innovation activities, the enterprises engage in intensive technological innovation rather than non-technological innovation, see Table 1.

Table 1 Innovation activities of enterprises by type of innovation [2]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovating enterprises total</td>
<td>51.7%</td>
<td>43.9%</td>
<td>42.0%</td>
</tr>
<tr>
<td>Enterprises with technological innovation</td>
<td>34.8%</td>
<td>35.6%</td>
<td>35.7%</td>
</tr>
<tr>
<td>Enterprises with product innovation</td>
<td>9.5%</td>
<td>8.8%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Enterprises with process innovation</td>
<td>8.2%</td>
<td>7.5%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Enterprises with product and process innovation</td>
<td>14.7%</td>
<td>16.5%</td>
<td>14.6%</td>
</tr>
<tr>
<td>Enterprises with unfinished or stopped technological innovations</td>
<td>2.4%</td>
<td>2.8%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Enterprises with non-technological innovation</td>
<td>42.4%</td>
<td>31.6%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Enterprises with marketing innovation</td>
<td>11.5%</td>
<td>11.2%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Enterprises with organizational innovation</td>
<td>12.8%</td>
<td>9.2%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Enterprises with marketing and organizational innovation</td>
<td>18.1%</td>
<td>11.2%</td>
<td>10.4%</td>
</tr>
</tbody>
</table>

The largest share of enterprises engaged simultaneously both in the technological and non-technological innovations.

3.2. Costs on technological innovations

In 2014, the investments of enterprises in introducing innovations of products and processes were 131 billion CZK. This is the highest recorded rate of enterprise investment in technological innovation for the whole monitored period of innovation activities. The highest share of costs of technological innovations is attributable to investments in the acquisition of machinery, equipment, software and buildings. In 2014, the total enterprise investment related to technological innovations in the acquisition of equipment, software and buildings was 65 billion CZK, which is 49.9% of all costs on technological innovations. The aggregate enterprise costs on research and development was 53.5 billion CZK, of which on internal R&D 31.2 billion CZK, see Figure 2. [2]
The total cost for innovation activities related to technological innovations in 2014 amounted to 130.9 billion CZK. More than two thirds of this amount was invested by large enterprises - 86.6 billion CZK. Big companies embody one of the most important actors of local and regional development. The amount spent on technological innovation by medium-sized enterprises was 30.2 billion CZK. The investment of small businesses in technological innovation was 13.8 billion CZK. The investments of technologically innovating foreign affiliates in introducing innovations were almost double - 85.7 billion CZK that of the Czech enterprises - 44.9 billion CZK.

4. NEW ECONOMICS

The importance of information and communication technologies is growing and in many cases the value of companies dealing with ICT technologies is skyrocketing. Talk about the "new economy" has started, which will be based on the development of this segment. Considering the substantial dependence of the Czech economy on the economic development in Germany, it is useful to take a closer look at the strategic goals of that country which showcases the continued development of the industry as the "Industrie 4.0".

The first industrial revolution brought mankind the steam engine and the first production machines driven by steam. The second industrial revolution is associated with the introduction of production lines and the expansion of the division of labor. The third industrial revolution introduced automation of production. The forthcoming fourth industrial revolution is based on the principle of automating everything that can be automated, linking not only production but also logistical and distribution systems, while ensuring high flexibility together with integrity. In this context we refer to several aspects of integration, so called horizontal and vertical. The horizontal integration represents very flexible production units involving both production networks inside the company as well as their links within the value chain, i.e. between the enterprises and in relation to the customers. The preconditions for mutual communication are single, common platforms. The vertical integration are the production equipment, machinery, material handling equipment and other production elements involved in the production network, communicating with each other. These are not autonomous, albeit automated workplaces, but integrated manufacturing systems.
For the Czech Republic, with its character close to Germany, the above-mentioned German economic goals call for at least thinking about what direction the economy will take.

5. **CONCLUSION**

The enterprises must increasingly realize that product or service innovation, process innovation, organizational innovation or marketing innovation are the key in the tough competitive environment. The ability to improve the internal environment and engaging in appropriate forms of cooperation often determines the level of competitiveness of the organization. In 2014, the innovating enterprises invested into their product and process innovation the most since 2008. Half of the funds went to the acquisition of buildings, machinery, equipment and software. "Enterprises spent 31.2 billion CZK on R&D in relation to innovations. 22.3 billion was then spent on research and development services from other operators", said Iva Ritschelová, President of CSO. Overall in 2014, enterprises invested 2.4% of revenue in the development of their innovations.

To keep up with the leaders in the industry and to meet the needs of customers, we must spend large enough capital on innovation activities. This capital can be our own or foreign, but it is important to invest it efficiently and continue to seek funding for further development. Improvement of products or business processes can be achieved relatively inexpensively, through cooperation of enterprises with academia. Enterprises usually cooperate with a partner from the Czech Republic on the introduction of technological innovations, when the development of product innovation takes place mostly within the enterprise and only a few companies cooperate with a university or research organization. Up to November 11 of this year, a survey is running on cooperation between higher education institutions and the application sphere. The goal of this survey is to map the current situation and to help formulate measures to promote mutual cooperation. In the area of financing of enterprise development, the long-term programs to support innovative activities from the European Union also play a significant role. Today, innovation is an undisputed part of modern society and an essential prerequisite for long-term competitiveness, whether of individual companies, regions or countries.

**ACKNOWLEDGEMENTS**

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**REFERENCES**

ANAALSIS OF REALIZATION OF PUBLIC TRANSPORT BETWEEN KATOWICE CITY AND PYSKOWICE TOWN IN THE SILESIAN AGGLOMERATION USING BUSES OF THE KZK GOP COMPANY

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Abstract

The organization of public transport is an important element of a sustainable transport policy in the region. This is particularly relevant and important to the organization of transport in areas with a high degree of urbanization, for example Silesian Agglomeration. The article presents an analysis of connections organized by KZK GOP on the route allowing access from Katowice city to one of the smaller towns (Pyskowice) located in the Silesian Agglomeration.

Keywords: The Silesian Agglomeration, sustainable transport, public transport, bus transport, KZK GOP, Katowice & Pyskowice bus connections

1. INTRODUCTION

Due to numerous of factors: historical, political and technical The Silesian Province is one of the most densely populated and urbanized areas of Poland. Silesian province is an area which is rich in deposits, mainly coal, as well as an area with well-developed industrial infrastructure and transport. As a result, the Silesian province is an area in which instead of one specific center was established a few core centers. Of course there is one main center which is Katowice city, it is also capitol of the province, but there are few neighbor cities with very common infrastructure (social, industrial etc.). As a result, in the Silesian province is well-developed transport network, and the people to carry out daily trips (related to school, work, leisure, etc.) very often have to move around a large area of the region. Importantly, a significant part of the population does not live in the same big city (eg. in Katowice, or immediately adjacent to cities), but due to less noise, air pollution, etc., in the smaller neighboring towns. These people expect a well-organized and efficient transport system. This expectation is also consistent with the principles of sustainable transport by which should be strived to increase the share of public transport in the implementation of daily trips [1, 25]. One of the most important elements of transport system is timetable of available means of transport. Creating a proper timetable is very difficult and complicated task [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 24,]. Very often it requires to use some simplified methods [11] or computer support [2, 7]. When the timetable is done and I use it is very important to analyze them in order to check whether they fulfill the expectations of travelers.

This is especially important in the implementation of travel to or from further afield from the center of the region of small towns, which include, among others, Pyskowice town.

Public transport system in the Silesian Province agglomeration (in its central part) is carried out by several operators with different legal status (company, association of municipalities, etc.) in different modes of transport. The entity implementing the majority of bus transport within the Katowice conurbation is a KZK GOP company, which according to the data provided by them supports an area of 1.7 thousand km², which is inhabited by almost 2 million people [26]. KZK GOP also organizes public transport between Katowice city and Pyskowice town.
2. PYSKOWICE TOWN

Pyskowice is one of the oldest towns of Upper Silesia [28]. The town is located in south-western Poland, in the western part of Silesia, and Upper Silesian Industrial Region (GOP), in the northern part of the district of Gliwice Katowice Upland, on the Drama river. Historically it lies in Upper Silesia and is directly adjacent to the city of Gliwice and municipalities: Rudziniec, Toszek, Wielowieś (district of Gliwice) and Zbrosławice (district tarnogórski). [27]

According to the data of the Pyskowice municipal office area of the municipality is 3 114 [ha], of which 1 693 [ha] are covered by buildings of a city. The population as of 31 December of 2015 amounts to 17205 people, including: 2722 from age 0 to 17, 11771 from age 18 to 64 and 2712 with age over 64 [28]. The town is located in the west-northern part of the KZK GOP activity.

The most important aim of the trip from Katowice to Pyskowice is necessary to use the minimum of 2 buses, between which you have to change in the center of Gliwice.

Travel from Katowice to Pyskowice is possible with the use of several different connections, but the carrier on their website, using the search engine, suggests to take bus number 6, 840 or 870 to Gliwice, then change to a bus 677 in the direction of Pyskowice;

A very important element of those connections is place to make the changes of the means of transport. When we plan to use connection with bus line 6 to bus line 677 we should change bus at Gliwice Dworzec PKP bus station, and for connections with bus lines 840 or 870 to bus line 677 we should change the bus at Gliwice Plac Piastów bus station. Both stops are located in the center of Gliwice, and the transition between them takes about 4 minutes, but on these relationships, in contrast to the relationships Pyskowice - Katowice, there is no need to change the bus stop to continue the journey.

3. RESEARCH METHODOLOGY

As part of the study were analyzed the plates of bus routes, bus trips and web applications provided by KZK GOP, whose task is the ability to search a connections. Studies presented below are an extension of the research described in [12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23] of the connections made to other popular in the region of connections relationship. The following article describes the number of connections and the transfer time for the line No. 677 from Gliwice to Pyskowice aim of switching from KZK GOP lines that allow access from Katowice to Gliwice.

The studies were obtained times of departures of line KZK GOP 677 from the bus stop Gliwice Dworzec PKP (for relations with KZK GOP buses line number 840 & 870), departures times of line KZK GOP 677 from the bus stop Gliwice Plac Piastów (for relations with KZK GOP buses line number 6) and arrival times on bus stops buses coming from Katowice to Gliwice (KZK GOP bus lines 6, 840 & 870).

The following Tables 1 to 3 presents a comparison of the departure time of the bus line KZK GOP 677 with arrival times of buses KZK GOP lines 870, 840 and 6. In Tables 1 to 3, blue color indicated waiting time between connections amounting to more than 30 minutes, while red indicated time expectation equal to 5 minutes or less - it is a short waiting time, for which there is a high risk of being late for buses going in Pyskowice direction due to the delay in the timetable of the first bus (for interchange on the line 677). Purple color indicated a situation in which a bus in the direction of Pyskowice departs just before the arrival of the bus from Katowice.
### Table 1 Analysis of the waiting time between KZK GOP 6 & KZK GOP 677

<table>
<thead>
<tr>
<th>Arrival of KZK GOP 6 on bus stop Gliwice Dworzec PKP</th>
<th>Departure of KZK GOP 677 from bus stop Gliwice Dworzec PKP</th>
<th>Waiting time [min]</th>
<th>Arrival of KZK GOP 6 on bus stop Gliwice Dworzec PKP</th>
<th>Departure of KZK GOP 677 from bus stop Gliwice Dworzec PKP</th>
<th>Waiting time [min]</th>
<th>Arrival of KZK GOP 6 on bus stop Gliwice Dworzec PKP</th>
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<th>Waiting time [min]</th>
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### Table 2 Analysis of the waiting time between KZK GOP 840 & KZK GOP 677

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Table 3 Analysis of the waiting time between KZK GOP 870 & KZK GOP 677

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<th>Departure of KZK GOP 677 from bus stop Gliwice Plac Piastów</th>
<th>Waiting time [min]</th>
<th>Arrival of KZK GOP 870 on bus stop Gliwice Plac Piastów</th>
<th>Departure of KZK GOP 677 from bus stop Gliwice Plac Piastów</th>
<th>Waiting time [min]</th>
<th>Arrival of KZK GOP 870 on bus stop Gliwice Plac Piastów</th>
<th>Departure of KZK GOP 677 from bus stop Gliwice Plac Piastów</th>
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The above data on the possible number of transfers apply to all possible connections, but how it is presented in Tables 1 to 3, buses going from Katowice to Gliwice run more frequently than buses from Gliwice to Pyskowice, which means, that passengers do not benefit a large number of connections, because they choose earlier connection to continue their journey.

The information contained in Tables 1 to 3 relating to waiting times and the number of connections, together with their percentage share in relation to the timetable of the bus line KZK GOP 677 is shown in Figure 1, these data also include connections that require long waiting time, which probably would not be used by the passengers to continue a journey on this relationship.

Figure 1 The percentage of connections, waiting times and the number of connections to KZK GOP 677 from the other lines which drive from the center of Katowice.
Source: Own calculations based on Tables 1+3
Also very important is the difference during a trip undertaken using public transport and individual transport (car). Travel by public transport takes about 1 hour 30 minutes to almost 2 hours, by individual transport the same route is carried in a period of about 50 minutes.

Figure 2 shows the number of connections and the waiting times to change buses between the line KZK GOP No. 677, and line KZK GOP No. 6 which drive from the center of Katowice and change is made on Gliwice Dworzec PKP bus stop, and between the line KZK GOP 677, and lines KZK GOP No. 840 or 870 (change is made on Gliwice Plac Piastów bus stop).

Figure 2 Number of connections and the waiting times to change buses between the line KZK GOP 677, and line KZK GOP No. 6 (change is made on Gliwice Dworzec PKP bus stop), and between the line KZK GOP 677, and lines KZK GOP No. 840 and 870 (change is made on Gliwice Plac Piastów bus stop).

Source: Own calculations based on Tables 1+3.
4. CONCLUSION

Implementation of connections from Katowice city to Pyskowice town using the line KZK GOP 677 and proposed by the KZK GOP lines No. 6, 840 and 870 is realized in a pretty good manner. Noteworthy is the fact that there are quite a large number of possible connections and the average waiting time is not too long. Importantly, there are only few connections for which, buses from Gliwice depart in Pyskowice direction before the arrival of the bus from Katowice (in total 4 connection proposal for bus lines No. 840 and 870).

Unfortunately, the proposed connections have also some elements require further elaboration. A large number of connections are with waiting time of more than 30 minutes, in the extreme case it is even 3 hours 56 minutes (connection with bus line No. 840). Like was shown before, buses going from Katowice to Gliwice run more frequently than buses from Gliwice to Pyskowice, which means, that passengers do not benefit a large number of connections - they choose earlier connection to continue their journey.

The main problem observed by the author is - like in other analyzed connections between other cities, eg. [12, 13] - a travel time by public bus transport which is almost two times longer than in the case of individual transport.

Therefore, according to the author, KZK GOP should consider a slight modification of the proposed timetables and what is important, increase the traveling speed of buses (mainly on the route Katowice - Gliwice), so that the travel time was comparable to the driving using individual transport.

Those actions should contribute to the gradual ever greater interest in the use of public transport instead of individual transport.

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FORMULATION AND IMPLEMENTATION OF GREEN SUPPLY CHAIN STRATEGY

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Abstract

The aim of the paper is to propose the Green Supply Chain Strategy Management model, which can be used for formulation and implementation of Green Supply Chain Strategies. The proposed model is based on the Balanced Scorecard method and contains seven elements: green vision and strategic goals, supply chain analysis, supply chain business environment analysis, business environment scenarios, green supply chain strategy formulation, green supply chain strategy implementation, and green supply chain strategy control.

Keywords: Green strategy, Supply Chain Management, Balanced Scorecard

1. INTRODUCTION

The supply chain strategy created in the context of strategic management is the key to long-term direction of the supply chain. Generally, it is possible to identify a number of goals and their particular specifications, which can be identified with regard to the strategic areas of the supply chain. One of them is an effort to achieve reducing negative impacts on the environment at the lowest cost and in the shortest time. Decision about to deal with environmental issues in the context of the supply chain strategy can be motivated by various reasons such as own environmental concerns (individually perceived threats), shareholder or public pressure, improving corporate image or legal regulations.

The aim of the paper is to propose the Green Supply Chain Strategy Management (GSCSM) model using Balanced Scorecard (BSC) method, which can be used for formulation and implementation of Green Supply Chain Strategies (GSCSs).

2. METHODOLOGICAL BASIS

2.1. Green Supply Chain Management

As in the past and so also in the present is practice of Green Supply Chain Management (GSCM) understood as a multi-dimensional concept, which can be measured from different perspectives and at different dimensions. Zhu et al. [1] propose a four-dimensional GSCM practices, namely internal environmental management, external GSCM, eco-design and investment recovery. Holt and Ghobadian [2] suggest internal environmental management practices, logistics, supplier assessment and evaluation, green procurement and logistics policy, supplier education and mentoring, and industrial networks as important GSCM practices.

According to Ninlawan et al. [3] and Thoo et al. [4], important dimensions of GSCM practices needed by manufacturing sectors to achieve enhanced sustainability performance are green procurement, green manufacturing, green distribution and green logistics. Green et al. [5] suggest that GSCM practices should include internal environmental management, green information systems, green purchasing, cooperation with customers, eco-design and investment recovery. Lee et al. [6] published opinion that GSCM practices are composed of corporate and operational strategies to improve environmental sustainability such as internal environmental management, green purchasing, cooperation with customers and eco-design.
2.2. Strategic Management Models

Strategic management is a process that involves leadership, creativity, passion and analysis, building an organization that both generates and responds to change, developing compensation systems to reward staff, devising appropriate structures and systems, competing for funds in global financial markets and ensuring necessary resources are developed and allocated to worthwhile opportunities [7]. The strategic management process may best be illustrated in the form of a model, i.e. the strategic management model. Major components of the model are (1) Understanding strategy, (2) Strategy formulation, (3) Strategy analysis, (4) Strategy selection, (5) Strategy implementation, and (6) Strategy evaluation control [8]. Lomas and Mishra [9] define more detailed elements in strategic management models: (1) Defining the vision of the company, (2) Defining the mission of the company, (3) Determining the purposes or goals, (4) Environment scanning, (5) Carrying out corporate appraisal, (7) Developing strategic alternatives, (8) Selecting a strategy, (9) Formulating detailed strategy, (10) Preparing a plan, (11) Implementing a strategy, (12) Evaluating a strategy.

2.3. Balanced Scorecard

BSC is a method of management that creates a link between strategy and operational activities with an emphasis on performance measurement [10]. The BSC model was first introduced in 1992 by Kaplan and Norton, and has since then become a widely adopted approach to management control and performance management by both business and government. The BSC was created as a complement to financial measures, not as a substitute [11], and worked on balancing the four perspectives in order to give a comprehensive description of the business. By using the BSC, the strategy and vision of the company can be converted into performance measures that include both outcome measures and the drivers of these measures. For a strategy to be successful, it needs to consider financial ambitions, processes to be improved, markets served and the people in the organization that implement the strategy [12]. The BSC uses all these perspectives by considering both internal and external aspects [13]. Every perspective should contain four different sections: objectives, measures, targets and initiatives. For employees to be able to act upon the organization’s vision, translating the strategy and mission of the company into objectives is the first step in the creation of each perspective.

3. PROPOSAL OF GREEN SUPPLY CHAIN STRATEGIC MANAGEMENT MODEL

The proposed GSCSM model contains seven elements: (1) green vision and strategic goals, (2) supply chain analysis, (3) supply chain business environment analysis, (4) business environment scenarios, (5) green supply chain strategy formulation, (6) green supply chain strategy implementation using BSC method, (7) green supply chain strategy control.

3.1. Green Vision and Strategic Goals

The first step of the proposed model is definition of the green supply chain vision and strategic goals. The general vision of each GSCSM is to build an eco-friendly supply chain, i.e. decrease negative environmental impacts caused by the supply chain. Thus, the vision of the green supply chain is primarily centred on those process operations that influence environmental performance [14]. On the other hand, the conventional supply chain management is focused on increasing its competitiveness through improving its customer service and reducing its supply chain management costs. A green vision should be specified into a set of green strategic goals. Mutingi [15], on the basis of his literature search survey, categorized main goals of GSCM practices into three groups: (1) minimal waste, (2) minimal energy usage, and (3) optimized resource usage.
As the proposed GSCSM model is based on the BSC approach, the green strategic goals should be defined for all four perspectives: (1) financial, (2) internal business processes, (3) learning and growth, and (4) customer. This approach is recommended e.g. by Epstein and Wisner [16].

3.2. Supply chain analysis

A good understanding of the supply chain is a necessary condition for the successful GSCSM. Each supply chain has certain specific features that need to be taken into account when the GSCS is formulated and implemented.

The basic examined areas include the supply chain structure (type and number of elements, their locations, mutual links), raw materials, material, semi-finished and finished products (structure, variability, price, quantity), the used technologies (production, logistics) and the controlling processes (plan, source, make, delivery, return [17]).

Supply chain analysis is necessary to determine recent state of GSCSM and possible actions to be taken in order to increase the green performance of the supply chain.

3.3. Supply chain business environment analysis

Every real supply chain is influenced by the business environment, which must be respected during GSCS formulation and implementation. The main aim of the analysis is listing all business environment factors influencing the GCS. The basic tools usable in this area are the PEST analysis [18] and Porter five forces analysis [19], which must, however, be adapted to the analysis of the entire supply chain.

Proposal of the supply chain business environment analysis is schematically shown in Figure 1. Unlike the classical analysis of the company business environment, the existing suppliers are part of the supply chain and other supply chains (existing, potential and substitution) compete with this one.

![Figure 1 Scheme of the supply chain business environment analysis](image)

3.4. Business environment scenarios

Scenarios are a method, which involves the development of plausible alternative scenarios of how the business environment might develop in the future. Through the process of scenario planning, a supply chain is able to identify alternative ways of planning its operations in order to minimize the consequences of changing the business environment [20]. Each alternative scenario is intended to envision a possible course of factors influencing GSCSM and its consequences.
According to Johnson et al. [21], scenarios typically start from the key factor of the business environment with the greatest uncertainty. Such key factors could create radically different views of the future according to how they turn out. Johnson et al. propose two internally consistent and plausible scenarios: one based on low growth and high instability, the other based on high growth and low instability.

3.5. Green supply chain strategy formulation

Next step of the GSCSM model is selection of an appropriate GSCS for each developed scenario and its specification. For that purpose, the authors offer GSCS matrix, which is shown in Figure 2.

![Figure 2: Green supply chain strategy matrix](image)

The GSCS matrix is based on the following criteria: (1) expected green effect after the GSCS implementation - low or high, (2) estimated cost of the GSCS implementation - low or high, (3) responsibility to decide on the GCS implementation in the given company: I. in the responsibility of the implementers, II. limited responsibility of the implementers (e.g. within the responsibility of corporation).

The result are four main GSCSs: (1) ideal - high green effect can be achieved at low costs or even cost savings, (2) economic - only a limited green effect can be achieved at low costs or even cost savings, (3) ecological - incurring high costs will achieve a high green effect, (4) ineffective - incurring high costs brings only a limited green effect.

Selected GSCSs should be specified into main green initiatives. Authors recommend initiatives in four areas: (1) structure - initiatives creating the basis of a successful application of other initiatives or they have the character of supply chain structural changes, (2) management - initiatives focused on planning and subsequent execution of supply chain, (3) technology - innovations of technologies and elements used in supply chain management, (4) staff - initiatives whose motive power is represented by the people and their skills.

Selection of an appropriate GSCSs and main green initiative should be in accordance with defined strategic vision and goals, the contemporary green supply chain performance, and business environment scenarios defined in previous elements of the GSCSM model.

3.6. Green supply chain strategy implementation using BSC method

The authors developed GSCSM BSC model shown in Figure 3 to support the GSCSs implementation. There are two basic differences in comparison with traditional BSC model: (1) only green measures are taken into
consideration, (2) in addition to target values, there are threshold and real values. Thresholds represent minimum accepted values of the measures. Realities describe real values of the measures.

Specific green objectives, measures, thresholds, targets, and initiatives should be determined for selected alternative GSCSs.

3.7. Green supply chain strategy control

The task of this model element is the creation of a system for measurement of reaching the implemented GSCS using proposed GSCSM BSC model, comparison of the contemporary green performance with target values, and conducting corrective actions if the green strategic goals weren’t reached. For that purpose it is necessary to assign weights to the four perspectives and their measures. The authors suggest the ANP method for that purpose because there are significant dependences between the perspectives and also their measures [22].

Using collected real values (realities) of BSC measures and the ANP method, the green performance of the supply chain can be calculated. The evaluation of the results may include: (1) comparison of the calculated value with the overall threshold and target values, (2) inclusion of the calculated value into the pre-defined categories (unacceptable, bad, good, very good, excellent GSCS reaching), (3) analysis of the trend if the evaluation of the GSCS reaching is performed repeatedly. If there is an unsatisfactory GSCS reaching, it is desirable to focus on the perspectives and measures with the highest weight.
4. CONCLUSION

Practical application of the proposed GSCSM model will only rarely have the “linear” form and will not be realized in such a transparent and clear manner. It will be necessary to take into account the following facts:
(1) the GSCSM will be an iterative process with returns to previously adopted and re-evaluated procedures, (2) the partial elements in the proposed model will often be interrelated, (3) the SDCSM will be a nonstandard, original and creative process, which does not exclude the use of partial formal methods and tools making the thought processes easier, the GSCSM will be a process of continuous adaptation to changes in the internal and external environment, which are continuous as well.

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REFERENCES


MODELLING OF WAREHOUSE PROCESSES IN TERMS TO SIMULATION RESEARCH-
SIMMAG3D

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Abstract

The paper presents results of research carried out under one of the SIMMAG3D project tasks. Main goal of
the project is to prepare system for modelling and 3D visualization of warehouse facilities. Accordingly, in the
paper the main attention was paid to the problems of modelling warehouse process in various types of logistic
objects. Presented approach to modelling warehouse process allows to carrying simulation researches of
selected sub-processes and activities. The model includes transformations of loads and information related
with them. Importantly, developed model will be compatible with WMS, which will be source of data needed to
the simulation studies. In paper, authors identified basic elements of the warehouse processes in selected
organizational and functional variants of warehouses.

Keywords: Modelling, warehousing, SIMMAG3D

1. INTRODUCTION

The productivity and reliability of warehouse are key assets in supply chain and should be constantly measured
and improved. Warehouse productivity can be improved in many ways. It could be done by using better suited
material handling technologies or through better usage of disposed resources and spaces. But the basic way
to increase efficiency of logistics facilities is to appropriate design and construct warehouse process (logistics
process implemented in that warehouse). Logistics process could be defined as a sequence of changes of
logistics system states occurring between the initial and the final state of that system. Changing the logistics
system state is correlated with place, time and form transformations of materials and information [1].

Current logistics is basically oriented on customer needs. Because of that, logistics process could be also
defined as a sequence of activities designed in such a way, that as a result of their implementation the logistics
service will be created [2]. The final customers are only interested in results of logistics process (logistics
service). However, in the interest of logistics is shaping logistics process in such way that it will be economically
efficient. Very often to achieve this, must be performed a multi-step process of finding a suitable organizational
variant of the logistics process. This in turn is related to necessity of developing a mathematical model of the
warehouse process, as well as carrying out simulation studies using that model.

Analysis of commercially available tools for simulation indicate that they very often do not allow mapping
warehouse processes effectively and with the required accuracy. This is primarily about the possibility of
analysing the individual logistics units with identification of their location in space. Furthermore, because of the
need of having the specific data for research, it is essential that the simulation tool will be compatible with
WMS systems. Because of that, we start research about mathematical modelling warehouse process, what
after its implementation (with 3D visualization of warehouse and its stock) could be used for improving real
logistics facilities.
2. WAREHOUSE PROCESS MODELLING ASSUMPTIONS

The initial and essential step in modelling warehouse process is identification and analysis of its logistics tasks. These tasks usually result from technological sequence, which warehouse units are subject to - starting from receiving, by put-away, replenishment, order picking until shipping [3]. Size and scope of these transformations results from main functions and tasks of logistics facility. Therefore, in this case logistics task is a formal notice of cargos transformed by the warehouse facility.

Description of tasks and requirements that must be fulfilled by warehouse process concerns definition of:

- the structure of warehouse shipment and supplies - describe amount of unit loads of a given type that appear at the input and output of warehouse in a certain period of time or his subsequent intervals,
- technological, organizational and cost parameters of warehouse process,
- measures and criteria for evaluation of warehouse process.

Quantitative description of cargos inputs and outputs can be integers (historical data of logistics facility is needed), however, very often it is necessary to describe these values by probability distributions. It is very useful in case of using simulation methods to analyse warehouse processes.

For modelling warehouse process the knowledge of its technological and organizational parameters is extremely important. The main attention in this case should be focused on [4]:

- identification of functional areas and their basic functions, as well as tasks and warehouse operations assigned to them,
- identification the area and capacity of functional areas and assigning to them warehouse locations,
- identification and characterization of non-mechanical equipment in functional areas (e.g. type and layout of storage racks) - important for the assigning materials and transport means to functional areas,
- identification of connections between functional areas - defining areas of internal transport, internal transport roads (important for estimating the distance between these areas),
- identification and parameterization of labour resources (transport means, employees) used in warehousing, etc.

It is also very important to correctly represent the principles of work organization in logistics facility. Therefore, it is necessary to take into consideration:

- scheduling warehouse operations,
- organization of employees movement - identification of routing methods,
- rules of replenishment of picking area - determination of replenishment levels, below whose pick locations should be replenished,
- rules of storage assignment in functional areas and pick (storage) locations - slotting,
- rules of processing customer orders, preparing pick lists, etc.,
- order picking strategies (single picking, zone picking, batch picking, wave picking, etc.)
- rules of packaging and constructing unit loads in accordance with requirements of customers and sub-system of external transport.

Warehouse process is defining as a set of activities correlated with receiving, storage, order picking and shipping material goods, in an appropriately adapted for this purpose areas and under certain organizational and technological conditions [5]. Therefore, it can be assumed that warehouse process consist of cargo receiving, storage, order picking and shipping. Nevertheless, this is a very overall approach, because warehouse process may take many different forms, and include a plurality of sub-processes. Basic transformations related to warehouse process whose are considered in this research (according to [3], [6], [7]) are:

- place transformation - intended change of unit loads locations carried by internal transport,
- time transformation - intended stop of unit loads for buffering, storage or because of inability to performing the subsequent sub-processes,
- form transformation - intended change of type, species, physical characteristics of unit loads or they number, amount.

Table 1 presents examples of the most common sub-processes and activities included in warehouse process and specifies basic transformations related to them.

Table 1 The most common sub-processes and activities included in warehouse process

<table>
<thead>
<tr>
<th>Sub-process</th>
<th>Activity</th>
<th>Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving</td>
<td>Unloading</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Cargo identification and control</td>
<td>time</td>
</tr>
<tr>
<td></td>
<td>Buffering</td>
<td>time</td>
</tr>
<tr>
<td>Put-away</td>
<td>Transport to storage area</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Placing unit loads in storage location</td>
<td>place</td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td>time</td>
</tr>
<tr>
<td>Replenishment</td>
<td>Transport to order picking area</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Transformation of unit loads to form offered in order picking</td>
<td>form</td>
</tr>
<tr>
<td></td>
<td>Replenishment to pick locations</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Placing remaining unit loads in storage location</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Placing in selected location empty bins (pallets)</td>
<td>place</td>
</tr>
<tr>
<td>Order picking</td>
<td>Replenishment to pick locations</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Preparing items for picking</td>
<td>form</td>
</tr>
<tr>
<td></td>
<td>Picking items</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Sorting, packing, preparing picked unit loads for transport</td>
<td>form</td>
</tr>
<tr>
<td></td>
<td>Transport of prepared unit loads to selected place in order picking area</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Transport of prepared unit loads to buffer</td>
<td>place</td>
</tr>
<tr>
<td>Co-packing</td>
<td>Transport of unit loads to co-packing stations</td>
<td>place</td>
</tr>
<tr>
<td></td>
<td>Preparing items for co-packing</td>
<td>form</td>
</tr>
<tr>
<td></td>
<td>Creation new SKU (e.g. promotional SKU sets, combined SKU)</td>
<td>form</td>
</tr>
<tr>
<td></td>
<td>Packaging, labelling, tagging, foiling, etc.</td>
<td>form</td>
</tr>
<tr>
<td></td>
<td>Transport of prepared unit loads to selected place of buffer</td>
<td>place</td>
</tr>
<tr>
<td>Consolidation, deconsolidation, sortation</td>
<td>-</td>
<td>form (quantity)</td>
</tr>
<tr>
<td>Shipping</td>
<td>Buffering</td>
<td>time</td>
</tr>
<tr>
<td></td>
<td>Cargo identification and control</td>
<td>time</td>
</tr>
<tr>
<td></td>
<td>Loading</td>
<td>place</td>
</tr>
<tr>
<td>Material return policy, utilization</td>
<td>Cargo identification and control</td>
<td>time</td>
</tr>
<tr>
<td></td>
<td>Buffering</td>
<td>time</td>
</tr>
<tr>
<td></td>
<td>Loading</td>
<td>place</td>
</tr>
<tr>
<td>Crossdocking</td>
<td>Transport from input buffer to output buffer</td>
<td>place</td>
</tr>
</tbody>
</table>

The complexity of activities included in warehouse process, as well as their variability in time, causes that reasonable seems to be using dynamic models for modelling that kind of processes. Exemplary simulation model of warehouse process is shown in next paragraph.
3. SIMULATION MODEL OF WAREHOUSE PROCESS

Warehouses could transforming a lot of many different types of unit loads. So, we assumed that we have set $R$ of such different logistics types of unit load (1), where $r$ is particular logistics type of unit load and $\bar{R}$ is the number of all logistics types. Unit loads of particular types are represented by set $N(r)$ (2).

$$R = \{ r : r = 1, \ldots, \bar{R} \}$$  \hspace{1cm} (1)

$$N(r) = \{ n(r) : n(r) = 1, \ldots, \bar{N}(r) \}, \ r \in R$$  \hspace{1cm} (2)

All transformations of unit loads in warehouse are given by the set $P$, where $p$ is particular transformation of unit load and $\bar{P}$ is the number of all transformations.

$$P = \{ p : p = 1, \ldots, \bar{P} \}$$  \hspace{1cm} (3)

Elements of the set $P$ can be additionally divided into sets $PM$, $PT$, $PP$, which are sets of transformations of place, time and form. If $p$-th transformation concerns transformation of places, then $kp(p) = 1$, if it concerns transformation of time, then $kp(p) = 2$, or if it concerns transformation of form, then $kp(p) = 3$.

$$PM = \{ p \in P : kp(p) = 3 \}$$  \hspace{1cm} (4)

$$PT = \{ p \in P : kp(p) = 2 \}$$  \hspace{1cm} (5)

$$PP = \{ p \in P : kp(p) = 1 \}$$  \hspace{1cm} (6)

Any warehouse fulfill specified logistics task $ZL$. This task include many activities and processes which are caused and carried out according to so called internal orders. We assumed that set $Z$ is a set of internal orders, where $z$ is particular internal order and $\bar{Z}$ is the number of all internal orders.

$$Z = \{ z : z = 1, \ldots, \bar{Z} \}$$  \hspace{1cm} (7)

Internal orders in warehouse process include sequence of transformations on selected logistics units. Therefore, we assumed that set $R(z)$ is a set of unit load types included in z-th internal order, set $N(r,z)$ is a set of unit loads $r$-th type included in z-th internal order and set $P(z)$ is a set of transformations included in z-th internal order:

$$R(z) = \{ r \in R : \lambda(r) = 1 \}, \ z \in Z$$  \hspace{1cm} (8)

$$N(r,z) = \{ n(r) \in N(r) : \lambda(1(n(r))) = 1 \}, \ r \in R(z), \ z \in Z$$  \hspace{1cm} (9)

$$P(z) = \{ p \in P : \lambda2(p) = 1 \}, \ z \in Z$$  \hspace{1cm} (10)

where: if in z-th internal order are included logistics units of r-th type $\lambda(r) = 1$; if in z-th internal order is included $n(r)$-th logistics units of r-th type $\lambda(1(n(r))) = 1$; if in z-th internal order is included $p$-th transformation of logistics units $\lambda2(p) = 1$.

In reference to the above, the logistics task can be formally presented as:

$$ZL = [R(z), N(r,z), P(z) : r \in R(z), z \in Z]$$  \hspace{1cm} (11)

Realization of logistics task needs to using labour resources (workers, warehouse equipment). These labour resources in model are represented by set $ZP$, where $zp$ is particular labour resource and $\bar{ZP}$ is the number of all labour resources.

$$ZP = \{ zp : zp = 1, \ldots, \bar{ZP} \}$$  \hspace{1cm} (12)

In warehouse process could be used different types of labour resources, e.g. different types of warehouse equipment, different types of transport means, workers with different types of skills. Therefore, set $M(zp)$ is a set of labour resource types.
\( M(zp) = \{m(zp) : m(zp) = 1, \ldots, M(zp)\}, zp \in ZP \)  

Besides, warehouse structure can be divided into elements GS, e.g. functional areas, unit load locations or connections between them - road of internal transport. These elements, as well as labour resources have specified characteristics FS (e.g. surface and capacity of functional areas, labour costs, technical readiness indexes, speed, efficiency, productivity). Warehouse logistics tasks is also implemented under specified rules, logics or strategies ZR (e.g. storage assignment method, picking strategy, routing method, replenishment method, assigning labour resources to task method).

Considering above, model of the logistics facility MOL can be defined as follows:  
\[
MOL = \{ZL, ZP, GS, FS, ZR\}
\]

where: ZL is logistics task of warehouse, ZP are labour resources, GS is structure of logistic facility, FS are characteristics of logistics facility elements, ZR are specified rules, logics or strategies of warehouse process.

For research, we need to observe changing of states of selected elements. These elements are unit loads and labour resources (transport means, workers, and its combinations). As the impact of the environment on a logistics facility we consider delivery, customer orders, as well as the disruptions for warehouse process (e.g. accident situations and randomness in unit loads handling).

It should be noted that, both the intensity of inputs of logistics unit loads and transformations of these unit loads are time dependent. Therefore, we assumed that, set \( T \) is a set of moments of logistics facility work where \( t \) is particular moment and \( \bar{T} \) is the number of all moments.  
\[
T = \{t : t = 1, \ldots, \bar{T}\}
\]

States of selected elements of logistics facility are also analysed in particular moments. State of the whole facility is determined by states of its particular elements. State of \( n(r)\)-th unit load of \( r\)-th type in \( t\)-th moment we define as \( x(r,n(r),t) \) and state of \( m(zp)\)-th labour resource of \( zp\)-th type in \( t\)-th moment is define as \( y(zp,m(zp),t) \).

\[
X(r,t) = \begin{bmatrix} x(r,1,t) \\ \vdots \\ x(r,n(r),t) \\ \vdots \\ x(r,N(r),t) \end{bmatrix} \\
Y(zp,t) = \begin{bmatrix} y(zp,1,t) \\ \vdots \\ y(zp,m(zp),t) \\ \vdots \\ y(zp,M(zp),t) \end{bmatrix}
\]

So, state of the whole facility in \( t\)-th moment can be defined as follows:
\[
S_O(t) = [X(t), Y(t)]
\]

\[
X(t) = \\
\begin{bmatrix} X(1,t) \\ \vdots \\ X(r,t) \\ \vdots \\ X(R,t) \end{bmatrix} \\
Y(t) = \\
\begin{bmatrix} Y(1,t) \\ \vdots \\ Y(zp,t) \\ \vdots \\ Y(ZP,t) \end{bmatrix}
\]

State of the whole facility in \( t\)-th moment results from its previous state, from internal orders generated in \((t-1)\)-th moment and from disruptions in \( t\)-th moment. Set of internal orders generated in \( t\)-th moment and set of disruptions in that moment are defined as follows:
\[
Z(t) = \{z \in Z : \tau(z) = t\}, t \in T
\]
\[
A(t) = \{a(t) : a(t) = 1, \ldots, A(t)\}, t \in T
\]
Considering above, and treating the process as a series of subsequent changes in the system, warehouse process can be formally represented as:

$$\text{SO}(t) = f(\text{SO}(t-1), \text{Z}(t-1), \text{A}(t)), t \in T$$ (22)

The scope of the research requires consideration of representation states of each logistics unit in modelled process. Locations of these units in system and time which remains to end of servicing each of them should be also taken into account. Similarly, in the case of states of labour resources. They should be identified according to their localization and occupancy (busy, idle, etc.). Internal orders in model are represented as a lists of logistics units that need to be serviced in particular way and in particular location or transported between some locations.

4. CONCLUSION

Paper presents basic assumptions for simulation model of logistics processes in warehouses. The main attention was paid to formal and mathematical representation of warehouse process. Presented research includes dynamical aspects of warehouse process and possible changing its states in time.

Developed simulation model allows to analysing transformations of individual logistics units with precise identification of their localization in logistics facility. This allows to use in implementation of that model the various procedures and heuristics (e.g. routing heuristics, storage assignment). Thus, this model will be allowing constructing the tool that will be able to map the logistics processes with required accuracy. In addition, this tool will be compatible with the WMS systems.

Considerations from in this paper are results of research carried out within the project SIMMAG3D. Its goal is to develop the system for modelling and visualization warehouse facilities in the 3D. The system will be constructed on the basis of mathematical models, computational algorithms and functional relations, which are needed in designing the warehouse facilities. Currently, the authors are developing simulation model of warehouse process and algorithmization of the warehouse activities.

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DETERMINATION OF DEPENDABILITY OF THE LOAD HANDLING PROCESS

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Abstract

In recent years intermodal transport is one of the most dynamically developing sectors of transport services. From year to year increases the number of transhipped integrated cargo units in the world. Crucial part of intermodal infrastructure are transshipment terminals, which are both handling points and storages for integrated loading units. To transport the cargo smoothly in relation door-to-door, inland terminals, as a point infrastructure should work reliably. The article is about the issue of dependability of the intermodal terminal land in the context of the information flow and its role in the proper implementation of the processes.

Keywords: Container terminal, intermodal transport, dependability, event tree analysis

1. DEPENDABILITY - LITERATURE REVIEW

Operational dependability [2] is defined as the ability of a facility to meet requirements which have been set for it. In the context of an inland terminal, it will be the ability of the system to fulfil orders. In the simplest of cases, however, two states of a facility, sometimes three, are distinguished. We distinguish the state of ability \( s_1 \) and inability \( s_2 \) and a state of partial inability \( s_3 \). The issue of dependability has been brought up in many studies concerning various systems or technical facilities. Dependability, susceptibility, resistance in a logistics system has been discussed in different studies [1, 2, 3]. The issue of dependability is also described in various branches of transport, e.g. in rail transport [4], air transport [5, 6, 7]. In the study by [8], an assessment method was assessed for road transport using the example of waste transport. Modelling and analysis of dependability for technical facility is described, for example, in studies by [9,10]. Dependability in intermodal transport at inland terminals is presented, for example, in studies by [11, 12] These studies present a systemic approach to dependability assessment; however, there is not processual approach to the assessment of dependability at the container terminal. Therefore, the aim of this article is to determine dependability for the load handling process in the rail-road relationship at the inland terminal. Several operations must be performed to determine the dependability of this process [6]. They are presented in the algorithm in Figure 1.

![Figure 1](image_url)

**Figure 1** Method for the assessment of the loading process dependability.
Prepared by the author on the basis of [6]

**Figure 1** presents the individual steps which need to be completed to assess the dependability of the load handling process at the inland terminal. This article presents the first three steps, i.e. general process characteristics, decomposition of the process structure as well as determination of the dependability of the handling process.
2. IDENTIFICATION OF THE LOAD HANDLING PROCESS

This chapter presents the characteristics of the handling process. Its general and detailed aims have been formulated. The decomposition of the process has been performed together with the presentation of the load handling process at the inland terminal using the BPMN tool (Business Process Modelling and Notation).

The inland terminal is a complex man-machine-environment system [13, 14, 15]. It is a load handling point where two basic functions can be distinguished. The first of them is the handling of integrated load units (containers, swap bodies and semi-trailers) to put them on various means of transport. The other function involves storage of these units, i.e. warehousing. Depending on the nature of the operations at the terminal, its location and on the clients’ cooperation, the storage of units can last from several minutes to several days. It is also possible that units are not stored at all but unloaded from one means of transport onto another to be transported to the client. Man, information and infrastructure are situated at the entry of the system, while the performance of set orders and tasks is situated at the output. The load handling process is moving an integrated load unit (a container, semi-trailer or swap body) using load handling equipment, taking into account various means of transport. The load handling process at the inland terminal can be performed in various relationships; they are presented in the studies [16, 17].

Load handling process

General aim - load transport from point A to point B,

Detailed aim - transport of the container from the moment of entry into the system (rail transport) to the moment of leaving the system (road transport) using load handling equipment.

In this study, the case of load handling in the rail-road relationship will be considered. This process begins the moment containers $e_1$, enter the inland terminal by rail transport. Next, depending on the type of the container, whether it is empty or loaded, the process is executed in a slightly different manner.

For empty containers, their status $d_1$ is checked - i.e. whether the container is damaged. Next, the class of the container is assigned $d_{11}$, which provides information about its fitness for use. If the container is not fit, it is placed in the storage yard and explanatory procedures are undertaken to decide what to do next with this container, the process ends at this time $e_2$. If the container is fit, an appropriate class is assigned to it and the load is accepted at the terminal by entering the load into the computer system $d_{12}$. Following that, machine operators place loads $d_{13}$ at the storage yard; if a load is not placed in the storage yard, it is not regarded as an error. It is a situation in which a container from a train can be loaded directly onto a truck. Next, the terminal employee enters instruction $d_{14}$ into the system to release the container, according to the client's order. The last operation is loading $d_{15}$ of a given container onto a truck and the process $e_3$ is completed.

The long path of load handling is the handling of loaded containers. After the load arrives by rail transport $e_1$, the container status is checked in terms of damage to the frame and also broken seals. Next, the containers are entered into the system $d_{21}$. If the containers have not been cleared, customs clearance $d_{22}$ takes places, usually at the inland terminal. If the customs clearance has not taken place, this is not regarded as an error or lack of possibility to perform the task. In this study, it was accepted that a failure to perform customs clearance means that it was not necessary and such containers were cleared earlier, e.g. at the port. The next activity in the discussed process is the placement of containers in the storage yard $d_{23}$. This does not have to be considered an error, like in the case of the empty containers. Next, according to the clients’ order, an instruction $d_{24}$ to release the container is issued. The last activity is loading the container $d_{25}$ onto a truck and this is the moment when the process $e_2$ ends. The structure of the load handling process is presented in Figure 2.
An event that initiates the load handling process is known as “entering” $e_1$ (acceptance / entry of an integrated load unit into the terminal) and the end event is known as its “exit” $e_3$ (release of an integrated load unit). The analysed process also includes the end of the system marked as $e_2$, which is the end of the process in the case of a damaged, empty container. The path in the serial structure, beginning with $d_1$, applies to the handling of an empty container, while the path beginning from $d_2$ concerns the loaded container. Figure 2 presents the serial-parallel structure of the load handling process $P_{ol}$, so it can be defined as:

$$P_{ol} = <E, D, R>$$

where:

$E = <e_i: i=1, \ldots, I>$ set of events of process $P_{ol}$,

$D = <d_j: j=1, \ldots, J>$ set of operations of process $P_{ol}$,

$R = <r_k: k=1, \ldots, K>$ set of relations of process $P_{ol}$.

3. DETERMINATION OF DEPENDABILITY OF THE HANDLING PROCESS

Many studies on risk assessment use the following methods: event trees, Markov models, hybrid methods, computer simulations and Bayesian networks. In this study, the event tree method will be used for the assessment of the dependability of the handling process, which is often used in logistics processes. For example, in [18] the Event and Fault Tree Analysis method (EFTA) was presented which made it possible to examine the mechanism of catastrophe (100 fires) in cotton warehouses. The combination of two methods, i.e. Event Tree Analysis and Fault Tree Analysis, allowed for finding issues concerning fire safety. In the study [18], event trees were used for the analysis of inflammable materials on the basis of 580 accidents. 3 events...
were regarded as accidents: explosion, fire and emissions. In [19] presents an attempt to find a method to assess safety of damaged ships. This research, conducted as the method contained in the SOLAS regulation, does not include a certain type of shops. In another study [20], a risk analysis model was proposed for the assessment of information security. The study presents a combination of the Event Tree Analysis with fuzzy decision theory, twelve different possible scenarios of probability of risk occurrence were analysed using two different methods. The article [21] presents a new approach to the problem of organization and keeping distribution processes in a dependability state in the context of accompanying information system. The analysis was performed on the basis of an actual logistics system consisting of 13 points using the Event Tree Analysis. The overview above indicates that the Event Tree Analysis tool is used by numerous authors in various logistics systems. This tool will also be used in this article to determine dependability in the load handling process. After decomposition of the structure presented in Figure 2, the process was divided into two parts, the first of these applies to the process of handling and empty container, while the other involves a loaded container. Using the Event Tree Analysis, both subprocesses are presented in Figure 3 and Figure 4.

**Figure 2** Event Tree Analysis for the empty container handling process $P_{op}$

**Figure 3** Event Tree Analysis for the loaded container handling process $P_{ol}$
The ETA method was used to determine all 23 possible sequences of the handling process. The performance of sequence $S_i$, a failure to perform sequence $S_i$ was marked as $Z_2$. The analysed load handling process $P_{ol}$ at the land terminal will perform its function in a reliable manner if all subordinate processes are reliable. Therefore, the dependability of the process is equal to:

$$R_{ol} = P(P_{olp}) \times P(P_{oll}) = (S_{11} + S_{14}) \times (S_{21} + S_{24} + S_{27} + S_{30})$$  \hspace{1cm} (2)

Research was performed at the inland terminal, making it possible to calculate the probability $P_x(d_i)$ of individual actions for an empty container and a loaded container, the $P(e_i)$ is 1. The results are presented in Table 1.

**Table 1** Table of probability of occurrence of individual actions

<table>
<thead>
<tr>
<th>Empty container</th>
<th>Loaded container</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_i$</td>
<td>$P_x(d_i)$</td>
</tr>
<tr>
<td>$d_1$</td>
<td>1.00</td>
</tr>
<tr>
<td>$d_{11}$</td>
<td>0.99</td>
</tr>
<tr>
<td>$d_{12}$</td>
<td>0.99</td>
</tr>
<tr>
<td>$d_{13}$</td>
<td>0.99</td>
</tr>
<tr>
<td>$d_{14}$</td>
<td>1.00</td>
</tr>
<tr>
<td>$d_{15}$</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Considering formula 2 and data from Table 1, dependability of the load handling process at the container terminal can be calculated, therefore:

$$R_{ol} = 0.98 \times 0.97 = 0.95$$  \hspace{1cm} (3)

The dependability of the handling process at the inland terminal equals 0.95. To guarantee that dependability of the handling process is as high as possible, both processes of handling an empty container $P_{olp}$ and a loaded one $P_{oll}$ must be implemented in a reliable manner. The lower probability index applies to the loaded container handling process. This value was influenced the most by actions related to customs clearance $d_{22}$, as well as the placement of containers at the storage yard $d_{23}$. This results from the fact that non-performance of actions does not mean an error, but simply the lack of necessity of performing this action.

4. **CONCLUSIONS**

Inland terminals must operate in a reliable manner to make it possible to transport loads from the shipment point to the collection point. The development of a structure of the handling process made it possible to determine two subprocesses of handling. The use of the ETA tool made it possible to determine 23 structures of the load handling process. In the analysed case, the dependability of the load handling process is influenced by the dependability of the handling process of an empty container $P_{olp}$ and a loaded container $P_{oll}$.

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THE ALGORITHM FOR DESIGNATING THE NUMBER OF TRANSSHIPMENT VEHICLES IN THE CROSS-DOCKING SYSTEM

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Abstract

This paper presents the algorithm for designating the number of the transshipment vehicles in the cross-docking system. The problem of minimizing the number of vehicles was presented in a mathematical way. For the examined problem the decision variables, limits and the function of criterion were determined. The crucial importance in this problem is to designate the minimum driving routes of transshipment vehicles in the transshipment facility. For this purpose, the optimization algorithm was developed. The scientific work carried out in the frame of PBS 3 project "System for modeling and 3D visualization of storage facilities" (SIMMAG3D) financed by the NCBR.

Keywords: Cross-docking system, genetic algorithm, optimization

1. INTRODUCTION

Cross-docking is a process of the consolidation of the cargo which are transported in the same direction from different places of the origin [4], [8], [3], [11]. Rationalization of cross-docking is to minimize the labor intensity of the process and the interference in the cargo through the omission of storage of the material between the phase of loading and unloading or storage in a short time [6], [1], [2], [9], [5]. Processes of this type are carried out in cross-docking terminals which are objects of an appropriate spatial shape and the organization of work. The Figure 1 shows an example of multi-touch cross-docking facility.
The cargo collected in the area of service and imported from other terminals are accepted and unloaded into the buffer areas on the input of the system (unloading docks). Then they are transported to the respective areas in the output buffer in accordance with the direction of transport (loading docks). The aim of the paper is to present the way of designating the number of the transshipment equipment (e.g. internal transport vehicles) realizing transport of pallet loading units on relations: unloading dock (entrance dock) - loading dock (output dock) in the cross-docking system.

2. DESIGNATING THE NUMBER OF THE TRANSSHIPMENT EQUIPMENT IN THE CROSS-DOCKING SYSTEM

The presented model of the problem of determining the number of the transshipment equipment in the cross-docking system refers to a multi-touch object. Unloading vehicles in the entrance docks and loading in output docks takes place in different time windows. The cargo are temporarily stored in the input buffer. The reloading process takes place after unloading all vehicles in a given time window. In order to determine parameters of model indications are defined as follows in Table 1.

**Table 1** Parameters of the model

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_d )</td>
<td>working time of the object</td>
</tr>
<tr>
<td>( \varphi_{az} )</td>
<td>the coefficient of the use of working time</td>
</tr>
<tr>
<td>( \varphi_g )</td>
<td>the coefficient of technical readiness</td>
</tr>
<tr>
<td>( \varphi_{zo} )</td>
<td>the coefficient of work area variation</td>
</tr>
<tr>
<td>( \lambda(i, j, r) )</td>
<td>the decision variable which determines the number of transportation cycles between ( i )-th unloading dock and ( j )-th loading dock for ( r )-th type of the product</td>
</tr>
<tr>
<td>( T = [t(i, j, r)] )</td>
<td>the matrix of time of transportation cycles between ( i )-th unloading dock and ( j )-th loading dock for ( r )-th type of the product</td>
</tr>
<tr>
<td>( DI = {1, ..., \overline{DI}} )</td>
<td>the set of the numbers of unloading docks at the entrance of system</td>
</tr>
<tr>
<td>( DO = {1, ..., \overline{DO}} )</td>
<td>the set of the numbers of loading docks at the output of system</td>
</tr>
<tr>
<td>( DIR = {1, ..., \overline{DIR}} )</td>
<td>the set of numbers of types of products which are unloaded and loaded in the docks</td>
</tr>
<tr>
<td>( VIR = [\overline{vir}(i, r)] )</td>
<td>the matrix of value of ( r )-th type of the product in ( i )-th unloading dock</td>
</tr>
<tr>
<td>( VIR1 = [\overline{vir1}(j, r)] )</td>
<td>the matrix of value of ( r )-th type of the product in ( j )-th loading dock</td>
</tr>
</tbody>
</table>

The number of the transshipment equipment may be calculated by the use of the formula [7]:

\[
n = \frac{\sum_{k=1}^{K} \lambda_k \cdot t_k}{t_d \cdot \varphi_{az} \cdot \varphi_g \cdot \varphi_{zo}}
\]

where: \( \lambda_k \) - the size of the cargo volume transported in \( k \)-th transportation cycle, \( t_k \) - execution time of \( k \)-th transportation cycle, \( \varphi_{az} \), \( \varphi_g \), \( \varphi_{zo} \), \( t_d \) - see Table 1.
Taking into account the specific nature of cross-docking terminals in which at the input we have the homogeneous cargo, the pattern (1) can be modified to the form:

\[
  n(\lambda) = \frac{\sum_{i \in DI} \sum_{j \in DO} \sum_{r \in DIR} \lambda(i, j, r) t(i, j, r)}{\lambda_d \cdot \varphi_d \cdot \varphi_g \cdot \varphi_{zo}} \rightarrow \text{min}
\]  

(2)

In order to determine the transshipment equipment, limits were defined:

- All products of the given type from each unloading dock must be exported:
  \[
  \forall r \in \text{DIR}, i \in \text{DI} \sum_{j \in \text{DO}} \lambda(i, j, r) = \text{vir}(i, r)
  \]  
  (3)

- The demand for the product in each loading dock must be met:
  \[
  \forall r \in \text{DIR}, j \in \text{DO} \sum_{i \in \text{DI}} \lambda(i, j, r) = \text{vir}1(j, r)
  \]  
  (4)

According to the pattern (2) assuming that the value of the denominator is constant, the number of the transshipment equipment depends on the numerator of the pattern, that is the total time of all transportation cycles performed in the reloading process. For the known times between docks \( t(i, j, r) \), the total time depends on the number of cycles performed between the unloading docks and loading docks, these cycles are determined by the decision variable \( \lambda(i, j, r) \). It is difficult to determine the amount of cycles between these docks for which the total time would be a minimum size. It should take into account the fact that the stream of the cargo from any unloading dock may enter to the each loading dock. This situation determines the different times of transportation cycles. Determining the optimal size of the number of cycles in given relations will minimize the total time of transshipment operations between the input and output buffer. The process of determining the number of the transshipment equipment on relations: vehicles - the unloading dock and the loading dock - the vehicles has been omitted. In this case, the transshipment cycle time is constant and is not regarded as a problem of decision-making.

Additional assumptions:

- The minimum number of transshipment equipment is determined for a given time window in which a reloading process is realized.
- The cargo are delivered and reloaded in pallet loading units.
- The mean of transport used in the transportation cycle carries exactly one unit of cargo from unloading dock to the loading dock. Transportation cycles are carried out using one type of the mean of transport.
- The size of the product in each loading dock is known.
- The demand for the product in each loading dock is known.
- The transportation cycle consists of the following steps: transport the unit load from the input buffer to the output buffer and the return to the starting point.
- Geometric centers of unloading and loading dock determine the length of the driving route with or without the cargo.
- In order to simplify the model the assumption was taken that driving time with the cargo is equal to the driving time without the cargo.
3. THE GENETIC ALGORITHM FOR DESIGNATING THE NUMBER OF TRANSSHIPMENT EQUIPMENT IN THE CROSS-DOCKING SYSTEM

In order to determine the minimum number of the transshipment equipment a genetic algorithm was developed. The main task of the algorithm is to determine the minimum number of cycles in individual relations \((i, j)\). To form a genetic algorithm it is advisable to define the chromosome structure, the adaptation function, cross-linking process and mutation. Subsequent steps of formulating an algorithm are as follows:

- Step 1: determination of the structure of input data. The structure of input data was presented as matrices \(M(r)\), which present the number of transportation cycles between the unloading and loading docks for \(r\)-th type of the product. Lines describe the numbers of unloading docks and columns describe the numbers of loading docks. An example of a matrix of seven unloading and loading docks was shown in Figure 2.

![Figure 2](image)

**Figure 2** The structure of input data of a genetic algorithm for \(r\)-th type of the product.

Source: own study.

- Step 2: definition of the adaptation function. To search for the minimum value of the function of adaptation \(F_p\) for \(n\)-th structure, this function acquires the following form:

  \[
  F_p = C - T_n
  \]

  where: \(C\) - value higher than the value of total transportation time, \(T_n\) - the total transportation time in the \(n\)-th structure of the matrix \(M(r)\), \(m_{i,j,r}\) - the cell of the matrix:

  \[
  \forall r \in \text{DIR} \quad T_n = \sum_{i \in \text{DI}} \sum_{j \in \text{DO}} m_{i,j,r} \cdot t(i, j, r)
  \]

- Step 3: determination of the cross-linking operator. The cross-linking operator is adequate to the adopted matrix structure. To implement the cross-linking process for each type \(r\), two matrices are developed: \(\text{DIV}(r)\) which comprises rounded up average values from both parents, and matrix \(\text{REM}(r)\) containing information whether the rounding up was indeed necessary. Assuming that the value of matrices \(M_1(r)\) and \(M_2(r)\) (parents) in all cells assume determination \(m_{i,j,r}^1, m_{i,j,r}^2\) values of elements of matrices \(\text{DIV}(r)\) and \(\text{REM}(r)\) are calculated from the following dependencies:

  \[
  \text{dim}_{i,j,r} = \left\lfloor \frac{m_{i,j,r}^1 + m_{i,j,r}^2}{2} \right\rfloor
  \]

  \[
  \text{rem}_{i,j,r} = (m_{i,j,r}^1 + m_{i,j,r}^2) \mod 2
  \]
The full description of the cross-linking process was presented in [10], and presented in a graphical way to Figure 3. The applied cross-linking operator guarantees the correctness of individuals following a completed cross-linking process, without the necessity of using repair algorithms.

![Figure 3 Cross-linking of the matrix structure. Source: own study.](image)

- Step 4: determination of mutation operator. The operation rule of mutation operator consists in sampling of two figures $p$ and $q$ from the range: $2 \leq p \leq k$ and $2 \leq q \leq n$, which determine the number of lines and columns of a sub-matrix with dimensions $p \times q$ ($p$ - number of lines in the main matrix (processed by the algorithm), $q$ - number of columns in this matrix). The generated matrix is modified in such a way that the total value in columns and lines before and after the modification process is not changed. The detailed mutation process has been outlined in [10], and in a graphical way it was presented on Figure 4.

![Figure 4 Cross-linking of the matrix structure. Source: own study.](image)

Steps 2-4 of the algorithm are reiterated a given number of times, until the stop condition has been achieved. A condition for stop in the developed algorithm is the fixed iterations number. In the selection process the roulette method was adopted, while the process of cross-linking and mutation occurs with a defined likelihood set at the beginning of functioning of an algorithm. The final effect of the algorithm is the matrix that specifies the minimum number of cycles between the unloading and loading docks for $r$-th product and generates the minimum time of transportation cycles (minimum driving routes) for this product. The number of transportation cycles shall be determined separately for each type of the product. After entering the data into the formula (2),
we obtain the minimum number of the equipment which realize the transshipment of the cargo from the input to output docks.

4. CONCLUSION

Determination of the number of the reloading equipment in the cross docking system is a problem optimization. A decisive role in determining this number plays a total transportation cycle time between the unloading and loading docks. This time depends on the number of cycles between docks that are designated by the proposed genetic algorithm. A further direction of research related to the presented genetic algorithm is its implementation in the form of a computer application. To allow an in-depth analysis of functioning of the algorithm research should be performed using various selection methods.

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LOGISTICS WITHIN ECO-DESIGN OF PRODUCTS - SELECTED ISSUES AND CASE STUDY

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Abstract

Logistics is now becoming the key factor of competitiveness for many enterprises. It does not only result from economic reasons but is also the effect of stricter environmental protection requirements. The requirements are increasing with advancements in the development of tools that enable assessment of the environmental impact of products in their full life cycle. This involves the manufacturer's greater environment-wise responsibility for the product in the entire supply chain, which makes it necessary to consider solutions that will lessen the environmental impact at the earliest possible stages of the product design. A constant need arises to support enterprises in eco-design and to conduct research in this field to improve the eco-design methodological and organizational aspects. This paper discusses selected issues and challenges of the logistics process eco-design. In order to put a more practical perspective on the problems under consideration, it also presents a case study of eco-design towards logistics processes optimization using the SimaPro - a tool that assists in the product life cycle assessment. An environmental analysis of three eco-design variants is presented with a comparison of solutions applied to the assembly and disassembly of the turbine stator blades. 

Keywords: Eco-design, logistics process, turbine blades, life cycle assessment, environmental analysis

1. INTRODUCTION

The product design is usually created as a result of research and development activities of the manufacturer having appropriate knowledge and specific production potential. However, the knowledge turns out to be insufficient if eco-design is to take account of parameters concerning environmental functions and aspects which are essential from the point of view of suppliers, carriers, customers, retail dealers, waste management enterprises and those involved in the final phase of the product life cycle (the supply chain perspective). Therefore, eco-design assumes such supply chain management that enables effective communication and cooperation between partners in terms of the flow of environmental information, specification and discussion of environmental requirement (e.g. using the supplier's standards or environmental measurement systems), assessment of the suppliers' environmental activity, product re-design based on the customers' environmental preferences, establishment of programmes concerning the recycling of packaging, materials or the product as such, as well as the suppliers' involvement in environmental projects [1]. The importance of these actions increases due to the need to analyse environmental aspects at the earliest possible stages of the product eco-design and development. If done at later stages, inclusion of environmental aspects in the analysis may turn out to be impossible because of prior decisions of technical nature. The outline of problems related to the inclusion of environmental issues in the logistics process design presented herein is enriched with a case study revealing the impact of key decisions made at the design stage on the product assembly and disassembly being under the user's control.

2. ECO-DESIGN OF LOGISTICS PROCESSES - OUTLINE OF PROBLEM

The logistics process requires that the distribution, state and flows of its components, i.e. people, material goods, information and financial means, should be co-ordinated with other processes with respect to the criteria of location, time, costs and efficiency of satisfying desired objectives of the organization [2]. One of the examples of the logistics flow multidimensionality is the environmental impact [3], which depends, inter alia,
on the kind and amount of used resources and emitted pollution. It is worth noting the comprehensiveness of this impact in the holistic approach to the product life cycle reflected in the logistic supply chain. Due to changes in the customers’ purchasing habits and expectations, the supply chain has been expanded in recent years. More and more often now it is a logistics network. The logistics network concept assumes the use of the partners’ complementary capabilities not only to reduce transactional costs substantially and adapt to changes occurring in the environment quickly but also to create new technical standards and develop shared technologies [4]. This seems to be a chance for enterprises using eco-design as a tool that enables integration of environmental objectives at the product life cycle individual stages represented by the individual partners in the logistics network (Figure 1).

On the one hand, partners in the supply chain or in the logistics network (suppliers, manufacturers, consumers, logistic operators and third parties) are responsible for a certain part of the product environmental impact [3]. On the other, however, achieving a product with the smallest possible environmental impact in the entire life cycle requires synergistic actions taken as early as at the design stage. Owing to the development and implementation of environmentally friendly solutions based on synergistic actions in the supply chain, it is possible to improve environmental parameters in relation to the entire product system, and even to develop and implement eco-innovations [5].

It is not only that early inclusion of environmental aspects in the logistics process design provides a wider range of possible optimal solutions. In fact, it often conditions them. The solutions are the effect of design variants developed with respect to numerous criteria applied in the traditional design concept (such as operating properties, quality, costs, etc.) and additionally taking account of environmental criteria, including those related to the wide range of potential environmental impacts. Competitiveness, implied by the product functionality at different stages of its life cycle, has to be ensured as well. Eco-design also requires a search for compromise solutions within the environmental, technical, economic, societal, qualitative and other aspects.

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**Figure 1** Eco-design in the supply chain perspective

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under consideration [1]. Section 3 below gives consideration to challenges arising due to the application of these principles in the logistics process eco-design.

3. CHALLENGES OF THE LOGISTICS PROCESS ECO-DESIGN

The complexity of issues related to the eco-design of logistics processes involves the need to face the challenges in the subjective, objective and process dimension.

The eco-design subjects are users and designers [6]. The task of the designer taking account of the logistics process specific parameters is to identify the real needs of users, one of whom will often be the hypothetical user performing the function of the direct user [6]. It should also be remembered that design solutions do not only affect the direct user. They also have an impact on persons whose needs are often opposite, which is of special importance in the case of environmental aspects. For example, if a certain design solution involves polluting the atmosphere, health problems may arise for its other “indirect users”. Thus, the design objectives can be many and they may be perceived differently by different users. In the case of the design of logistics processes it may be necessary to apply participatory design, which assumes direct participation of all users in the design decision-making process [6]. A challenge that has to be faced in this context is the complexity of actions and decisions to be taken and made by the designer. This stands in contrast to the situation when a product is designed without taking account of logistic parameters that are beyond the manufacturer's control. Moreover, due to the present state of the art in the field of the product life cycle environmental impact, decisions made in eco-design are largely intuitive. In many cases designers do not have sufficient knowledge or experience needed to make the product meet environmental requirements at every stage of the product life cycle. It should also be noted that the designers’ responsibility for the final effect is now greater - it comprises not only the gate-to-gate analysis but also the wider cradle-to-grave perspective. Another important problem which is often ignored is the designers' position in the structure of the division of labour, especially in the case of designing complex logistics systems that require co-operation along the supply chain links. The challenge in this context is communication between partners in the logistics chain or network and in the team of designers.

The degree of the object design complexity is the premise for the application of systemic modelling in the logistics process design [6]. In it, an analysis can be conducted of the system elements, of the relations between separate systems and of the system-environment relationships. A systematic approach to logistics processes, such as transport, storage, packaging and reverse logistics processes, makes it possible to take account of the entire range of environmental impacts resulting from emissions of pollutants into the atmosphere, water and soil, from fuel, water and electricity consumption and from waste generation and management. The added value produced in the eco-design process is in this case the expansion of the design object by inter-system and system-environment relationships. An analysis of such a wide range of issues related to the object of design, with the multivariance of the solution concepts, is the challenge in eco-design of logistics processes, especially in the context of the need to find compromise solutions including actions taken to improve material and energy efficiency, economic use of land, cleaner production and use, durability of the product, optimized functionality, reuse, recovery and recycling of waste and elimination of hazardous substances and materials [1]. The selection of the design approach / approaches determines the environmental advantages gained throughout the product life cycle.

The main challenge of the eco-design process successful completion is the eco-design paradox, according to which the opportunity to improve a product in terms of its environmental impact decreases as eco-design proceeds. The course of the eco-design process is a function of the enterprise individual approach, within which patterns can be adopted from developed models of the inclusion of environmental aspects in the product design and development. However, it also depends on the complexity of the eco-design tasks. The technical report ISO/TR 14062 includes a general model of the inclusion of environmental aspects in the product design
and development process. The model is composed of typical stages of the process of the product design and development - planning, concept design, detailed design, testing / prototype, manufacture, launching into the market and the product review to introduce continuous improvements [1]. In the context of the logistics process eco-design, it should be stated that a possible alternative to sequential design is concurrent engineering. An essential feature of concurrent engineering is team work and simultaneous realization of individual stages of the design process. Concurrent engineering contributes to taking account of later stages of the product development at a possibly early design stage, which is especially valuable in the design of logistics processes. At the same time, however, it is also a great challenge of the eco-design process organization. The effect of the need to focus primarily on specific aspects of products and on the processes taking place in the product design is that the following concept is distinguished in concurrent engineering: the Design for X (Design for Excellence) [7], including for example the design for assembly, the design for disassembly or the design for recyclability - i.e. the approaches directly or indirectly related to logistics processes. The challenges arising from the design process computerization are also worth mentioning. The most important impact in recent years on the design process, and on the activities of designers, has come from computer-based data processing [8]. Computer-aided design (CAD) affects not only the design method, but also the organizational structure, the division of labour and the creativity of individual designers. Moreover, employees performing new functions (e.g. system managers, CAD specialists) get involved in the design process [8]. Consequently, many design tasks are performed using CAD tools, which is also important in the inclusion of environmental aspects in the design process [9]. Eco-design additionally makes use of tools dedicated to the analysis of environmental aspects. Methods, techniques and tools useful in the eco-design process can be divided into: (1) methods and techniques intended specifically for the environmental impact assessment, (2) methods and techniques dedicated to the assessment of eco-design options, the fulfilment the eco-design criteria and comparison of alternative variants and products and (3) software tools supporting the environmental impact assessment and eco-design, as well as tools broadly used in the design process, containing modules which enable to take the environmental aspects into account (e.g. SimaPro) [10]. The difficulty in the application of eco-design assistant tools lies not only in the selection of an appropriate tool from a large number of options but also in the fact that the tools do not have a universal character and specialist expertise is needed to use them. Another problem is that eco-design assistant tools, as instruments intended for a qualitative and quantitative assessment of environmental impacts, are not integrated with tools assisting in design in other areas (e.g. technical, qualitative, safety-related, ergonomic, etc.). Another challenge is the limited access to data gathered on the supply chain individual links. At the same time, it is possible to use databases containing a rich body of data related to logistics processes such as transport, packaging or waste recycling.

4. CASE STUDY

This paper presents an environmental analysis of selected variants of eco-design of the steam turbine stator blades in relation to an eco-design task performed within the design for assembly and the design for disassembly. Selecting the constructive variant within the eco-design affects the processes of assembly and disassembly, including the logistics processes and the related environmental issues. This impact is related, for example, to the transport conditions (taking into account protection of the blades from possible damage), the consumption of energy and materials and the production of waste concerning the packaging process, as well as the energy consumption concerning the logistics operations carried out under the turbine renovation and reverse logistics.

Additionally, adopting the perspective of the user (i.e. of the power plant), important parameters of the assembly and disassembly of blades are the ease of the operations and the time needed to perform them. These two parameters determine the undesirable downtime of turbines, which is eliminated or minimized. Therefore, the analysis of these aspects of the blade life cycle is conducted using many criteria. Consideration
of different variants of the blade design offers the chance to select the best solution satisfying both the manufacturer and the other stakeholders in the supply chain.

The analysis of environmental parameters was conducted for three variants of the stator blades:

- B1 - blades with spacers made separately,
- B2 - blades with integrated spacers,
- B3 - blades mounted on the stator ring.

A typical stator blade is composed of the profile and the root. The blade profile is streamlined to guide passing steam. The bottom part of the blade is the root with appropriate fastenings that keep the blade in a groove on the stator perimeter. The spacer is made together with the blade, but it can be made separately (Variant B1) or it can be the blade integral part (Variant B2) [11]. Blades with integrated spacers can also be mounted on the stator ring (Variant B3).

Blades with spacers made separately and those with integrated spacers are mounted in the grooves individually (one by one), and they need proper adjustment during the assembly (additional mechanical working). In the case of the stator ring (Variant B3), it is slid into a groove, prepared in advance, and secured with steady pins.

Blades with spacers made separately and those with integrated spacers are usually removed individually either by knocking or turning them out of the stator groove. In the case of Variant B3, the entire element is disassembled in a single operation, which makes it possible to save time and energy.

The environmental analysis of the variants described above was conducted using the SimaPro 8 Analyst in relation to a functional unit of 100 stator blades ready for assembly in a steam turbine and constituting the turbine stage.

![Figure 2](image)

**Figure 2** The normalized results of the environmental analysis of Variants B1, B2 and B3 in respect of the damage categories. A - life cycle perspective; B - assembly and disassembly perspective

Taking account of the stage of the sourcing of raw materials, of the manufacture of steel and blades and of the assembly and disassembly of ready blades in the turbine, the obtained results indicate that Variant B2 is the most favourable solution (**Figure 2A**). Variant B3 is the least favourable one in this case, as it involves the need to make an additional element - the ring.

Considering the environmental impact related to the assembly and disassembly operations, the best solution is Variant B3, whereas Variant B1 is the worst (**Figure 2B**). The knowledge concerning the environmental impact of the variants under analysis may be the subject matter of further research and of decisions made in co-operation with partners in the supply chain. It may also stimulate the search for compromise solutions taking account of other criteria, including economic and societal aspects [12].
5. CONCLUSION

The analysis of selected issues related to the logistics process eco-design reveals many problems and challenges. Overcoming them may contribute to the creation of environmentally friendly solutions satisfying the requirements of partners in the supply chain and those resulting from implementation of new systemic solutions. However, satisfactory green solutions cannot be obtained without co-operation of partners in the supply chain. Moreover, organizational problems have to be overcome, too. Environmental aspects are additional essential variables in the design process. This can be seen in the case study concerning the stage of the assembly and disassembly of the turbine stator blades. It is worth seeing in these additional variables not only a chance to reduce the negative impact of products on the environment but also an opportunity to gain economic advantage, stimulate innovation and improve the organization image.

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REFERENCES


APPLICATION OF SIMULATION TECHNIQUES IN LOGISTICS SYSTEMS DESIGN
USING A CASE STUDY OF WAREHOUSE FACILITIES

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Abstract

The effectiveness of simulation techniques in the design of logistics systems is becoming increasingly emphasized nowadays. With this in mind, a system design procedure, including simulation research, is proposed in this article. An important element of the developed procedure is the generation of the initial solution using classical design and optimization methods. This allowed us to obtain a solution from the decision maker which meets accepted functional and efficiency criteria for a tested logistics system. The application of this developed procedure is illustrated in the research project SIMMAG3D. A description of the created model was provided following the literature review of methods used to support logistics systems design and selected tools for simulation research of logistics processes. Analysis of the literature review shows that the current approaches turn out to be insufficient, especially when implemented separately.

Keywords: Modeling, simulation research, SIMMAG3D

1. INTRODUCTION

Currently, simulation research is a crucial element in system design and implementing changes within these systems. IT tools for simulation and visualization of logistics processes are considered essential in procedures by many researchers for the analysis and evaluation of a suggested logistics design option (see [3], [15], [17]). Application of the appropriate IT systems significantly improves logistician, analyst and designer work. This allows for the result analysis of decisions made in complex systems with variable parameters. While decisions are not made by the simulation, they do provide essential knowledge about system behavior during various disruptions.

Due to the high cost and length of time associated with creating and reorganizing logistics systems, extensive knowledge about the effects of implemented changes in such dynamic and rapidly changing surroundings is required. Therefore, simulation studies which allow us to predict the outcomes of decision making in hypothetical situations are particularly important. Unreliability of information and emergency situations are also taken into account in this type of research. In addition, by taking into consideration many different project design options for a specific logistical system, it is possible to choose the best option and improve upon it.

A procedure for logistics system design along with simulation research is presented in this article. This procedure may be applied to the design of logistical systems, including, for example, micro, mezzo and macro scale systems. The application of this procedure and simulation is demonstrated using the SIMMAG3D research project.

2. PURPOSE AND SCOPE OF CREATING SIMULATION MODELS

In theory, the definition of a system is very broad and may refer to many various fragments of our reality, including the flow of material goods and logistics systems [18]. Elements and relationships defined in a system
must ensure a possibility of carrying out specific functions resulting in the completion of its objective. The main goal of a logistical system is completing the conversion of cargo steams and their associated information streams on their path from the production site to the place of consumption [14].

It is crucial to create extremely precise models while analyzing existing or designing new logistical system structures on account of the fact that process completion is complex and determined by many technical, technological, organizational, economic and ecological factors.

Utilizing computer technology, it is possible to study the behavior of a created logistical system model under various conditions. The simulation allows us to observe how the analyzed system will respond in a given situation and accurately predict the result of decisions under certain conditions. The simulation method should be applied if it is not possible to use analytical methods. Therefore, simulation methods are particularly useful for studying complex systems, including logistical systems [18].

Furthermore, when considering uncertain information, it is appropriate to perform simulation studies for proposed and existing logistics systems because it is unfeasible to develop analytical relationships concerning the theory of mass service for complex systems (see [12], [14]).

The simulation model enables us to track the process in a certain system and obtain information that can be transferred over to reality [9]. Hence, this model is especially useful in determining the results of various decisions during logistics system development, analysis of current solutions and management [12].

Simulation methods are divided into two categories, fixed step and random, based on the way the simulation is performed [7], [12]. In the fixed step method, the simulations are completed periodically, whereas in the random method, they are only performed in moments of defined occurrences. Thanks to this, the effectiveness of the chance method calculation is usually significantly higher [12].

Furthermore, we can determine answers to research questions by: a complete review, undirected random search, directed random search, systematic search along consecutive coordinates, directed systematic search or heuristic search.

We can include the following as common goals of creating logistics system simulation models [12]:

- To determine a qualitative / quantitative influence of selected factors on system operation
- To establish values of specific functional characteristics of the system
- To compare alternative systems or factors under certain conditions or choose the best system option from a set of options.

3. PROCEDURE OF WAREHOUSE DESIGN TAKING INTO ACCOUNT SIMULATION RESEARCH

Designing logistics systems may pertain to new or existing systems. In the latter case, new solutions ensuring system adaptation to changing circumstances are sought out. When the design process concerns an existing warehouse, detailed information about its operation is available and can be obtained with the help of WMS software. However, in the case of new facilities, references should be made to their position in the logistics network, the resulting connections and intended flow of materials. A simplified procedure of new and existing logistics system design is presented in Figure 1.

According to this figure, simulation research must be performed after identifying the tasks which must be completed by the logistics system and creating a variant solution design.

In order to accomplish this, a simulation model must be created. They can be developed by using one of the tools available on the market (see point no. 5) or by applying an original program for warehouse process simulation, as was done in the SIMMAG3D project. Following a positive assessment of results from the
simulation experiments, it is possible to implement the design solutions into economic practice. Additionally, the best solution obtained with the help of analytical methods may be improved during simulation research according to the developed procedure.

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**Figure 1** Procedure for Warehouse Facility Design (own elaboration)
4. GENERAL ASSUMPTIONS OF WAREHOUSE FACILITIES SIMULATION MODEL

It is accepted that the created simulation model will allow the movement of individual loading units in a logistical facility to be reflected. In order to achieve this, it is necessary to consider the model’s technical resources, the technical, operational and economical characteristics and the occupations of employees. The visualization of the state of the warehouse facility will be ensured by reflecting the occupation status of individual locations through unit loads. Unit loads serviced by a given facility may vary by size, mass, color and other cargo characteristics, which may depend on capability and requirements on many levels of detail, from material groups to SKU. The types of loading units are defined in the set \( \mathbf{R} = \{ r : r = 1, \ldots, R \} \), and individual unit loads in sets are defined as \( \mathbf{N}(r) = \{ n(r) : n(r) = 1, \ldots, \overline{N(r)} \} \), \( r \in \mathbf{R} \). In the warehouse facility, unit loads undergo various conversions which can be classified based on location, time and state. The number of individual conversions are defined in the set as \( \mathbf{P}(p) = \{ p : p = 1, \ldots, \overline{P} \} \). The aforementioned conversions result from internal orders which are initiated by recipient orders or stock replacement processes. As part of the internal orders \( \mathbf{Z}(z) = \{ z : z = 1, \ldots, \overline{Z} \} \) defined loading units \( \mathbf{N}(r,z) = \{ n(r) : n(r) = 1 \} \), \( z \in \mathbf{Z} \) of individual types \( \mathbf{R}(z) = \{ r \in \mathbf{R} : \lambda(r) = 1 \} \), \( z \in \mathbf{Z} \) undergo certain conversions \( \mathbf{P}(z) = \{ p \in \mathbf{P} : \lambda(2p) = 1 \} \), \( z \in \mathbf{Z} \). Internal orders defined in this way reflect the logistical objective of a given warehouse facility. Completion of logistic objectives requires, with specified performance criteria, commitment of certain work crews (material and human resources) in established areas of the warehouse facility. These types of crews are defined in the set \( \mathbf{M}(zp) = \{ m(zp) : m(zp) = 1, \ldots, \overline{M(zp)} \} \), \( zp \in \mathbf{ZP} \).

Moreover, there are functional areas in a warehouse facility, such as zones, locations and connections between them. Both logistics facility resources and its structural elements have defined characteristics, for example, fixed cost and variable cost indicators of labor, technical readiness indicator, unit costs of servicing logistical units in individual elements of a logistics facility and capacity. Additionally, logistic tasks are completed by taking into account defined principles, including the choice of storage location, choice of labor resources, etc.

It should be noted that both requests to service unit loads in a warehouse facility and the conversion processes of the units themselves are dependent on time. The number of analyzed time of work at a warehouse facility is denoted in the set \( T = \{ t : t = 1, \ldots, \overline{T} \} \). The state of the warehouse facility is related back to individual moments in time, and the state of the warehouse facility is determined by the state of its individual elements. As it was already established, these elements are logistic units and work crews. The state of the \( n(r) \) th logistic unit of the \( r \) th kind at time \( t \) is denoted by the symbol \( x(r,n(r),t) \) and the state of the \( m(zp) \) th work crew of the \( zp \) th kind at time \( t \) is denoted as \( y(zp,m(zp),t) \). Therefore, the state of a warehouse facility at time \( t \) is defined as follows:

\[
\begin{align*}
\mathbf{X}(t) &= \begin{bmatrix} x(r,1,t) & \ldots & x(r,n(r),t) & \ldots & x(r,\overline{N(r)},t) \end{bmatrix} \\
\mathbf{Y}(zp,t) &= \begin{bmatrix} y(zp,1,t) & \ldots & y(zp,m(zp),t) & \ldots & y(zp,\overline{M(zp)},t) \end{bmatrix} \\
\mathbf{X}(t) &= \begin{bmatrix} x(1,t) \\ \vdots \\ x(\overline{R},t) \end{bmatrix} \\
\mathbf{Y}(t) &= \begin{bmatrix} y(1,t) \\ \vdots \\ y(\overline{ZP},t) \end{bmatrix} \\
\mathbf{SO}(t) &= \begin{bmatrix} \mathbf{X}(t) & \mathbf{Y}(t) \end{bmatrix}
\end{align*}
\]
The state of the system at time \( t \) results from its previous state, previously generated internal orders \( Z(t-1) = \{z \in Z : \tau(z) = 1\}, t \in T \), as well as disturbances occurring at time \( t \) \( A(t) = \{a(t) : a(t) = 1, \ldots, A(t)\}, t \in T \). Given this, and looking beyond the general definition of the process as a series of consecutive changes to the state of a system, the warehouse process is denoted in the following way:

\[ S_0(t) = f(S_0(t-1), Z(t-1), A(t)), t \in T \] (6)

5. SELECTED COMPUTER TECHNIQUES FOR LOGISTICS SYSTEM RESEARCH

Many suggestions for designing logistics systems using simulation research applications can be found in literature on this subject ([1], [2], [7], [12], [17], [18], [19]). It is possible to observe and track changes in system productivity, resources within the system and labor organization with the help of this type of research. This, in turn, allows us to appropriately select elements for equipping the facility.

Some specialized applications for simulation research mentioned in the literature are ([9], [16]): DYNAMO (DYNAmic MOdels) developed in 1959-1986 [4]; EXTENDSIM (formerly Extend) [10], [www.extendsim.com]; GPSS (General Purpose Simulation System) [www.minutemansoftware.com]; SIMPLE (Simulation of Industrial Management Problems with Lots of Equations) the first programming language used to convert model solutions into machine code [6]; SIMSCRIPT [www.simscript.com/about/]; SIMULA (SI MUlation LAnguage) developed until 1967 the first object- oriented programming language (Simula I, Simula 67) [11]; SIMULINK serves to perform computer simulations as a MATLAB numerical suite [www.mathworks.com/products/simulink/]; SLAM (Simulation Language for Alternative Modeling) [13]; STELLA (Systems Thinking, Experimental Learning Laboratory with Animation, also known as iThink) [4], [www.iseesystems.com/store/products/stella-architect.aspx]; VENSIM [https://vensim.com].

Another well-known tool for simulation research used in logistic system analysis is the program DOSIMIS ([8] or Flexim [20]). Moreover, there are many other tools for logistics process simulation with advanced graphics interface available. One of the new tools in this class is the program, eM-Plant. Among the new simulations tools which can be applied to logistics system research, the Enterprise Dynamics suite (formerly Taylor II) deserves attention [9]. It is a simulation program with advanced process flow visualization in 3D. This program can be applied to production, logistics and other system research [5].

The described simulation research tools often offer an ability to create cause and effect charts and structural diagrams, more or less customized to the nature of processes taking place in warehouse facilities. There is a lack of commercial tools, which fully reflect the nature of the processes which take place in real warehouse facilities, and most importantly, allows optimization of these facilities based on the productivity of processes. At most, it is possible to start with an initial solution, acquired by analytical methods in this field, and take a trial and error approach in order to obtain a solution meeting all required efficiency criteria. Therefore, a need to develop a tool dedicated to process simulation in warehouse facilities and visualization of the warehouse state has been identified, where the initial solution will be obtained with the help of implemented optimization tools or by importing real data from a WMS system.

6. CONCLUSION

An approach to logistic process simulation in warehouse facilities for the need of 3D visualization was presented in this article. The complexity and costliness of decision-making processes needed to appropriately design and equip warehouse facilities particularly justify the need to perform simulation research on initially obtained solutions. Thanks to this, it will be possible to discover potential errors and obtain insight on how the designed logistic facility will respond when its function is somehow disrupted. Additionally, due to the potential
application of many organizational solutions to specific areas of the warehouse facility, it is warranted that a system for simulation research contains a selection optimization of these solutions.

A developed simulation model allows a detailed analysis to be performed concerning the completion of converting individual loading units along with identifying their exact location in the logistics facility. Thanks to this, implementation of, for example, procedures pertaining to selection of assembly paths and obtaining near real-time completion of individual orders, will be possible. At the same time, the model will enable the acquisition of tools which will accurately reflect processes in warehouse facilities. Moreover, this tool will be compatible with WMS systems. To the authors’ knowledge, this kind of solution is not currently available.

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REFERENCES


WAREHOUSE LOADING FRONT SHAPING IN TERMS OF VARIOUS TECHNOLOGICAL SOLUTIONS OF THE EXTERNAL TRANSPORT

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Abstract

The choice of the proper loading area technology influences the warehouse process efficiency. That is why the efficient loading / unloading needs the optimal parameters of this area. Thus, the choice of the front load technological solution is one of the important stages of the cargo flow in the warehouse. It has a decisive influence on the quality of work carried out in the warehouse and the costs associated with the use of a particular type of technological solution of the loading / unloading area. The article presents the problem of the warehouse front load shaping. Authors examine 2 variants of technological solutions of the cargo front load. For the variant selection, the expenditures for the front load implementation were calculated.

Keywords: Warehouse, front load, SIMMAG3D

1. INTRODUCTION

The warehouse is one of the basic elements of the logistics infrastructure. In the logistics system, warehouse acts as a node where the goods are temporarily stored. The purpose of the warehouse is to ensure rapid and smooth flow of inventory, as well as the protection and maintenance of their value in use. Moreover, the warehouse task is also to ensure prompt and comprehensive flow of information [1, 2].

The basic function of warehouses, which are the main nodes in the logistics chain, is to receive, storage and then transfer materials to another nodes of a supply chain. Each warehouse has to be characterized by the optimal size and capacity. Capacity depends on the level of the warehouse mechanization, loading tasks, handling, storage and shipment. Providing adequate capacity is always associated with ensuring the optimum flow of goods through the warehouse [3].

Storage process is a set of activities performed during the flow of goods through the warehouse, from the unloading of external transport, by receiving, storage, completing, shipping and loading on the external transport. Carrying out the storage process provide technical and organizational conditions, which are: storage space, adequate facilities and qualified personnel [1, 4]. In the warehouse all the operations are carried out in separate areas, which are:

- Receiving area - external transport unloading, control, acceptance,
- Storage area - goods storage,
- Order picking area,
- Shipping area - shipping, control and external vehicles loading.

The speed of the warehouse process is influenced by the loading and unloading of external transport vehicles [5]. The loading front is one of the most important elements of the warehouse infrastructure. This is an area (loading docks or loading ramp) intended to carry the load work such as: loading, unloading, reloading [6]. Imprecise estimation of the size of loading front can lead to the reduction of system performance caused by too small loading front surface. On the other hand, the too large surface of the loading front will involve additional costs associated with the necessity of the fixed element maintenance.
2. TECHNOLOGICAL SOLUTION FOR WAREHOUSE LOADING FRONT

Technological solution of the loading front depends on the type of means of transport and handling, as well as the technology of loading work. The choice of technological solution of the loading front has a big influence on the storage process. In order to efficiently load or unload the cargo it is also necessary to determine the parameters of the loading front.

There are two alternative technological solutions of the loading front, which are the loading docks and the loading ramp. In the non-ramp warehouse, the warehouse floor level is at the level of loading platforms of external transport means. Docking system is fitted with mechanical or automatic gate suitable both for loading and unloading cargo units from the external means of transport. Standard loading dock consists of: gates; loading bridge and seals that protect the inner space of the dock and loading units against external influences. The number of loading docks specifies the number of the external transport means which can be operated simultaneously.

The ramp is a part of the construction of a warehouse building, which is an extension of the floor outside the building wall with a higher floor level. The height of the ramp should be equal to external transport means’ floor. Moreover ramps should have a smooth surface, indelible and adapted to the working pressure of handling equipment [3]. Examples of solutions of loading fronts are shown in Figure 1.

![Figure 1 Loading fronts examples a) ramp, b) dock](image)

Modern ramp as well as the docks are also equipped with loading bridges. The main task of loading bridge is to bridge the difference in height between the warehouse floor surface with the floor of an external transport vehicle. In warehouses serving vehicles of a fairly uniform machine park, where the height difference between warehouse floor storage / ramp and the floor of the vehicle is very small can, mechanical (manual) loading bridges can be successfully applied. On the other hand, in warehouses serving vehicles of varying floor heights, it is necessary to use hydraulic bridges. Examples of loading bridge solutions are shown in Figure 2.

![Figure 2 Loading bridges examples a) manual, b) hydraulic](image)
The use of loading docks is dictated by preventing heat loss inside the building as well as the securing of loads and the inner transportation against adverse weather conditions. In addition, depending on the organization of warehouse operation, individual loading docks can assign maintenance tasks to only certain types of vehicles or certain transport relations. Dependent on the dock, it is possible to use a dock as a “night delivery chambers”, where it is possible to unload the consignment just by a vehicle driver without any participation of the warehouse personnel after warehouse regular working hours [7].

The loading ramp in opposite to loading docks does not protect the load and the inner transportation from atmospheric conditions (particularly temperature for covered ramps). However, given the dimensions of the cargo docks and the recommended distance between them, it is clear that the loading ramp is capable of handling a larger number of vehicles at the same time on the same length of the magazine. Thus, to use the same amount of vehicle ramp will occupy less space, more versatile than the docks and also ensure a better use of space. Furthermore, in the case of the ramp it is also possible to unload the side of the vehicle [8].

3. CASE STUDY

In order to show the advantages of a given solution for the loading front, the expenditures connected with the setup of a loading ramp as well as the setup of the loading docks were calculated. The analyzed case is shown in Figure 3.

![Figure 3 Loading front variants a) loading docks, b) loading ramp](image-url)
The expenditures $D_C$ connected with the use of a variant with the loading docks were obtained through the equation 1 [7]:

$$D_C = (B_W \cdot W_H \cdot W_W \cdot C_W) + d \left( C_G + C_{LB} \right) + \left( MA_W \cdot D_L \cdot C_{MA} \right)$$

(1)

Moreover, the expenditures $R_C$ connected with the use of a variant with the loading ramp were obtained through the equation 2 [6]:

$$R_C = (B_W \cdot W_H \cdot W_W \cdot C_W) + \left( R_W \cdot R_L \cdot C_R \right) + \left( b \cdot C_G \right) + \left( LB_N \cdot C_{LB} \right) + \left( MA_W \cdot R_L \cdot C_{MA} \right)$$

(2)

The data necessary for the calculations are presented in Table 1.

The ramp length was calculated based on the number of operation places. In the article it is assumed that there is 9 operation places, and the single operation place width is 4 m.

On the basis of equation 1 and parameters for the Table 1, the expenditures $D_C$ connected with the use of the loading docks are:

$D_C = 2613600$ PLN

On the basis of equation 2 and parameters for the Table 1, the expenditures $R_C$ connected with the use of the loading ramp are:

$R_C = 2386400$ PLN

<table>
<thead>
<tr>
<th>Table 1 Calculation data</th>
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<tbody>
<tr>
<td><strong>Parameter</strong></td>
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<tr>
<td>$B_W$ - buffer zone width, [m]</td>
</tr>
<tr>
<td>$W_H$ - warehouse height, [m]</td>
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<tr>
<td>$W_W$ - warehouse width, [m]</td>
</tr>
<tr>
<td>$C_W$ - expenditures for the 1 $m^3$ of the warehouse [PLN / $m^3$]</td>
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<tr>
<td>$d$ - loading dock number</td>
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<tr>
<td>$R_W$ - loading ramp width, [m]</td>
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<tr>
<td>$R_L$ - length of the loading front for the ramp, [m]</td>
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<tr>
<td>$C_R$ - expenditures for the 1 $m^2$ of the loading ramp area [PLN / $m^2$]</td>
</tr>
<tr>
<td>$D_L$ - length of the loading front for the docks, [m]</td>
</tr>
<tr>
<td>$b$ - number of loading ramp gate</td>
</tr>
<tr>
<td>$C_G$ - expenditures for a single gate, [PLN]</td>
</tr>
<tr>
<td>$LB_N$ - number of the loading bridges for the ramp</td>
</tr>
<tr>
<td>$C_{LB}$ - expenditures for a single loading bridge [PLN]</td>
</tr>
<tr>
<td>$MA_W$ - maneuvering area width, [m];</td>
</tr>
<tr>
<td>$C_{MA}$ - expenditures for the 1 $m^2$ of the maneuvering area, [PLN / $m^2$]</td>
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</table>

4. CONCLUSION

Analyzing the calculations presented in the case study it is worth to notice that the choice of a solution of a loading front resolve the costs of its implementation. In the calculation example, the expenditures connected with the loading ramp implementation are 9.5% lower than the expenditures connected with the loading docks.
Both solutions have advantages and disadvantages specified in chapter 2. Taking into account the warehouse process time, the loading front is one of the most important elements of the warehouse.

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REFERENCES

MULTI-ECHELON INVENTORY MANAGEMENT - CURRENT STATE OF ART ANALYSIS
AND PROPOSED FUTURE RESEARCH DIRECTIONS

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Abstract

In the paper spare parts inventory management issues in the multi-echelon structures are discussed. Differences between spare parts and finished products inventories have been pointed out and discussed as well as differences between single-echelon and multi-echelon inventory optimization and structure. Current state of art analysis has been prepared as well as proposed future research directions.

Keywords: Inventory control, multi-echelon distribution systems, spare parts management

1. INTRODUCTION

As main functions of inventory management smoothing out irregularities in production flows and protecting against fluctuations in demands, lead times, differences in quality levels, differences in machine production rates or any other characteristics can be mentioned [1]. Therefore, the objective of inventory management can be considered as fulfilling the customer’s needs by stocking the right quantity of the products at the right time such that the total associated costs and investments in them are minimal [2]. Those statements can refer to work-in-process (WIP) or finished products inventories. However in service parts inventory management there can be identified some crucial differences. Spare parts can be defined as items kept in case other items of the same type are lost, broken or worn out [3], so their role can be considered as assisting a maintenance staff in keeping equipment in operating condition [1]. This statement indicates that the spare parts inventory management is a very important and sophisticated process because of its prevailing nature, magnitude and complexity [4].

Another issue related to inventory management and considered in this article are differences between single-echelon and multi-echelon systems. In single-echelon distribution system there is a management focus on determining the appropriate level of inventory for an item separately for every single supply chain level - the material flows coming out or entering the considered level are negligible [5]. In a multi-echelon inventory structure however, there is a need for determining the size of the orders for each echelon during each period so as to maximize a final customer service level and products availability and in the same time minimize total associated inventory costs across the entire network [6, 7].

The aim of this article is to present and discuss current state of art referring to inventory management in these two, mentioned and shortly characterized above, specific fields - there has been discussed spare parts inventory management issues as well as multi-echelon inventory problems.

2. MULTI-ECHELON INVENTORY MANAGEMENT

The problem of multi-echelon inventory control has been investigated by many researchers. One of the earliest works in this area were Clark’s and Scarf’s considerations on determining optimal purchasing quantities in a multi-installation model [8]. The authors, as one of the firsts pointed out that the assumption that a time lag is independent of the size of the order placed are not tenable in multi-echelon inventory management practice. The proposed Clark-Scarf model is the best-known technique for determining safety stocks in a multi-echelon inventory system [9]. Later on, S.A. Bessler and A.F. Veinott Jr. have devoted their work to search for the
optimal policy for a dynamic multi-echelon inventory model [10]. The authors have developed the model dedicated for single-echelon inventory problem with negotiable lead times. Another work, devoted to the dynamic analysis of multi-echelon supply systems was presented by J.F. Burns and B.D. Sivazlian [11]. Few years earlier, S.C. Aggarwal has presented a schematic diagram for inventory models taking their dynamics as the main criterion of classification [12]. Similar study devoted to classification of inventory systems was presented by R.H. Hollier and P. Vrat [13]. The authors decided to select such classification criteria as distribution channel structure, external company environment, inventory replenishment policy and inventory associated costs.

A.J. Clark and H. Scarf considered a finite time horizon in their model [8]. Their researches have been extended to the infinite-horizon case few years later by A. Federgruen and P. Zipkin [14]. P. van Beek has made an analysis of a multi-echelon inventory system comparing several alternatives for the way in which goods are forwarded from factory, via stores to the customers [15]. W.H.M. Zijm has provided a framework for the planning and control of the materials flow in a multi-item integrated production system [16]. The prime objective of this study was to achieve a pre-specified customer service level at minimum overall costs. Later on, M.C. van der Heijden et al. have analysed stock allocation policies in general multi-echelon distribution systems, where it is allowed to hold stock at all levels in the network in order to achieving differentiated target customer service level [17]. In another paper, the same author, has determined a simple inventory control rule for multi-echelon distribution systems under periodic review without lot sizing [18].

A dynamic multi-echelon inventory problem with nonstationary demands was studied by T. Iida [19]. The author proved that near-myopic replenishment policies are sufficiently close to optimal one not only in the single-location nonstationary inventory problem but also in the multi-echelon inventory problem. The research objective has been achieved by Markov decision process formulation for the decomposed serial inventory problem. Markov decision process technique has been used by the other researchers. F.Y. Chen et al. analysed the multi-echelon inventory control system with a periodic-review or lot-size reorder point replenishment policy for each location. The authors showed that each location's inventory positions are stationary and the stationary distribution is uniform and independent of any other's [20]. Optimal replenishment policies for multi-echelon inventory problems with Markov-modulated demand has been discussed earlier by F. Chen and J.-S. Song [21]. Optimal replenishment policies and approximations for a serial multi-echelon inventory system with time-correlated demand have been studied also by L. Dong and H.L. Lee, who provided a simple lower-bound approximation to the inventory levels and an upper bound approximation to the total system cost for the basic Clark-Scarf model [22].

S. Axsäter suggested and evaluated an approximate method for optimization of a two-echelon inventory system with continuous review and compound Poisson demand [23]. The proposed method was of interest in case of relatively large demands. In another work, the same author has provided a simple approximate technique for optimization of the reorder points in a quite general two-echelon distribution inventory system with batch-ordering [24]. The author has concluded that the proposed technique can be generalized to more than two echelons. M. Seifbarghy and M.R.A. Jokar also considered a two-echelon inventory system consisted of one central warehouse and many identical retailers [25]. The authors have developed an approximate cost function for a two-echelon inventory system where unsatisfied demand was lost and the control policy was continuous review. Similar studies were presented by R.M. Hill et al. [26] and S. Mitra [27]. Later on, S. Axsäter et al. have proposed three heuristics for handling direct upstream demand in two-echelon distribution inventory systems [28].

A. Ben-Tal et al. considered the problem of minimizing the overall cost of a supply chain over a possible long horizon under demand uncertainty [29]. M.-F. Yang an Y. Lin proposed a serial multi-echelon integrated just-in-time (JIT) model based on uncertain delivery lead time and quality unreliability consideration [30]. In another papers, the implications of considering power demand pattern and backorders in the one-warehouse N-retailer problem are addressed [31], and a multi-echelon inventory management framework for stochastic and fuzzy
supply chains has been proposed [32]. A.T. Gümüş and A.F. Güneri, had also proposed a literature review on multi-echelon inventory management in supply chains with uncertain demand and lead times [33]. Another work, proposed by K.-J. Wang et al. deals with optimizing inventory policy for products with time-sensitive deteriorating rates in a multi-echelon supply chain [34]. Proposed study empirically investigated how different deterioration rates in each echelon affected performances of individuals and integrated inventory policies. The authors have proved that joint cost function is convex to deteriorating rates of products. Similar study, where multi-echelon supply chain management for deteriorating items with partial backordering under inflationary environment was analysed was proposed by A. Shastri et al. [35].

A multi-echelon inventory system with supplier selection and order allocation under stochastic demand was introduced by C. Guo and X. Li [36]. The objective of the proposed model was to select suppliers and to determine the optimal inventory policy that coordinates stock levels between each echelon of the distribution system while properly allocating orders among selected suppliers to maximize the expected profit. A continuous review system was considered, but the authors noted that future work may consider a periodic review system. In another paper, L.E. Cárdenas-Barrón and S.S. Sana introduced a production-inventory model for a two-echelon supply chain when demand is dependent on sales teams’ initiatives [37]. In another study [38], O.H.D. Isaksson and R.W. Seifert have investigated quantifying the bullwhip effect using two-echelon data. Finally, N. Ekanayake et al. have presented a comparison of single-echelon and multi-echelon inventory systems using multi-objective stochastic modelling [7].

At the end of this paragraph it should be written that spare parts inventory management issues in multi-echelon structures has been intentionally neglected - they will be discussed in the next paragraph.

3. SPARE PARTS INVENTORY MANAGEMENT IN MULTI-ECHELON STRUCTURES

Numerous researchers have contributed to the development of spare parts inventory management systems. One of the earliest works in this area was Sherbrooke’s METRIC (multi-echelon technique for recoverable item control) model for repairable items [39]. The author considered the minimization of the total expected backorders at the depots in two-echelon spare parts inventory system, where item demand was compound Poisson with a mean value estimated by a Bayesian procedure. The researcher noted that, for high-cost and low-demand items the most appropriate inventory control policy is continuous review according to the (s-l, S) rule. The generalization of Sherbrooke’s model was presented later by J.A. Muckstadt [40]. Presented the MOD-METRIC model allowed for an inclusion of multi-indentures, i.e., hierarchical parts structures. Similar model, but for a single base was developed earlier by C.C. Sherbrooke [41]. Once again, C. C. Sherbrooke improved Muckstadt’s MOD-METRIC model in 1986 [42]. Presented VARI-METRIC model did not overstate expected backorders and did not overstate the expected availability of repairable items as pre-existing models. To achieve such quality of the VARI-METRIC model, the Grave’s approximation had been used [43].

These standard analytical models have been improved further. Y. Wang et al. analysed a two-echelon system for repairable items with a central repair depot and multiple inventory stocking centres [44]. The model extended former works by allowing depot replenishment lead times to be stocking-centre-dependent. J. Andersson and P. Melchiors, using METRIC-approximation as a framework, analysed a one warehouse several retailers inventory system and proposed a heuristic for finding cost effective base-stock policies [45]. A. Sleptchenko et al. considered multi-echelon, multi-indenture supply systems for repairable service parts with finite repair capacity [46]. The VARI-METRIC method has been modified and used - the authors have proved that the commonly used assumption of infinite capacity may seriously affect system performance and stock allocation decisions if the repair shop utilization is relatively high. M. Kalchschmidt et al. described an integrated system for managing inventories in a multi-echelon spare parts supply chain, in which customers of different size laid at the same level of the supply chain [47]. In another study, H.Ch. Lau et al. considered time-varying operations to repair items with no-indenture [48]. The authors studied a multi-echelon repairable item inventory system under the phenomenon called passivation. An efficient approximation model to compute
time-varying availability has been proposed and validated. In another work, K.E. Caggiano et al. considered inventory optimization in a multi-echelon system subject to time-based service level constrains [49]. In the paper, a practical method for computing channel fill rates in a multi-item, multi-echelon service parts distribution system has been described and validated.

M.H. Al-Rifai and M.D. Rossetti presented a two-echelon non-repairable spare parts inventory system that consisted of one warehouse and m identical retailers and implemented the reorder point, order quantity (R, Q) inventory policy [50]. The policy decision problem was formulated in order to minimizing the total annual inventory investment subject to average annual ordering frequency and expected number of backorder constraints. In order to solve the problem, the system was decomposed by echelon and location, expressions for the inventory policy parameters have been derived, an iterative heuristic optimization algorithm has been developed. Experimentation showed that the proposed optimization algorithm was an efficient and effective method for setting the policy parameters in large-scale inventory systems. A multi-item two-echelon spare parts inventory system in which the central warehouse operates under a (R, Q) policy was also considered by E. Topan et al. [51]. The objective of this study was to find the policy parameters minimizing expected system-wide inventory holding and fixed ordering subject to aggregate and individual response time constraints. Using an exact evaluation a very efficient and effective heuristic has been provided.

4. CONCLUSIONS AND PROPOSED FUTURE RESEARCH DIRECTIONS

The aim of this article was to present current state of art referring to multi-echelon inventory management. There has also been presented current literature on spare parts inventory management in multi-echelon structures. Analysing the pre-existing studies it should be noted that there are only few works, where authors analysed spare parts demand forecasting in multi-echelon distribution systems. It is necessary to extend those researches especially using non-conventional techniques.

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Abstract

The paper presents analysis and simulation studies on pallet rack system with shuttle trucks - version of shuttle-based storage and retrieval system (SBS/RS). The main attention was paid to systems based on Pallet Radio Shuttle technology. Paper concerns research and analysis of technical and organizational parameters selection in storage system Pallet Radio Shuttle type. For this purpose was developed FlexSim simulation model. Various structural and organizational variants of racking system were investigated. Individual variants were distinguished by different numbers of rack bays, storage levels, depth of the tunnels, as well as the number of shuttles.

Keywords: FlexSim simulation, shuttle truck, pallet rack system, SBS/RS

1. INTRODUCTION

Different technologies are applied to store materials, but four factors are always considered: 1/ efficient space usage, 2/ maintaining proper storage conditions, 3/ maximizing accessibility to materials, 4/ maximizing throughput. Racking systems of different types serve these four conditions to a different extent.

Striving for better space utilization and higher input/output rates led to storage systems combing dense storage like drive-in or drive-through racking with automated storage and retrieval systems based on robotized units for material handling. This is how pallet racks with shuttle trucks (PR-ST) appeared. PR-ST are considered as space effective, but considerably expensive solution. The cost of one autonomous shuttle can reach 20 000 euros what makes PR-ST expensive in comparison to classic racking systems. This is why PR-STs must be carefully configured to achieve proper effectiveness and productivity but there are no general rules for that. Consequently simulation can be used as a strong support in configuration. The purpose of this paper is to evaluate throughput performance of an PR-ST using simulation with FlexSim software. The performance of the studied system is evaluated in terms of average cycle, time (for dual command), which is expressed by the system throughput capacity and number of handled units (cycles per hour).

PR-ST is a type of shuttle-based storage and retrieval system (SBS/RS) discussed in [4], [5], [6] or [8] and defined as system of tier-captive shuttle carriers, multiple elevators with a lifting table, and racks. Lerher et al. (2015, [4]) present a simulation-based performance evaluation of SBS/RS. Performance comparison of the studied SBS/RS is contrasted with alternative storage rack configurations. The same authors present (2015, [5]) analytical travel time model for SBS/RS confirming their simulation experiments. Ning et al (2015, [6]), examine SBS/RS by simulation and propose efficient simulation model that can be auto-remodeled for different rack configurations. Model allows to test a large number of rack alternatives and to determine the optimal solution efficiently. Eder and Karting (2016, [7]) examine geometry of the rack for shuttle system as a critical factor influencing throughput. Similarly Ekren et al. (2015, [8]) look for best rack design for shuttle-based storage and retrieval system, but under class-based storage policy (CSP). They evaluate by simulation performance of the system in terms of utilizations of lifts and storage / retrieval devices and cycle times of storage / retrieval transactions. In other place Ekren (2016, [9]) provide a graph-based solution for performance evaluation of SBS/RS, under different number of bays, aisles and tiers for the rack design and arrival rate of storage / retrieval. Zou et al. (2016, [10]) investigate the same problem and propose a parallel processing
policy for the system, under which an arrival transaction can request the lift and the vehicle simultaneously. The concept is validated by simulation. Güller and Hegmanns (2014, [1]) discuss miniload multishuttle system which is similar to pallet version. Authors propose agent-based simulation approach to evaluate the performance of the system. Perotti et al. (2014, [2]) study Automated Vehicle Storage and Retrieval Systems by analysing their performance through analytical modelling and simulation. Chen and Li (2015, [3]) check the double-shuttle system with AS/RS and prove by simulation its effectiveness. Jacyna et al. (2015, [12]) as well as Lewczuk (2012, [12]) place a PR-ST in warehouse design procedure and discuss the role of storage systems in warehousing.

2. PALLET RACK SYSTEM WITH SHUTTLE TRUCKS (PR-ST)

PR-ST is automatized version of block storage of palletized goods in racks. It has inherited advantages of conventional drive-in, push-back and gravity flow racks but eliminated some of their disadvantages. The basic idea of block storage is to store large stock of palletized goods while extra warehouse space is freed by eliminating work aisles from the system. Using racking constructions ensures safe storage of delicate and instable goods which can’t be stacked.

PR-ST is considered as last step in block storage and as a successor of drive-in racking systems. Both systems are based on the storage by accumulation principle, which enables the highest use of available space. Two operation versions are possible: the drive-in system, with only one access aisle, and the drive-through system, with access to the load from both sides of the rack. In both options rack is fed and emptied by a truck entering the racking construction (Figure 1). In the first option first loaded unit is placed on position 1. and rack is fed from bottom to top and from back to front (Figure 1a). Emptying happens in reverse from front to back and from top to bottom. Loading and emptying sequence is realized according to LIFO. In drive-through racking systems loading and emptying is done from opposite sites according to FIFO (Figure 1b).

Push-back is another technology of block storage in racks. Push-back uses flow-through racking system which is loaded and emptied from one side only. This technology ensures high space utilization by eliminating work aisles, but it supports only LIFO principle and is limited by number of wheeled carts in rack. To feed push-back rack palletized load is placed on a cart and pushed against gravity inside the rack. Wheeled carts are stacked inside each other (usually 3 to 5) and wait on the rack forehead to be pushed inside with a pallet on it. To empty the rack the first pallet in a line is retrieved so the gravity forces other carts down. Empty carts stack together.

Gravity flow rack uses tunnels with rollers to make gravity flow of pallets possible. It is fed from one side and emptied always from the other one. Construction is limited only by durability of pallets while the first one in line is squeezed by the rest pushed by gravity. Gravity flow rack is not expensive and supports only FIFO.

All discussed constructions can be superseded by PR-ST. Pallet rack system with shuttle trucks consists of specialized rack frame and remotely controlled transfer (satellite, shuttle) trucks. Racks form multilevel
structure with tunnels (or lines) for palletized products. Typically whole tunnel is intended for single, homogenous product. Pallets are handled in tunnels by shuttle trucks (Figure 2), which are disposed to the front or rear of tunnel by standard forklift truck in semi-automated system or by pallet crane in fully automated system. Loading and unloading pallets is done automatically by shuttle truck while work-orders are transmitted to the truck remotely. Shuttle truck travels under the pallet line on special rail system and lifts selected units up to move them according the work-order. After accomplished task truck returns to the initial position and can be disposed to other tunnel by forklift truck or pallet crane.

PR-ST can be configured in different ways to support different flow-strategies:

- FIFO - feeding and emptying tunnels on opposite sides,
- LIFO - feeding and emptying tunnels from the same side,
- pick tunnel - combination of PR-ST with a dynamic pallet flow case pick tunnel (higher levels of rack handled by shuttle trucks are used as reserves for picking areas on lower levels),
- mezzanine for staging (PR-ST system in combination with a structural mezzanine) - Figure 3.

Unlike conventional drive-in or drive-through racking, the operations guided by shuttle trucks eliminates any unwanted entry of material handling equipment or human into the racking structure, thus ensuring higher safety of material, equipment and people.

![Figure 3](http://www.radioshuttle.co/)

**Figure 3 Examples of configuration pallet rack system with shuttle trucks.**

Drive-in racking accommodates a large number of pallets for each SKU. High-density of storage favors PR-ST systems for compact storage, cold storage, and buffers for temporary storage of replenished materials or ready-to-ship units. It is good for cold storage since it maximises the use of the cold store volume, reduces manoeuvring times and eliminates human factor from harmful environment. So PR-ST system is an ideal solution for FMCG, pharmaceutics, electronics etc. It is typically used where huge volumes of standard type products are stored. System is even more efficient when used in conjunction with automated feeding and emptying systems. The advantages of PR-ST compared to conventional compact systems are the following:

- Reduced pallet loading and unloading times.
- Different SKUs can be stored in each lane, and one SKU can be in different tunnels.
- Storage tunnels can be more than 40 m deep.
- Single work aisle is needed regardless of tunnel depth.
- Productivity can be increased by adding more shuttles.
No need to drive forklifts into the racks (safety, lower rack damage risk, lower risk of accidents).
Less forklifts and their operators.
Elements of AS/RS.
Better stock control.

The disadvantages of PR-ST systems compared to conventional compact systems are the following:

- Expensive automated shuttle trucks are necessary for operation.
- Some space is wasted for technical tunnel for shuttle truck.
- Materials are not immediately accessible from the front of rack like in gravity flow or push-back rack.
- Insufficient number of shuttles reduces productivity of storage.

The advantages and disadvantages listed above name the basic problems with PR-ST to be solved:

- What is the rational number of shuttle trucks to make the process reliable and smooth?
- How deep, wide and high should be racking construction to keep the stock and be effective?
- How many forklift trucks or cranes must be used to support PR-ST?
- Is the PR-ST really cost-effective in analysed case?

3. ASSUMPTIONS FOR SIMULATION ANALYSIS

Model of pallet rack with shuttle trucks (PR-ST) developed in FlexSim is composed of (Figure 4):

- single pallet rack for block storage, rack height, length and depth can be arbitrarily modified,
- set of shuttle trucks for handling pallets in rack tunnels,
- set of cranes to dispose shuttle trucks between tunnels and transport pallets to/from tunnel forehead,
- sources of entries and dispatches, and mouths for pallets leaving the racking system.

![Figure 4 Model of PR-ST in FlexSim](image)

System is initially empty. Time of enter of batches of units is given by Poisson distribution time. The number and type of units in a batch is set by uniform distribution (2 to 10 units of one of 50 types). Units are assigned to tunnels where other units of the same type are actually placed. The tunnel for new type of unit is selected according to location sequence. All units for which there is no place in rack are moved to temporary buffer where they wait for re-disposal. Dispatching orders are generated in accordance with normal distribution. Type
and number of dispatched units follow the same distributions as entries. If demanded SKU is awhile not on stock order is added to the list of waiting orders where it stay until appropriate SKU enters the system. Modeled racking system supports LIFO. Each tunnel can keep only one SKU at the time.

The procedure of putting units into rack is realized as follows:

- Unit is assigned to the location in a specific tunnel when task enters the system.
- Algorithm browses all tunnels starting from the closest one (locations sequence). If the same SKU was found in and there is free place in that tunnel unit is assigned to. If that SKU is not on hand at the time or tunnel if full algorithm takes the closest empty tunnel and assigns unit to.
- Successful assignment pushes task to realization list while failed assignment pushes it to waiting list. Tasks from waiting list take priority in realization over new tasks appearing in a system.
- When task is picked from realization list, the algorithm checks availability of crane and shuttle truck on the forehead of the tunnel assigned to the unit.
- The closest free crane (in Cartesian coordinate system) is selected.
- If shuttle truck is available and in the place, crane puts the unit on the forehead of tunnel. Shuttle truck takes unit and transports it to the location in a rack.
- Empty truck returns to the tunnel’s forehead and waits for disposal. Crane doesn’t wait until truck returns.
- If shuttle truck is not available in tunnel it must be moved from other tunnel. The closest free shuttle truck (in Cartesian coordinate system) is moved to the assigned tunnel’s forehead by crane and waits for unit.

Retrieval procedure is similar to presented above.

4. SIMULATION RESULTS

Analyzed case covered 8 scenarios for 2 different variants of racking system. Each scenario involves different number of shuttle trucks (from 1 to 8). I the first variant racking system is constructed of 10 columns with 5 levels (50 tunnels) 30 units depth. In the second variant racking system embraces 30 columns with 5 levels (150 tunnels) 10 units depth. Simulation was replicated 20 times for all scenarios in both variants. Model was set for 24 hour work-day. Rack is initially empty. Entering starts from the beginning while dispatching starts in 6th hour of simulation (time shift necessary for saturating rack with units).

The evaluation criteria was total sum of stored and dispatched (serviced) units. Productivity of PR-ST system was reported for 18 hours, since 6th hour of simulation when both entering and dispatching processes burden system. Simulation results are presented in Figure 5 and Figure 6. It can be noticed that in both variants of racking construction total productivity of the system reaches quickly maximum and doesn’t grow despite an increase in number of shuttle trucks. In the first variant maximal productivity is reached with 4 trucks (but maximal average value is reached with 5 trucks for 90% confidence). In the second variant maximal productivity is reached with 2 shuttle trucks (but maximal average value is reached with 4 trucks for 90% confidence). In both variants significant increase in productivity is noticed when system switches between 1 and 2 shuttle trucks. Productivity in following scenarios doesn’t grow so intensively (see Figure 5 and Figure 6). The situation is clear since only one crane is used to dispose shuttle trucks and handle pallets.

One crane can operate efficiently only limited number of shuttle trucks. Potential usage of other trucks is hampered while system is limited by crane. The number of shuttles equal to number of tunnels eliminates re-disposing shuttles between tunnels so the productivity reaches the highest level and depends only from crane and units assignment pattern. Of course it is not economically justified.
Another important issue is a number of handled (put and retrieved) units, which is almost twice higher in all scenarios of second construction variant. The first variant compared to second one had fewer longer tunnels (50 tunnels with 30 locations in first variant and 150 tunnels with 10 locations in second variant). It means that average entering time was much longer in first option. That loss of time was not offset by shorter routes on the rack forehead in second variant. Therefore, the first construction variant is characterized by longer in-rack operation-times and consequently reduced availability of shuttle trucks for tasks.

5. CONCLUSION

Simulation study has shown that productivity of examined PR-TS is not proportional to the number of used shuttle trucks. The number of installed shuttle trucks is crucial, since it is strongly correlated with frequency and intensity of entries and dispatches, racking system configuration, number of disposing equipment (cranes) and task sequencing strategy for the selection of shuttle trucks. Racking configuration influences productivity of whole system. Productivity is higher in configurations with shorter rack tunnels, when shuttle trucks are more accessible because spent less time on in-rack operations.

Automated storage with pallet shuttle trucks allows a significant increase in productivity. When transfer cars are installed to work independently on each level, the number of incoming and outgoing pallets is increased exponentially, but configuration must be investigated before expensive trucks are bought.

ACKNOWLEDGEMENTS

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CUSTOMERS’ REQUIREMENTS AND LOGISTICS PROVIDERS’ READINESS FOR MAKING THE SUPPLY CHAINS MORE ENVIRONMENTALLY-FRIENDLY - POLISH EXPERIENCES

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Abstract

In order to reduce the negative effects of logistics services, a lot of attention has recently been directed towards the concept of green transport and logistics. The role of the customer (For the purposes of this paper, the party of the sale-purchase contract who is responsible for initiating a shipment and who bears the cost of transport is considered the customer (purchaser, buyer of the transport / logistics services)) - purchaser of transport and logistic services - is considered to be crucial in the development of green initiatives among freight forwarders and logistics services providers (FF/LSP). Therefore, the main purpose of this paper is to elaborate on the correlation between green requirements of customers, if any, and the readiness of FF/LSP to satisfy such needs and to design logistics operations that are aligned with the environmental objectives and targets.

This analysis is based on desk study research, content analysis as well as a survey among FF/LSP acting in Poland. The questionnaire was designed to give answers to, among others, the following questions: (a) Do the customers express their need or preference for supply chains or specific logistics process with the least negative impact on the environment? (b) Are the FF/LSP prepared to fulfil the green requirements of their customers?

The study revealed that there is a potential for developing green transport and logistic services on the Polish market, however, it is jeopardised by unsatisfactory environmental awareness of both parties of the transport / logistics contracts as well as insufficient infrastructure. Currently, there is no noticeable demand for the green solutions, which are still perceived as burdensome and requiring additional financial resources.

Keywords: Green purchasing, logistics service provider (LSP), green logistics services, customers’ green requirements, Polish logistics market

1. INTRODUCTION

Environmental concerns have spread across many areas of human life and activities. The sector of transport and logistics has also been affected by rising environmental requirements, especially due to negative external effects and its contribution to the global environmental problems. Despite a considerably reduction in air pollution from the EU transport sector over the past decade, it is still the largest contributor to NOx emissions (46% of total EU-28 Emissions), as well as a rising source of GHGs (21% above 1990 levels). [1] The concept of green transport and green logistics, where “green” means the least negative impact on the environment comparing to BAU, is an answer to the problem of air pollution emissions from these sectors.

This research is part of an ongoing project on the state of green transport and logistics in Poland and focuses only on one particular step in the transport / logistic process, namely the purchasing of transport, forwarding or logistics (TFL) services. There is a gap in research of relationships between freight forwarders / logistics services providers (FF/LSP) and their customers with regard to green purchasing. This research gap in green buyer-LSP relationships was also noticed by Evangelista et. al. [2] and there are only a few papers that explore this topic, of which none concerns the Polish market.
Therefore, the purpose of the paper is to bridge this gap and elaborate on the correlation between “green” requirements of customers, if any, and the readiness of logistics operators and freight forwarders to satisfy such needs and to design logistics operations that are aligned with the environmental objectives and targets. This research only considers the Polish TFL market.

2. PURCHASING GREEN TRANSPORT AND LOGISTICS SERVICES

The literature offers a lot of definitions for green logistics, starting in the late 1990s, which have evolved over time alongside with the rising importance of environmental concerns and development of such concepts as green manufacturing, green product design, waste management, reverse logistics, and finally the green supply chain management concept. It is enough to refer to the definition provided by Rodrigue and Slack [3], that green logistics is “supply chain management practices and strategies that reduce the environmental and energy footprint of freight distribution. It focuses on material handling, waste management, packaging and transport.”

This is an interdisciplinary topic which may be researched from different points of view as there are different instruments (e.g. legal, technical, organizational) which enable tackling this complex issue. There are also different factors initiating the incorporation of environmental consideration into a decision-making process in logistics. These include governmental and international laws and regulations, organizational green awareness, environmental activists and non-governmental organizations, and finally, customer requirements. [4]

The customer-FF/LSP relationships are particularly interesting with regard to purchasing of green transport and green logistic services and the role of purchaser is considered to be crucial in the development of green initiatives among LSPs. [2] The process of purchasing is that one, where both parties may interact: customers may express their needs for a green service and urge the FF/LSP to provide it, and the FF/LSP may offer green services and try to persuade their customers to buy them. As the environmental concerns are likely to grow in the near future, the importance of the “green” criterion for selecting FF/LSP is also expected to rise. FF/LSP should follow the needs of their customers, e.g. producers / retailers, who pursue their environmental goals and are investing a lot to reduce their environmental impact. [5]

The problem of green purchasing and offerings may be considered and researched from different perspectives. A majority of studies investigates this problem exclusively from the perspective of LSPs [e.g. 6, 7, 8] and their involvement in applying green logistics initiatives in the event of rendering logistics services to its customers. The companies researched have typically already adopted green practices in their transport / logistics business. [9] The customer perspective is elaborated much less frequently, for example, by Sarkis [10] and Martinsen and Björklund [11]. The issue of green purchasing has been researched generally or with regard to the particular domestic TFL market as for example the well-developed Swedish, Italian and Irish markets [2], or still being in the phase of development - the markets in Malaysia [9] or in South Africa [12].

3. TFL COMPANIES AND THEIR GREEN PRACTICES

There are different rankings of TFL companies that operate in Poland, however, the most recognized is that prepared by H. Brdulak. [13] Its latest, 21st edition, provides information about 62 TFL companies, the biggest ones according to their volume of revenues. These companies, considering their scale of operations, are usually very innovative and may establish certain trends, including green ones. The comprehensive content analysis of their websites, newsletters, reports, etc., with regard to information on their green practices revealed that 37% of these companies do not provide information of such kind. The remaining companies carry out (or write that they carry out) more or less advanced green activities. The table below (Table 1) presents the most popular green activities and the number of companies that informs about putting them into practice.
Table 1 The most popular green activities and the number of companies that put them into practice

<table>
<thead>
<tr>
<th>Green initiative / activity</th>
<th>Number of companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 14001 Environmental Management Certification</td>
<td>16</td>
</tr>
<tr>
<td>CO₂ Calculator</td>
<td>4</td>
</tr>
<tr>
<td>Eco-driving (inter alia: periodical trainings for drivers; eco-driving school; monitoring of eco-driving parameters)</td>
<td>7</td>
</tr>
<tr>
<td>Vehicle technology (engines EUR 5 and EUR 6, use of energy saving tires)</td>
<td>9</td>
</tr>
<tr>
<td>IT optimized route planning and fleet management</td>
<td>6</td>
</tr>
</tbody>
</table>

Other initiatives that have been mentioned include: e-documents instead of paper documentation; carbon dioxide emissions reporting; environmental policy; improvement of environmental awareness of employees - environmental education for staff; selective waste collection and cooperation with recycling organizations; certification for warehouses.

4. SURVEY FINDINGS

In order to accomplish the purpose of this paper, we decided to conduct a survey among freight forwarders and logistics providers acting in Poland. We decided to evaluate the problem from a FF/LSP perspective while getting to know what the real demand for environmental services is in Poland.

We created a questionnaire using the form template provided by Google Forms and we also used this tool for distribution of the questionnaire as well as for collecting answers. In order to send the questionnaire to as many TFL companies as possible, we asked the Polish International Freight Forwarder Association to place information about the research and a link to the questionnaire in their weekly newsletter. To enrich the survey results, as the number of responses was significantly lower than originally envisaged (the respond rate was 27%), we also decided to conduct an open-ended interview with management staff of well recognized FF/LSPs.

As far as the phase of purchasing transport / logistic services is concerned, the outcome of the survey revealed that:

- Only ⅓ of respondents admitted that customers expressed their requirements with regard to design / perform the transportation / logistics process with the least negative impact on the environment. These requirements are reflected in relevant documents as forwarding orders or contracts.
- However, these requirements are incidental and concerns only a minority of customers, so the share of “green” requirements in the total number of customers / shipping orders is rather scarce and the maximum share according to the answers is 15%. Usually there are only a couple of customers (one or two) interested in green solutions in the total portfolio of customers.
- The large companies, both domestic and international, mainly producers or big retail chains, are the buyers of TFL services that expressed their needs for environmentally-friendly SC. Eco-friendliness is often a condition of signing a contract with an FF/LSP by global companies, which care about their public image (for example, Coca-Cola, Ikea). Usually it is not a single forwarding order but a long-term contract, when the FF/LSPs is inclined to introduce green solutions.
- In the majority of cases (60%) “green” requirements refer to the modes of transport (vehicle technology as EUR 5 or 6 standards or particular means of reducing the consumption of fuel and emissions). Customers also noticed the potential for intermodality and requested reducing the share of road transport in favour of rail transport or short sea shipping; however, the interest in these solutions is far
less (only 20%). According to the respondents, no interest was shown with regard to green warehousing processes.

- We also asked what parameters of TFL services are the most important to their customers. Unsurprisingly, the price of the service received the highest rank (67%), time of delivery as well as time-keeping gain almost of equal importance (about 50% of the highest rank), risk of loss and handling of complaints are factors of less importance. Influence on the environment is a factor of no or very low significance for 73% of respondents.

With regard to FF/LSP readiness for making the transport and supply chain more environmentally-friendly, the responses divulged as follows:

- Slightly more than half (54%) of FF/LSPs are prepared to fulfil the green requirements, however, nearly ⅓ have never been asked to do so. The remaining companies have admitted that they are focused solely on their costs and the quality of their services.
- The green criterion is not considered when choosing a subcontractor, unless it is expressly required by the customer.
- FF/LSPs do not encourage their customers to choose a green solution and do not offer a possibility of greening their service in order to enable them to distinguish themselves from other companies.
- The environmental factor is not considered a competitive advantage or an added value to the logistics services.
- Almost 40% of FF/LSPs predict a rising interest in green solutions, with the remaining part believing the opposite; the latter claimed that there is lack of both: eco-awareness and a willingness to pay for eco-solutions.
- Greening the TFL services is commonly perceived as burdensome and requiring additional human as well as financial resources and specialist know-how.

One of the answers from our respondents is an excellent illustration of the general attitude of FF/LSPs to the development of environmentally-friendly services in Poland: “Unfortunately (underlining added), we expect a rising interest from our potential clients in “green” solutions. We think that our sector is not yet prepared for introducing the green solutions. We are still far away in terms of infrastructure, as well as with regard to the environmental awareness. We are still trying to achieve Western standards and always something new disturbs our pursuit of normality.”

5. DISCUSSION

The lack of a broader interest in green TFL services on the Polish transport and logistics market may be attributed to its relative immaturity. The Polish TFL market is a very young market when comparing to markets of Western European countries. It is continuously being developed since the beginning of the 1990s alongside with the process of transformation of the Polish economy to the market rules and further accelerated in 2004 after joining the EU. Currently, there are tens of thousands of road transport companies registered in Poland and several dozens of companies that hold a licence for the carriage of goods by rail. As far as forwarding companies are concerned, it is difficult to provide their exact number, because forwarding is often regarded and registered as additional to the core activity of a TFL company. They include global, foreign-owned companies and smaller ones of mixed or Polish capital. Green solutions are usually implemented by medium and large-sized enterprises of sufficient financial capability and an international organizational culture that foster development of environmentally-friendly practices. The smaller LSPs are willing to do so mainly in the perspective of long-term cooperation with a significant customer which pursues its environmental objectives and has enough financial resources to put it into practice.

Some authors claim that “adoption of green logistics initiatives also varies according to the type of services a company provides” [9]. Close examination of the range of services provided by LSP on the Polish market
revealed that a majority of them offers from 1 to 9 of different logistics-type services [13] and there isn't any correlation between the number or type of rendering services and implementation of green logistics and transport solutions.

The Polish TFL sector still encounters problems connected with the liner infrastructure inherited after the period of the centrally planned economy. The “infrastructure gap” is gradually diminishing and the network of motorways is being developed (at the moment there are 1,631 km of motorways in Poland). However, the environmentally-friendly modal split is hindered by the condition of railway and inland waterway infrastructure accompanied by an insufficient number (only 30) of modern intermodal terminals. The same problem concerns warehouses. The majority of modern warehouse spaces in Poland does not foster the development of a green modal split, especially due to the lack of access to railway infrastructure, as well as to inland waterways.

Lots of changes are taking place in the area of warehousing. Modern warehouse spaces which were built in recent years have already incorporated other green solutions and 25 of them are also eco-certified (18 warehouses with BREEAM and 7 with LEED certificates) [14]. It is not an impressive amount, considering the fact that there is a total of 10.5 million square meters of modern, commercial spaces in Poland. This could be the reason for LSP’s limited opportunities for incorporating green warehouse services into their offer.

6. CONCLUSION

Although currently the demand for green transport and logistics services is not noticeable on the Polish market, there is a real potential for their development, and some of the FF/LSPs have already noticed a rising interest in green solutions. This potential may be supported by both: environmentally aware customers and LSPs that have already adopted or are ready to adopt green logistic solutions. They are aware that the green factor may also differentiate them from other companies on the market and should be considered as a competitive advantage.

Greening of the Polish TFL market is still in its early stage of development, but the process must be continued. Polish TFL companies do not operate in a business vacuum, they are actors in global supply chains and the lack of commonly known or implemented eco-standards on a mature market may put them out of business and result in re-configuration of such a supply chain in the future.

The phase of purchasing is crucial for incorporating green criteria into the particular forwarding order or the contract. The negotiation between customer and FF/LSP creates a space to exchange ideas as well as enables “mutual green education”. The importance of green purchasing should be acknowledged with regard to the development of green services on the Polish TFL market. However, in the current state of its maturity, the level of knowledge about green practices as well as the eco-awareness of FF/LSPs and their customers are far from satisfactory. Moreover, it also happens that even management staff of the largest TFL companies do not care about green practices and do not recognize their importance.

The greening of transport and supply chains should be regarded as an important issue, especially because it is in line with countries’ commitment to reduce global GHG emissions as is stated in the Paris Agreement and it is also subject to social supervision (e.g. tracing the carbon footprint). The relevant law and regulations, eco-education, dissemination of green know-how may foster implementation of green solutions in transport and logistics on the Polish market. Otherwise, greening will continuously be perceived as burdensome and costly.

REFERENCES


THE ASPECTS OF KNOWLEDGE LOGISTICS IN THE PROCESS OF CREATING UNIVERSITY HIGH-GROWTH TECHNOLOGY BUSINESSES. 
THE CASE OF THE AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY 

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Abstract

This paper is about knowledge logistics, the transfer of tangible and intellectual property, expertise, learning and skills between academia and the non-academic community. Innovations are essential for economic growth and development and are major determinants of long-term improvements in income and living standards. Innovation is one of the three elements of the Knowledge Triangle: education, research and innovation. The Knowledge Triangle aims to create an interaction between education, research and innovation thereby creating the conditions for increased relevance and utilization of the universities’ activities - the results of their research and developmental work.

Today, no one can imagine building a competitive economy without focusing on the academic community, the achievements of its researchers and PhD students as a basic potential source of new knowledge.

Technology transfer and the commercialization process provide a significant driving force for enhancing economic growth and societal well-being. The transfer of technology and the knowledge passed from academic institutions to businesses and the society in general can take place through various channels, such as education, publications, commissioned research, the flow of personnel, co-operation, licensing and the establishment of new business entities based on academic technology and knowledge, known as university spin-offs.

Such spin-offs are one of the ways of implementing the latest scientific discoveries into industrial practice, and thus building an innovative economy. The goal of universities is to establish efficiently managed, continually developing spin-offs.

The AGH University of Science and Technology is one of the best and most renowned modern Polish universities. The University is an important centre for the development and transfer of innovative technologies. The AGH UST is the leader among institutions submitting the largest number of inventions and utility models (confirmed by annual reports published by the Polish Patent Office).

Keywords: Knowledge logistic, knowledge transfer, innovation, technology transfer, spin-off, university of technology, academic entrepreneurship, technology commercialization 

1. INTRODUCTION 

The literature relevant to these issues, in the form of articles and discussions published in periodicals, dedicates much attention to today’s economy, and consequently to the conditions that accompany the manufacturing of goods and rendering services in response to the public demand. The term science-based economy, which describes the present stage of economic development, was first used in mid-1980s in OECD publications in the context of a breakthrough within civilisation which meant the substitution of the industrial era for the post-industrial civilisation (at that time only vaguely defined) for. Today we participate in an economy in which the development of countries, regions or organisations depends on the intellectual potential and
knowledge associated with the modern achievements of learning, in particular science and engineering. According to the Austrian economist J.A. Schumpeter in the first half of the 20th century, the main links of the contemporary economy are [1]:

- innovations and innovative processes,
- innovative entrepreneurs and the role of new companies in the transfer and commercialisation of technology,
- creative destruction and its economic, structural and social consequences,
- time regularities in technological changes (long prosperity waves - also known as Kondratieff cycles),

The foundation for the development of today's economy is knowledge, and primarily its conversion into new market application relating to products, processes, organisation or marketing (innovations). Innovation is of key importance to economic growth, societal well-being and the development and survival of companies. Innovativeness is one of the most important factors allowing us to achieve a high level of development and competitiveness.

If companies want to develop and survive on an increasingly competitive and demanding market, companies must increase the competitiveness of both their organisation and their offer. The best way to do so is to introduce innovation that is inspired by new knowledge, new technologies or research methods.

At this point it should be noted that an important way of transferring state-of-the-art technology to economic practice is to establish efficiently managed and constantly developed small businesses. Start-ups are businesses established to find a business model that would guarantee their development. S. Blank defines start-ups as experiments, temporary organisations established to search for a reproducible and scalable business model [2]. These businesses also build on new knowledge, advanced technologies and the results of research and development work. Innovativeness of large businesses is no match to that of start-ups. Innovation is created by duly motivated people focused on market success. Fast, entrepreneurial, creative, well-educated and fully committed enthusiasts become leaders of innovative business initiatives: undertakings characterised by great flexibility and acceptance of high risk. It is technological start-ups - often supported by what is known as business angels, i.e., seed funds or venture capital - that introduce innovative solutions, products or business models to the market. Innovative businesses that are being created contribute to fundamental changes in entire sectors or to the formation of new economy sectors.

In view of the above, today's universities are becoming very important places where knowledge and technology of high innovative potential are created. In the relevant literature one can find extensive discussions, as well as scientific research relating to the functioning of universities and institutions of higher learning in general in the post-industrial era. Many modern universities - aware of the changes taking place in their environment - implement fundamental changes in both their strategic endeavours and operational activity. Universities increasingly often depart from their model based entirely on science and tuition, striving instead toward a new model, known as the Third Generation University. In such universities, in addition to traditional goals such as scientific research and education, a third goal emerges, which is the cooperation with industry and the commercialisation of knowledge.

Extensive cooperation between scientists and business makes it possible to shape the added value of ideas, technologies and potential new products. H. Etzkowitz coined a new term, entrepreneurial university, which emphasises even more the new role of academic centres; this term is currently used to describe universities that efficiently implement their third mission, as mentioned above [3]. B.R. Clarke thinks that an entrepreneurial university tries to actively introduce innovations, while striving to make organisational changes and to become a meaningful market player who dictates his own conditions to the market [4]. It is difficult to imagine today's university without an extensive, efficient co-operation with its environment. According to L. Leydesdorff and H. Etzkowitz the model known as “triple helix” is appropriate for innovation: it comprises mutually comprehensive
relations occurring in the creation and transfer of knowledge between three types of entities: scientific centres (universities, research centres and supporting institutions), industry (businesses) and government (including local government institutions) [5]. Among the several models for technology transfer and commercialisation of knowledge that describe ties between the worlds of science and business, there is a network model which is in practice the Knowledge Integration Community (KIC). This community comprises six key nodes that bring together four institutional sectors (Industry, Government, Research and Education) through two binding mechanisms: knowledge exchange and the study of innovations in knowledge exchange [6].

One of the ways that can significantly strengthen the ties between universities and industry is to establish and develop university spin-offs. S. Shane understands university entrepreneurship as precisely the ability to create new undertakings in the form of spin-off businesses [7]. In the literature devoted on this topic, one can find many definitions and interpretations of the term academic entrepreneurship, but most often they focus on issues associated with the creation of new business undertakings conducted on the basis of intellectual property originating from a university, commercialization of knowledge and the transfer of technology as well as establishing businesses known as spin-offs. [8]. The establishment of new business entities that implement intellectual property created at universities is a very dynamic way of developing how to commercialize the results of research and development work (known as indirect commercialization). Observation of the ecosystems of knowledge transfer and commercialization that exist around the best academic centres in the world support the thesis that spin-offs exert a significant influence on regional economic and social development.

The creation of academic spin-offs around universities is considered to be the most innovative mechanism supporting the transfer of technologies originating from scientific communities [9]. However, one should bear in mind the fact - emphasised by researchers and those connected with practice - that commercialization proceeding along this path is a multifaceted complex process with many links and interactions. In this paper, the authors focus on the very process of university spin-off creations and on the challenges that technology transfer centres and university special-purpose companies responsible for the transfer and commercialisation of knowledge are faced with. An attempt was made to direct attention to these issues from the viewpoint of a new approach to the issues of knowledge management described by the term knowledge logistics.

2. LOGISTIC ASPECTS OF KNOWLEDGE COMMERCIALIZATION AT UNIVERSITIES

In the relevant literature, one can find dozens of various definitions of the term “knowledge logistics”. The authors of these publications emphasise various aspects of the meaning this word, most often focusing on economic knowledge. The Council of Logistics Management defines logistics as the process of planning, implementing and controlling the efficient and cost effective flow and storage of raw materials, production feedstock, finished goods and related information from point of origin to point of consumption for the purpose of meeting customer requirements [10]. In practice, logistics can be considered in terms of two aspects: systemic (thinking about the whole) and process-related (the principle of flows). Considering the increase in importance of knowledge, it can be noticed that organisations are increasingly focussed on the flow, diffusion and transfer of intellectual property. It is thus justified to strive to optimize these processes from the viewpoint of the organization’s goals. In this literature one can find attempts to adapt terms relating to logistics - which were worked out and based on material and physical elements - to the analysis and diagnostics of processes involving the sharing of intangible things and knowledge [11]. Knowledge logistics, as a new approach to issues of knowledge management, can mean supporting the distribution and storage of knowledge, while bearing in mind its flow and idle time.

In the context of changes occurring in the domain of legal regulations pertaining to the functioning of science and academic education, as well as the management of universities, the management of knowledge becomes
of key importance to the academic community. The mission of universities is to create, but also to transfer knowledge. Universities are faced with such organisation of their research (optimization of these processes), that their results can be applied in industry. This is in particular the case of universities conducting research, which are even more open to the business environment and focus on actions aimed at the commercialization of research results.

Among the various paths to such commercialization, spin-off businesses deserve special attention. These technology-related university start-ups are dynamic undertakings, which are based on knowledge, advanced technologies and organizational solutions; they introduce to the market the results of their research and development work done in the academic community. The process of commercialization of scientific discoveries and research results is not an easy task. Scientific research and commercialisation of its results are two entirely separate processes. The first one involves transformation of funds into knowledge, whereas the second one transforms knowledge into funds. A question thus arises, how commercialization of knowledge and technology should be managed by establishing spin-off businesses.

3. **THE CREATION OF THE UNIVERSITY SPINOFFS - INDIRECT COMMERCIALISATION**

With the emergence of the term “academic entrepreneurship”, which means business activity of the academic community, other new terms were coined, spin-offs and spin-outs. In the relevant literature one can find many definitions of university spin-offs, which are very often mutually contradictory and can make it more difficult to understand this notion unequivocally. A spin-off business is primarily distinguished by the fact that it is established by a scientific worker, PhD student, university undergraduate or graduate who uses the intellectual property developed at his university. These businesses constitute a separate legal entity, but they are characterised by a constant relationship with their university from their very creation.

A spin-off is a new enterprise that was established by at least one university worker, PhD or an undergraduate student and a university’s special-purpose company, with the purpose of joint commercialization of technology. It is thus established to generate profit and commercialize technology. A spin-off business usually has personal, formal, legal and capital ties with the university, which means the close cooperation of both parties [12].

In practice, one can find many factors that describe the motivation to starting this path to commercialization. Spin-offs make it possible to implement and develop inventions and technologies, which might miss their moment if not put into practical use, due to the high uncertainty associated with their implementation and, consequently, a lack of interest on the part of large companies [13]. Spin-offs guarantee involvement of creators and inventors in the development of university’s technologies, which is of primary importance when these technologies are based on tacit knowledge [7].

University spin-off businesses are increasingly gaining popularity among scientists, creators, as well as among potential partners from industry sectors and financial investors. They are an interesting vehicle for implementing innovative technologies to the market, developing the added value on the basis of the results of research work and development work or the scientists’ know-how. In situations where big companies and corporations turn out to be too large and too slow to create and implement innovations that change the rules of the game, academic start-ups gain particular significance.

It should be noted, however, that the creation of spin-offs is one of the most difficult ways of commercializing the scientific results of research facilities, although considering possible solutions in the long-term perspective; it is also one of the most profitable solutions. In general, the value of a developed technology, which becomes a basis for the creation and development of a business, is greater than a one-time sale of an idea or granting of a licence.
The difficulty of building a spin-off results, among other things, from the very specific character and way of functioning of scientific entities and legal conditions. In the relevant literature concerned with this topic, one can find attempts to describe the process of the creation of university spin-offs. Attempts are made to systematize the assumptions, specialised terms and relationships characteristic of the formation of businesses based on the university’s intellectual property in such a way that they best describe the reality and show the general course of the process (Table 1) [7,14,15].

Table 1 Models for the creation of University spinoffs (according to the individual authors)

<table>
<thead>
<tr>
<th>Ndonzuau, Pirnay, Surlemont</th>
<th>Shane</th>
<th>Vohora, Wrightm Lockett</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Generating a viable business idea.</td>
<td>1. Assessment by the scientist or inventor whether the new technology has the potential for commercialization.</td>
<td>1. Research. Opportunity recognition</td>
</tr>
<tr>
<td>2. Translating the idea into a business process.</td>
<td>2. Disclosing the technology to the university’s technology-licensing office (TTO).</td>
<td>2. Opportunity framing.</td>
</tr>
<tr>
<td>3. Creating a firm.</td>
<td>3. Evaluating the potential of the disclosed intellectual property from the viewpoint of its protection.</td>
<td>3. Entrepreneurial commitment</td>
</tr>
<tr>
<td>4. Contributing value to customers, employees, investors, and all other stakeholders (both internal and external).</td>
<td>4. Applying for protection.</td>
<td>4. Pre-organization. Threshold of credibility</td>
</tr>
<tr>
<td></td>
<td>5. Granting a licence for the technology by TTO to an existing company or to a spin-off created jointly with the scientist(s).</td>
<td>5. Re-orientation. Threshold of sustainability</td>
</tr>
</tbody>
</table>

In should be pointed out that the model proposed by Vohor et al. emphasises the need of a systematic approach to the creation and development of university spin-offs. The model recognizes that opportunity analysis and identification is critical to successful commercialization [16]. The condition of success is, therefore, not only knowledge and competence associated with a given field of science, but also knowledge of management and business. The commercialization process involves the shaping of the added value of ideas, research results or technologies in permanent dialogue with the expectation of the market and customers.

When building their multistage holistic model for creating university spin-offs, P.N. Pattnaik and S.C. Pandey try to answer the following questions, which are of key importance to indirect commercialization [16]:

- How does a researcher identify and decide on specific opportunities?
- What kind of funding is available for conducting research?
- Do similar opportunities exist for both pure and applied research and the results thereof?
- What modes for commercializing research results are available to the researcher or the university?
In accordance with the authors' intention, the multi-stage model of university spinoffs can be used by scholars in the area of academic entrepreneurship to build case studies and do phenomenological studies [16]. The model offers some value to practitioners who try to manage and transfer knowledge and thus make this process optimal from the viewpoint of university goals and benefits for the economy.

4. THE CREATION OF ACADEMIC SPIN-OFF COMPANIES AT THE AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN POLAND

The AGH University of Science and Technology in Krakow (AGH UST) is a modern nationwide public institution of higher learning. It is a technical university, where in addition to faculties closely associated with mining and metallurgy, there are faculties where the research is associated not only with traditional branches of industry and earth sciences, but also with fields of key importance for the development of modern economy, such as new materials, renewable energy sources, biomedical engineering or information technologies.
The model for technology transfer and commercialisation of innovative solutions at AGH UST assumes full co-operation of two AGH institutions pursuing different ways of commercialization; these are the Centre for Technology Transfer, a university entity (CTT AGH) and the special-purpose company INNOAGH. These entities jointly create a comprehensive offer for scientists, students, the university’s administration as well as industry.

The goal of INNOAGH is indirect commercialization of the results of research and development work; consequently, INNOAGH is responsible for the creation of university spin-offs. The mission of INNOAGH is to support inventors - both as regards the subject matter of their work and organization - in the creation of university businesses based on innovative technologies developed at AGH UST.

INNOAGH is thus itself a special-purpose company, the University’s investment fund, which has the goal of providing counsel and support to scientists interested in establishing innovative businesses building on the intellectual property created at the University, but also to invest in such companies, mainly by making contribution in the form of patent rights, know-how and also funding. INNOAGH is one of the key elements supporting - inside and around AGH - the transfer and commercialization of technology and knowledge.

The ecosystems, in which spin-offs are created at AGH UST, as is the case of other Polish universities, are still in the budding stage. After six years of INNOAGH operation and, consequently, more than a dozen case studies resulting in the establishment of more than twenty spin-offs built on the university’s intellectual property, an attempt can be made to model the process of the formation of spin-offs. Valuable experience is also provided by projects and technologies which, until now, have not led to the creation of new entities. In scientific communities that are still implementing the concept of actions focused on innovation, people are a particularly important component. Spin-offs that introduce innovation to the market can be built on the basis of human resources, teams of professionals: duly motivated, learning by mistake, accepting risks and ready to face challenges. Consequently, an important task of INNOAGH is to promote the idea of academic entrepreneurship, with special emphasis on the commercialization of intellectual property via the creation and development of start-ups. The building of models for the transfer of knowledge and the creation of spin-offs will be worthless without an entrepreneurial culture developed around Polish universities.

The process of spin-off creation on the basis of research work results, processed by their authors, which provides a potential basis for the construction of undertakings with a business potential, consists of the following stages.

1) Identification of research and development work conducted by scientists at the university’s departments.
2) Preliminary analysis of technologies and research work results prepared on the basis of interviews with their authors. This consists of a brief summary, identification of the field of engineering, the essence of the invention, quantitative and qualitative benefits, SWOT analysis, legal protection status, identification and verification of co-authors, but also of preliminary identification of possible ways to commercialization.
3) Preliminary market analysis comprising, among other things, the identification of potential target markets, competitive environment, resources, etc.
4) An in-depth analysis comprising the assessment of the legal and patent details, assessment of the current state of the knowledge, assessment of the technology in terms of its engineering correctness, assessment of the technology’s maturity, and analysis of actions necessary to bring the technology to the status of implementation readiness, assessment of the research team in terms of their goals and motivation, as well as assessment of the technological, environmental, market and legal risks.

Each of the subsequent stages of verification of the research work results is implemented after successful verification of the preceding stage. A great majority of technologies created by the university reaches at most the 4th level of readiness, as assessed using the Technology Readiness Levels (TRL) methods, which is inadequate a level to gain investors’ interest. In such cases commercialization is particularly difficult: it is a
lengthy process, spread over time, often over several years. The project's evaluation and an appropriate identification of market needs, both those we are aware of and those not, become the key element of the project application development. Defining the product, determining its commercialization path and finding an investor ready to co-finance the commercialization by the creation of a spin-off company is the key element of making academic knowledge commercial. A stage-based approach, based on gradual assessment of projects is in agreement with the “innovation funnel” concept, where the creation of a spin-off business and investment into it is preceded by the assessment of the concept, its development, the construction and verification of the prototype, market tests and preparation for launching on the market. It does not change the fact that it is possible to create a spin-off company in order to prepare for implementation of the results of scientific research and development work or the know-how associated with these results.

5.  **CONCLUSION**

Although the term “commercialization” is still - in the opinion of university workers, both scientists and administration staff - not clear and remains unrelated to the university community, this situation will have to change in the nearest future. Universities often have false opinions on research commercialization and often assume that that the process ends with dissemination of the results, rather than their implementation, which is confirmed by successive studies on barriers to commercialization of research work in Poland. For several years some Polish universities have been developing their systems for the transfer and commercialization of knowledge, improving the system in order to make it possible to use the results of scientific studies and development work practically. A particular challenge is the creation of spin-off businesses around the university, which attempt to implement the university’s inventions, patents or know-how to the market.

Establishing a university company is a complex and difficult process. It begins with an idea, project or the result of research or development work. This is followed by many decisions and actions associated with the protection of intellectual property, transforming the technology into a market product, formalisation of management and continuous raising of funds for development, etc.

According to the authors of this publication, who also have practical knowledge on managing the results of scientific studies and the university’s intellectual property, there is a need to map the processes of the creation and the transfer of knowledge at universities. This process should lead to effective implementation of research results to industry. Despite the abundant literature on the creation of new businesses, the cases of businesses established in the academic community, where the results of scientific research are the basis for building value for customers, requires an individualised approach. Similarly, it is difficult to assume that the knowledge transfer processes that have turned out to be successful in other academic centres (e.g., in American universities), can be directly translated to Polish conditions. Structural, mental, cultural, competence or financial conditions provide an entirely different background for commercialization of research work in Poland.

**REFERENCES**


THE PROPOSAL OF USING FUZZY MODEL FOR THE WAREHOUSE MANAGEMENT

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Abstract

The aim of the paper is to present the possibility of application the fuzzy sets theory to support warehouse management. In the second chapter the basic issues relating to fuzzy sets and fuzzy logic are presented. The third chapter shortly characterizes the company and shows results of classical ABC / XYZ analysis. The conception of a fuzzy model used to plan the deployment of the goods in the warehouse of electric parts is presented in the fourth chapter. The created fuzzy model allowed the reorganization of the placement of products to improve the process of orders picking. It can be used even in cases when data of sales volume, sales dynamics and weight of the product are not exact or when the classical allocation to group in ABC / XYZ method is not possible.

Keywords: Warehouse management, logistics, fuzzy sets, ABC / XYZ method

1. INTRODUCTION

The fuzzy set theory is successfully used in many fields of science and engineering for many years. Its main advantage is the ability to operate on uncertain and incomplete data that are often determined by subjective assessments of expert. Fuzzy sets are applied for example in the theory and practice of control systems [1], [2], [3], in the area of systems reliability [4], [5], [6], in the estimation of the various types of risk [7], [8], [9], as well as in logistics [10], [11], [12].

Essential meaning for the efficient organization of the warehouse management has the choice of the method of the goods storage in the warehouse area. The good arrangement of products allows you to minimize the work of means of transport, as well as allows to reduce the time of the warehouse operations related to orders picking. After the delivery the goods are divided into relevant loading units and are placed by the workers in the location that was previously established by specified method. The deployment methods are implemented differently depending on the preset level of the indicators and factors such as: the technical conditions, the type of warehouse, the flexibility requirements, the safety requirements and established strategies. Most importantly, these methods are often modified if the implemented solution does not meet expectations of the organization.

There are two main methodologies of goods deployment in storage space that are used for many years [13] - the storage method of permanent allocation and the storage method of free allocation. In addition to the storage method of products an important role plays the way of the management of the warehouse space. One of the most popular ways of the deployment is the arrangement of the products based on the ABC analysis, XYZ analysis or their synthesis. If you are using ABC / XYZ analysis the storage system is planned in such a way that the goods of AX group (i.e. with a high sales volume and low sales dynamics) should be located close to the shipping area, while from the YZ group (i.e. low sales volume and high sales dynamics) are placed far away from this zone. More advanced methods are created based on, among others, artificial neural networks, genetic algorithms, fuzzy logic, etc.

In this paper the proposal of the use of fuzzy logic to goods allocation in the warehouse space in order to improve orders picking process is presented. The aim is to reduce the picking time and to reduce the use of means of transport.
In the second chapter the fuzzy set theory is shortly described while in the third chapter the researched company is characterised as well as the results of classical ABC / XYZ analysis are discussed. The fourth section is about fuzzy model that was created to support the warehouse management of distribution company. In proposed model to sales volume and sales dynamics criteria the additional criterion is taking into account - the weight of the product that is stored in the warehouse.

2. FUZZY SET THEORY

The concept of Fuzzy Sets was introduced by Lotfi Zadeh in 1965 [14] as a generalization of Classical Sets Theory. According to fuzzy sets theory the certain element of a space $X$ may belongs partially to set $A$ and partially to its complement. Fuzzy sets are defined by membership function that is the equivalent of the characteristic function in classical sets theory where certain element if belongs to set $A$ cannot belongs to its complement. In fuzzy set to every element of space $X$ is assigned the value that specifies the level of belonging to given set. Membership of the standard fuzzy set is contained in the interval $[0, 1]$ and if the maximum value of membership function equals 1 we say about normal fuzzy set. Therefore, the membership function of $X$:

$$\mu_A : X \rightarrow [0,1]$$

We can distinguish three cases:

1) $\mu_A(x) = 1$ - that means full membership to fuzzy set $A$.
2) $\mu_A(x) = 0$ - that means the lack of the membership to fuzzy set $A$.
3) $0 < \mu_A(x) < 1$ - that means partial membership to fuzzy set $A$.

Fuzzy set $A$ includes in fuzzy set $B$ if and only if $\mu_A(x) < \mu_B(x)$ for every $x \in X$, while fuzzy set $A$ is equal to fuzzy set $B$ if and only if $\mu_A(x) = \mu_B(x)$.

The membership function may be of different form, such as trapezoid function, triangular function, gauss function, sigmoid function, etc.

Fuzzy sets are subject to the logical operations. Some examples of such operations are given as follows [15]:

1) algebraic product - $C = A \cdot B = \{x, \mu_A(x) \cdot \mu_B(x); x \in X\}$
2) algebraic sum - $C = A + B = \{x, \mu_A(x) + \mu_B(x) - \mu_A(x) \cdot \mu_B(x); x \in X\}$
3) sum - $\mu_{A+B}(x) = \mu(A) \cup \mu(B) = \max\{\mu(A), \mu(B)\}$
4) intersection - $\mu_{A \cap B}(x) = \mu(A) \cap \mu(B) = \min\{\mu(A), \mu(B)\}$
5) negation - $\mu_A^e(x) = 1 - \mu_A(x)$.

Decision-making process based on fuzzy logic depends on the fuzzy rules of the form:

IF ..... AND / OR ..... THEN, np.

IF a is A1 AND / OR b is B2 THEN c is C1
IF a is A2 AND / OR b is B1 THEN c is C2,

where a, b, c are the linguistic variables, and A1, A2, B1, B2, C1, C2 are the fuzzy subsets.

Data processing using fuzzy logic is performed in the following steps:

1) Preliminary data processing
2) Fuzzification
3) The interpretation of the IF-THEN rules
4) Defuzzification
5) Final data processing

On the basis on such rules the expert system can be built that will support any decision-making process including operations undertaken in storage process.

3. COMPANY CHARACTERISTICS AND ABC / XYZ ANALYSIS

Analyzed company deals with the distribution of the spare parts dedicated to services of the electrical devices. It was established in 2004 and constantly expanding the range of its products. Currently company includes 86 components in its offer. To ensure the best level of service and rapidly react on demand the company has its own warehouse. In 2015 company sold about 284 thousands of its products. The clients are mostly located in Poland. Data about sales volume for the individual months of 2015 that was used to the assortment analysis were received from the internal transaction system of the company.

ABC analysis allowed to subdivide the offered assortment into three groups. The creation of the three distinct classes of products makes an assessment of the importance of given component and its impact on the total sale of the company easier. The basis of the division was the sales volume in 2015. As a result of the ABC analysis we get the following groups:

- class A - contains of 16 products what makes 18.6% of the overall sale; the lowest sale volume in this group is about 7.5 thousands PCs and with a highest sale volume is about 12 thousands units;
- class B - contains of 30 products what makes 34.9% of the overall sale; the lowest sale volume in this group is less about 2 thousands units;
- class C - contains of 40 products what makes 46.5% of the overall sale; in this group there is one product that was not sale in any single unit.

The next step was the XYZ analysis that allowed to estimate the dynamics of consumption of individual products in 2015. This helps to specify the fluctuations in the demand and create forecast of future sales. As a result, XYZ analysis sets the following groups:

- class X - contains of 32 products what makes 37% of the overall assortment; the limit value of the variance coefficient is 15%;
- class Y - contains of 36 products what makes 42% of the overall assortment; the limit value of the variance coefficient is 40%;
- class Z - contains of 18 products what makes 21% of the overall assortment.

The result of ABC / XYZ analysis is shown in Table 1.

Despite the fact that in AX and AY class there are only 16 products their sales volume constitutes more than 50% of the total turnover of the company. The offered portfolio does not include products whose sales volume and sales dynamics would qualify them to AZ class. The largest group in the entire ABC / XYZ matrix is formed by BX class. There are mostly parts for devices in the maturity period of the product life cycle what is the reason of the regularity of their usage. In class BZ there is only one product. The analysis shows also the dead stock in the form of PK-006-000 article. For this position the sales volume in the observed period was 0.
Table 1 Result of ABC / XYZ analysis

<table>
<thead>
<tr>
<th>Sales volume</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>

Source: own elaboration

4. PRODUCTS ALLOCATION WITH THE USE OF FUZZY MODEL

The main purpose of this chapter is to present fuzzy model used for planning the deployment of the goods in the warehouse. The model was created on the basis of previously done ABC / XYZ analysis and other data from the transaction system of the company. As the summary of this chapter the graphical representation of the results of the developed concept is presented.

In the analyzed case the deployment of the products in the warehouse space was done according to three criteria: sales volume, sales dynamics and the weight of the component. One of the assumptions of fuzzy model construction was to place products with highest sales volume and lowest sales dynamics near the shipping area while products with lowest sales volume and highest sales dynamics locate far from the shipping area. As it is known the division for the groups in the classical ABC / XYZ method is sometimes problematic but in presented approach it is not so strict. What is more we do not have to know the exact level of the demand in the past and we may deal better with probable variations of the sale in the future. As it was shown in the previous chapter the sales volume ranges from 0 to about 12 thousand pieces. The variation coefficient ranges from 0 to 0.7. The second assumption was to place the light products far from shipping area while the heavy ones close to this area. The weight of components ranges from 100 g to 14 kg. Above assumptions guarantee the improvement of the completion process by shortening the completion time and reducing the use of transport means.
Table 2 Membership function for fuzzy variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>In/out</th>
<th>Linguistic term</th>
<th>Type of the membership function</th>
<th>Parameters of the membership function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales volume</td>
<td>input</td>
<td>small</td>
<td>Trapezoid</td>
<td>(0;0;1100;2700)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>medium</td>
<td>(1100;2700;6800;8500)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>high</td>
<td>(6800;8500;12250;12250)</td>
<td></td>
</tr>
<tr>
<td>Sales dynamics</td>
<td>input</td>
<td>small</td>
<td>Trapezoid</td>
<td>(0.00;0.00;0.12;0.18)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>medium</td>
<td>(0.12;0.18;0.35;0.40)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>high</td>
<td>(0.35;0.40;0.77;0.77)</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>input</td>
<td>light</td>
<td>Z-class</td>
<td>(1.7;7.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>medium</td>
<td>Gauss</td>
<td>(2.1; 7.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>heavy</td>
<td>S-class</td>
<td>(7.0;12.3)</td>
</tr>
<tr>
<td>Distance</td>
<td>output</td>
<td>close</td>
<td>Triangular</td>
<td>(0;0;14)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fairly close</td>
<td></td>
<td>(0;14;24)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>far</td>
<td></td>
<td>(14;24;40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>very far</td>
<td></td>
<td>(24;40;40)</td>
</tr>
</tbody>
</table>

Source: own elaboration

Figure 1 The conceptual scheme of fuzzy model

Source: own elaboration

Due to the relations among inputs the Mamdani model was applied [16]. There are three inputs - sales volume, sales dynamics, product weight and one output - distance. To calculate crisp value of the output the centroid method of the defuzzification was used. In the Figure 1 the general scheme of the fuzzy model is presented, while in the Table 2 the linguistic terms of inputs and output with parameters of membership function are included. Graphical representations of the membership functions are show in the Figure 2.
An exemplary rules in the fuzzy logic block (‘organization (mamdani) 27 rules) are given beneath:

1) IF “sales volume” is small AND “sales dynamics” is high AND “weight” is light THEN “distance” is very far.
2) IF “sales volume” is small AND “sales dynamics” is high AND “weight” is medium THEN “distance” is very far.
3) IF “sales volume” is small AND “sales dynamics” is high AND “weight” is heavy THEN “distance” is far.
4) IF “sales volume” is small AND “sales dynamics” is medium AND “weight” is light THEN “distance” is far.
5) IF “sales volume” is high AND “sales dynamics” is medium AND “weight” is light THEN “distance” is fairly close.
6) IF “sales volume” is high AND “sales dynamics” is high AND “weight” is light THEN “distance” is fairly close.
7) IF “sales volume” is high AND “sales dynamics” is small AND “weight” is medium THEN “distance” is close.
8) IF “sales volume” is high AND “sales dynamics” is small AND “weight” is heavy THEN “distance” is close.
As a result of the operation of the fuzzy model the values of distances in which products should be deployed in the warehouse were obtained. In the Figure 3 we can see relationship between the "distance" and the "sales volume" / "sales dynamics" as well as the "distance" and the "sales dynamics" / "weight". The area of the warehouse with the allocation of products to the certain location that was received as a result of MS Solver tool is presented in the Figure 4. It was assumed that the distance between the shipping area and the rack in the warehouse cannot be greater than the value received from the fuzzy model. In this case the sum of the absolute value of the all subtractions between calculated and real value of distance was minimized as the goal function.

Figure 3 The influence of a) „sales volume” and „sales dynamics” on „distance”  
b) „weight” and „sales dynamics” on „distance”  
Source: own elaboration

Figure 4 Conceptual plan of products allocation in the warehouse space  
Source: own elaboration
5. CONCLUSION

The efficient organization of the logistic processes is crucial in creating a sustainable competitive advantage and the image of an effective enterprise among customers. The company should control all processes that are realized continuously and in the same time try to find the opportunities to deploy new improvements. Sometimes there are situations that employees are negatively oriented to any changes. The role of managers is to break the resistance of subordinates by showing the benefits which can be established in the long term. Very often, many improvements in logistics enterprises, you can enter with a zero or a small financial investment. In contrast to changes in the field of quality management, any modification to the logistic processes are aimed at simplifying material flows and the accompanying information streams. Their main purpose is to facilitate the work of people, which affects the efficiency of human resources and capital, and as a consequence brings tangible benefits for the entire enterprise.

In the decision-making processes it is extremely important to ensure the availability and authenticity of data, which are the basis for the analysis, however, the excessive amount of data can be an obstacle in the synthesis of clear and useful information. In some cases, there is no possibility of obtaining complete and reliable data. The choice of the method used to solve the problem depends on its nature and complexity. To arrange the products in the warehouse the model which is based on the fuzzy sets theory was used. This approach has made it possible to develop a plan for storage space, tailored to the requirements of the logic of completion process. It may be based on not exact knowledge of sales volume, sales dynamics and weight of the products. Presented problem is only part of the area for which the logistics management can be a practice to help in the overall streamlining of the company. In the case of other than the examined object it is possible to take into account other criteria, however, the proposed model can be easily adapted to the new conditions.

REFERENCES


Abstract

Military Economic Branches are special budgetary units, third category beneficiaries of budgetary funds, established in order to perform financial and economic tasks for military units located within a single or several garrisons. Their organisational structure allows to fulfil the tasks related with securing current operating activities within the garrison. The essential criterion of functioning of a Military Economic Branch is effective fulfilment of tasks in order to maintain the required combat and mobilisation readiness of the secured military units.

Keywords: Logistics, logistic system, Military Economic Branches

1. INTRODUCTION

The issue of proper functioning of units within garrisons and excess of financial and logistic work to be done by operating unit commanders was analysed in 1998 in the course of the works related with the “Garrison” experiment, and also later, in relation with the “Garrison 2000” experiment. The works aiming at optimising the economy in this field had been scheduled for continuation in 2001, whereas the practical continuation took place at the beginning of 2002. However, in the same year 2002, the experiment works were discontinued, mainly due to failure to reach uniform views and opinions concerning the role and the rules of garrison functioning within the structures of the Polish Armed Forces, and also due to the fact that it had been concluded that it was impossible to create a body performing expected tasks without the necessity of additional employment. Another reason was the lack of any clear and credible cost estimates of the introduction of new solutions.

The issues described above, originating from the “Concept of changes in the Polish Armed Forces” developed in June 2000, have also contributed to the modification of the organisational and functional section of the Polish Armed Forces logistic system.

Between 2002 and 2004, practical fulfilment of the major aspects of the described issues was done at the level of Types of Armed Forces. The Air Force and Navy started to concentrate financial and economic tasks in stationary logistic units (Air Bases, Naval Port Commands), while the Land Forces started an experiment with centralising the purchase of food resources by the 2nd District Materials Base in Walcz. At the national level, a centralised purchase planning system implemented by the P4 General Logistics Management of the Polish General Staff began to operate, with the purchase plans fulfilled by the Military Property Agency.

These actions have not resulted in the expected releasing of military units commanders from fulfilling financial and economic tasks, which led to raising that issue during the official meeting of the Leaders of the Ministry of National Defence held on 31 March 2003, during which the Minister of National Defence ordered to take immediate systemic actions in order to minimise the scope of competences of military units commanders related to the said tasks.
The concept works aiming at development of systemic solutions to release military units commanders from fulfilling financial and economic tasks have been performed by various organisational units of the Ministry of National Defence, as well as subordinated units and institutions. On 17 November 2003, during the meeting of the Commanders of the Polish Armed Forces, the concepts developed by the Budgetary Department and the P4 General Logistics Management were discussed. According to the order of the Minister of National Defence, the Budgetary Department of the Ministry of National Defence, in cooperation with the P4 General Logistics Management, has developed a project of a regulation of the Minister of National Defence concerning the separation of the financial and economic functions and the operating and training functions in budgetary military units. However, the regulation has not been supported. Thus, the P4 General Logistics Management has drawn up a draft resolution of the Minister of National Defence concerning the appointment of the Ministerial Team working on development of the "Concept of separation of the financial and economic functions and the operating and training functions in budgetary military units", finally approved on 18 April 2005. On the same day, the Minister of National Defence appointed the Team as follows [1]:

1) Chairman - Deputy Head of the P4 General Logistics Management,
2) Vice-Chairman - Deputy Head of the Budgetary Department,
3) Vice-Chairman - Deputy Head of the General Strategic Planning Management - P5,
4) Head of the Administrative Office - Head of the Logistic Planning Board of the P4 General Logistics Management,
5) Administrative Office - 5 persons appointed by the Head of the P4 General Logistics Management,
6) Team members - representatives of:
   - the Head of the Budgetary Department,
   - the Head of the Infrastructure Department,
   - the Head of the Control Department,
   - the Head of the Administrative Department,
   - the Head of the P1 General Human Resources Management,
   - the Head of the P2 General Military Intelligence Management,
   - the Head of the P3 General Operating Management,
   - the Head of the P5 General Strategic Planning Management,
   - the Head of the P6 General Command and Communication Management,
   - the Head of the P7 General Support Management,
   - the Head of the Military Health Service Board,
   - the Land Forces Commander,
   - the Air Force Commander,
   - the Navy Commander,
   - the Warsaw Garrison Commander,
   - the Head of the Military Information Services,
   - the Chief Commander of the Military Gendarmerie,
   - the Chief Commander of the National Defence University of Warsaw.

The "Concept of separation of the financial and economic functions and the operating and training functions in budgetary military units" was scheduled for 15 September 2005.

It must also be mentioned that on 13 May 2005, during the meeting of the Commanders of the Polish Armed Forces, one of the topics discussed concerned the "Concept of functioning of logistics within the Ministry of National Defence". That concept envisaged implementation of a "pilot programme" in chosen garrisons. The programme encompassed organisational and competence changes in budgetary military units, aiming at creation of specialised military units that could perform the financial and economic (logistic) tasks within the garrison, as one of the fields of their activity.
The work of the Ministerial Team resulted in drawing up the “General concept of separation of the financial and economic functions and the operating and training functions in budgetary military units” in 2005, that had been consulted at the Ministry of National Defence and presented to the Chief of the General Staff of the Polish Armed Forces. In September 2005, the concept was approved by the leaders of the General Staff of the Polish Armed Forces.

According to the assumptions of the “General concept…”, implementation of the envisaged changes should have been preceded by a “pilot programme” that would provide clear explanations to a number of issues concerning the scope and the form of fulfilment of the planned goals. Additionally, the presented concept envisaged the commencement of the process of “grassroots” formation of the logistic system structures.

According to the assumptions of the "Logistic system development plan for 2005-2010", the schedule of implementation of the “Concept of separation of the financial and economic functions and the operating and training functions in budgetary military units” was coordinated with the “Schedule of modification of logistics functioning at the Ministry of National Defence”.

In the course of development of the concept it has been agreed that the scope of tasks to be implemented, as well as the consequent division of competences at the leadership and the operating levels, should be preceded by binding decisions concerning the future systemic solutions for:

- the system of management of the Armed Forces,
- the target structure of the Armed Forces,
- the role and the position of the Ministry of National Defence,
- planning and deciding on the use of funds,
- the scope of implementation of the “Concept of functioning of Logistics in National Defence”.

2. FINANCIAL AND LOGISTIC SYSTEM OF THE MINISTRY OF NATIONAL DEFENCE BEFORE THE INTRODUCTION OF THE NEW SYSTEM

A three-tier budgetary funds management system had been functioning at the Ministry of National Defence [2]. It had been more related with using the budgetary funds rather than with the system of budgetary planning. There had been no obligation for the budgetary planning system to be based on the three-tier system of beneficiaries, so it could have a different structure. Existence of quite different systems had been acceptable, so as budgetary planning and budget execution.

The major beneficiary was the Minister of National Defence, while the group of second-degree budgetary funds beneficiaries included: commanders of Armed Forces branches, Warsaw Garrison commander and the Chief Commander of the Military Gendarmerie. The group of third-degree budgetary funds beneficiaries appointed by the Minister of National Defence included: commander of Military Unit No. 2305, heads of military pension offices, heads of district (Warsaw, Military) infrastructure boards, heads of airfield divisions, head of the Communication Investment Office, head of the budgetary unit of NATO investments. The management of the third-degree budgetary funds for the units of the Ministry of National Defence had been carried out by the Manager of the Administration Department. Financial and accounting services had been performed by the Manager of the Budgetary Department.

Additionally, the second-degree budgetary funds beneficiaries had appointed around 220 subordinated third-degree budgetary funds beneficiaries.

It must also be pointed out that appointing a third-degree budgetary funds beneficiary was not synonymous with ordering fulfilment of logistic support tasks.

In the context of logistic support, the concept of Economic Division, that had been in use before the changes, had been practically performed by ordering logistic support tasks to various military units constituting third-
degree budgetary funds beneficiaries and performing the tasks assigned to the commanders of Armed Forces branches, Warsaw Garrison commander and the Chief Commander of the Military Gendarmerie by the decisions of the Minister of National Defence or the orders of the Chief of the General Staff of the Polish Armed Forces. In that system, not all units fulfilled the entire scope of the logistic support. It had been a common practice that certain units were assigned tasks only within specific areas of support. As a result, the recipients had been cooperating with many units in order to receive comprehensive services.

Additionally, central and long-term supplies purchased by the Military Property Agency had been distributed mainly by District Materials Bases to all second-degree budgetary funds beneficiaries. In the Land Forces, current supplies had been purchased mainly by District Materials Bases as well as other budgetary military units of the Land Forces, while in the Air Force and Navy, these tasks had been carried out by the Air Force Materials and Technical Bases as well as Air Bases and Navy Stores as well as Naval Port Commands, respectively.

The systems of financial and logistic support functioning within the Polish Armed Forces had not been coherent. The systems had not been synchronised at the level of the second-degree budgetary funds beneficiaries, appointing the third-degree budgetary funds beneficiaries, and their capabilities in providing logistic support had not been analysed.

At the central level, coordinating actions had not been fulfilled in the required scope, which resulted in discrepancies in finances and logistic supplies in garrisons with units of different branches of the Armed Forces. In order to sanction that, garrisons had been established within the Polish Armed Forces, causing an artificial division of towns and districts (e.g. Dęblin and Dęblin Twierdza garrisons). Additionally, financial and economic tasks had also been assigned to high readiness units as well as the units appointed to perform tasks abroad. Creating internal bodies within those units, appointed to perform financial and logistic services in places of permanent dislocation, had been only an organisational move, that in practice would not release commanders from performing these tasks.

Separate financing and logistic support systems had been functioning within the garrisons (separate for each Branch of the Armed Forces), not corresponding to the principles of the military units. Because of that, financial and logistic tasks had been assigned to high readiness units, which made the system of financial and logistic support inconsistent (single unit supplied from multiple sources).

The major drawbacks of the previous financial and logistic support system of the Polish Armed Forces included:

- lack of central integration of independent subsystems (financial and logistic) created by the second-degree budgetary funds beneficiaries,
- crossing the lines of financial and logistic support by second-degree budgetary funds beneficiaries,
- appointing third-degree budgetary funds beneficiaries that was not synonymous with providing comprehensive logistic support,
- functioning of multiple budgetary military units within a single garrison - being third-degree budgetary funds beneficiaries appointed by a single second-degreet budgetary funds beneficiary,
- assigning financial and economic tasks to high readiness units.

3. **PURPOSE OF CHANGES - CREATING MILITARY ECONOMIC BRANCHES**

The purpose of the "Concept of separation of the financial and economic functions and the operating and training functions in budgetary military units" was to indicate organisational, legal and competence-related solutions that would enable to release unit commanders from performing financial and economic tasks in a rational way, not depriving them of their influence on setting the priorities in providing logistic and financial supplies to the military units [3].

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It has been assumed that the developed solutions would reflect the directions of changes within the logistic system approved by the Minister of National Defence, resulting from the “Concept of functioning of logistics within the Ministry of National Defence”.

The target model of functioning of the financial and logistic support system at the lowest levels should reflect the outcomes of the Strategic Defence Review and relevant conclusions. The assumptions of the described “Concept …” have been reflected in the provisions of the “Polish Armed Forces Development Programme for 2007-2012”.

Irrespective of the actions to be taken in future, the essential goals of implementation of the described “Concept …” shall include:

- reorganisation of the structures of the current tactical military forces support system,
- including garrisons in the district system of logistic support,
- rationalisation of use of the logistic potential,
- savings made through reduction of costs of the financial and logistic service of military units in the garrison,
- forming the structures ensuring flexibility in conditions of intensified operating activity and continuity of operation in garrisons during the crisis or war,
- improving the quality of logistic service through professionalisation.

The idea of introducing certain changes in the existing system of financial and logistic support as well as the general support of current activities in military units was backed by the operating and training requirements related with ensuring most favourable conditions for combat forces to reach combat readiness and capability to fulfil their tasks. Another arguments were economic considerations.

The tasks were supposed to be completed by appointing a special military unit (Military Economic Branch) within the organisational structures. It could be formed (has been formed) by reforming the existing unit or forming a new structure. The major purpose of this unit is to perform financial and logistic services for operating units assigned for supplies [4].

The presented role of the Military Economic Branches results from the changes introduced to the logistic system of the Ministry of National Defence. As a consequence of these changes, the Military Economic Branch, being the direct support unit subordinated to the District Logistics Base (RBLlog), verifies requirement and provides support and services for military units, performing the tasks within the district supply system [5].

The essence of the Military Economic Branch activity is [6]:

- to ensure logistic and financial support using the separate special military units (Military Economic Branches),
- to organise economic supplies in line with the national coordination, consistent in terms of budget and fulfilment of logistic tasks in garrisons,
- to create a uniform support system, common for all types of Military Forces (also Military Gendarmerie and the Warsaw Garrison Command), providing services for all military units dislocated within a given garrison.

The “Concept of separation of the financial and economic functions and the operating and training functions in budgetary military units” was implemented in stages [7], and by the end of 2007, organisational activities have been conducted, related with drawing up the organisation and employment documentation and forming Military Economic Branches in chosen garrisons [8].

Between 2008 and 2010, a “pilot programme” [9] was conducted in selected garrisons. It was the basis to formulate the assumptions for the target model of the proposed solutions. The pilot programme has been conducted by four newly appointed Military Economic Branches, located in Wrocław, Dęblin, Gliwice and
Ustka. The feedback was positive [10]. On these grounds, the Ministry of National Defence decided to commence the 1st stage of the logistics reform, as a result of which 14 Military Economic Branches started their activity on 1st January 2012 [11].

In the following years, the appointed Military Economic Branches became fully capable and assumed all the tasks in providing support to the military units within the garrison. Currently there are 23 Military Economic Branches operating within the Polish Armed Forces, subordinated to the commanders of the District Logistic Bases (4 bases). There are also 13 units performing the functions of Military Economic Branches.

4. CONCLUSION

The Military Economic Branches have a clearly defined scope of tasks and competences, concerning their function in peace conditions, as well as during the crisis and war. They are subordinated to specific bodies, have defined organisational structures and employment as well as assigned funds. The competences of the commander of a Military Economic Branch include planning and fulfilment of budget as well as providing general support. The essential criterion of functioning of a Military Economic Branch is effective fulfilment of tasks aimed at maintaining the required combat and mobilisation readiness of the supported forces.

The implementation of the concept has resulted in significant changes in the tasks previously performed by military units, which in turn has led to the change in providing financial and logistic support in garrisons. The supply system has simplified fulfilment of financial and logistic tasks, eliminating excessive economic, financial and administrative work to be done within the garrison. It has also contributed to the flexibility of planning and fulfilling dislocation and organisational goals (including the change of headquarters, range and amount of garrisons).

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[8] Decyzja nr 201/MON Ministra Obrony Narodowej z dnia 24 kwietnia 2007 r. w sprawie powołania Zespołu do spraw wdrożenia programu pilotażowego oddzielenia w wojskowych jednostkach budżetowych funkcji finansowo-gospodarczych od operacyjno-szkoleniowych.
Abstract

The purpose of this paper is to present logistics management, which occurs in transport enterprises in the Lubuskie Province. These companies provide services which are part of a complex supply chain. Analysis of logistic processes was made in small, medium-sized and large enterprises. As a result of the study the importance of these logistics activities was indicated, which seek to develop their logistics potential. The logistics transport systems plays a fundamental role, which is why the attempt is made to verify the logistics management processes. Transport companies face a number of problems, including the search for new solutions in acquiring new customers, trying to overtake their position in the local market. Currently, the market is demanding transport to their customers, which is why logistics management is so important in these enterprises.

Keywords: Transport, logistics, logistics management

1. INTRODUCTION

Logistics should be considered in this sense as a science, the field of research, which provides new tools to management, in particular through the construction of logistics chains. Logistics is therefore the science of organizing processes of transporting and storage of raw materials and finished products in terms of the system, aimed at optimizing supply chains (from acquisition of raw materials to delivery of the product to the consumer). Logistics management consists of strategy formulation, planning, control and monitoring (which takes place in an effective way and minimizes the global costs) of process of flow and storage of raw materials, inventory of products in progress, finished goods and related information from point of acquisition to the point of consumption in order to adapt best to customer needs and satisfy them [11].

According to S. Abt "Logistics management consists of strategy formulation, planning, control and monitoring (which takes place in an effective way and minimizes the global costs) of process of flow and storage of raw materials, inventory of products in progress, finished goods and related information from point of acquisition to the point of consumption in order to adapt best to customer needs and satisfy them "[1]. A similar direction of improving processes of flow and storage of products is expressed by logistics management as "the process of flow management and storage of goods and materials, from the source of their acquisition to the point of final consumption (use) by the client, and information flow related to it [1]. " Below there is a triad of logistics terms by S. Abt (Figure 1).

Analysing a number of definitions, it should be noted that logistics combines more aspects and increases its importance to broader areas of the economy. "Logistics in fact can be considered as a new economic function performed by the company" [10]. According to S. Krawczyk "logistics management is an activity creating the overall concept of logistics projects, based on their progress both in the enterprise as well as with partners, and coordination of the implementation (in the broad sense) of this concept by appropriately assigned organizational units using appropriate instruments to manage and control "[6].
Analysing a number of definitions, it should be noted that logistics combines more aspects and increases its importance to broader areas of the economy. "Logistics in fact can be considered as a new economic function performed by the company" [8].

**Logistics** is a field of scientific research on organizing the processes of movement and storage of raw materials and finished products in terms of the system, aimed at optimizing the supply of cargo (from the point of obtaining the raw material to consumer) as well as dealing with post-consumer product management.

Quoted definitions of logistics management allow to specify its goal, which is to integrate all elements, which is the market, distribution network, production and supply process, so that the service the buyers receive was at a high level, taking into account the lowest costs [4]. The logistics purpose understood in this way in the management of the company sets the need [4]:

- knowledge of customer needs and expectations needed to formulate strategies and logistical plans,
- survey of customer preferences in collaboration with marketing,
- knowledge of the market to select the possibility of logistics services.

**Figure 1** A triad of logistics terms

Source: Abt S.: Logistyka w teorii i praktyce, Poznań 2001, p. 38
Formulation, planning, control and monitoring are the tasks placed in each company and include [2]:

- improving the management of flow and storage products processes, leading to satisfy the material needs of the participants of logistic processes.
- inclusion in the enterprise development strategy elements related to the construction of logistics chains.
- subordination of activities connected with logistics processes to requirements of service users (clients).
- increasing the efficiency of the flow of goods, thus reducing flow costs, and ultimately the costs of logistics processes.

Some authors, such as H. Ch. Pfohl [9] and M. Christopher [4], indicate the importance and functions of logistics management with what S. Abt [1] or M. Soltsysik [10] called logistics management. In these cases, the authors refer to the foundation of which is the concept of logistics, whose creation is introduced in various forms to the theory of business management [2].

Nowadays in highly-developed countries widely known are the basic advantages of logistics and benefits of logistics activities and the importance of logistics as a strategic management. It can be noticed that more and more enterprises begin to focus on creating efficient processes and their management in conjunction with other companies [3].

The impact of logistics management on company activities is becoming more visible and important. "In the organizational structure a leading role is attributed to logistics management focused primarily on such departments in the company, as: supply, production, distribution, transport, storage. (...) To make the process of logistics management implemented in the company in an efficient and effective way, the organization of logistics processes should be included in the logistics system "[7]. A company, wanting to be noticed in the market and in order to obtain a competitive advantage over other players, must not only care about its image, develop its business and to analyse the competition, but also a lot of attention should be paid to logistics management.

It can be seen that in Poland there is more and more demand for logistics knowledge. The introduction was devoted to theories of logistics, logistics management in the enterprise. It indicates the tasks that are placed to businesses by formulating strategies, planning, command and control of the entire process of goods flow. The importance of the role played by logistics, logistics management in enterprises increases the demand for knowledge, professionals working in this field. The acquired knowledge allows the use of current techniques and methods of managing logistics processes that enable to improve the systems of supply, production and distribution and flow of information in enterprises.

### 2. RESULTS OF THE RESEARCH

The aim of the research, carried out on a group of 109 transport companies in the Lubuskie Province, is the analysis of selected aspects of logistics management. The study was attended by representatives of 95 small transport companies and 14 medium-sized transport companies. The study did not cover any big companies. The reason for this is the lack of large transport companies operating in the market of the Lubuskie Province, which was confirmed by the information obtained from the Central Statistical Office in Zielona Gora.

#### Table 1 Structure of the sample - distribution due to company’s size

<table>
<thead>
<tr>
<th>Size of the company</th>
<th>Response rate</th>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. from 10 to 49 employees</td>
<td>86%</td>
<td>94</td>
</tr>
<tr>
<td>2. from 50 to 249 employees</td>
<td>14%</td>
<td>15</td>
</tr>
</tbody>
</table>

*Source: Own study based on the survey of companies*

In terms of number of employees, the largest group among the respondents are small businesses.
Table 2 Structure of the sample - period of company’s operation

<table>
<thead>
<tr>
<th>Period of the company’s operation</th>
<th>Response rate</th>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. from 5 to 10 years</td>
<td>18 %</td>
<td>20</td>
</tr>
<tr>
<td>2. from 11 to 20 years</td>
<td>47 %</td>
<td>51</td>
</tr>
<tr>
<td>3. above 20 years</td>
<td>35 %</td>
<td>38</td>
</tr>
</tbody>
</table>

Source: Own study based on the survey of companies

The research sample includes transport companies, which have operated in the market for 5 years. No clear trends of companies’ distribution are observed for the period of their functioning on the market.

The interviews were conducted with representatives of Polish small and medium-sized transport companies. These were people acting as decision-making and affecting the functioning of the company, its development and strategy.

The obtained results are a valuable source of information on the activities of transport companies in the Lubuskie. The largest group of respondents (40%) were the owners of transport companies. In addition to representatives of the executives, the interviews were conducted with employees of the logistics department authorized to provide information, as well as representatives of the accounting, administration.

Most transport companies, as many as 68, have 8-20 cars. 24 transport companies have the number of vehicle fleet in the range of 3-7. 11 companies have 21 to 50 units of vehicles. While 4 companies declared possession of vehicles in the range of 51 - 100 and above 100 - 2 company.

Figure 2 Structure of the surveyed companies due to the number of motor vehicles

Source: Own study based on the survey of companies

Figure 3 Structure of the surveyed companies due to the functioning of logistics department in their structure. Source: Own study based on the survey of companies
According to the indications of the respondents in 103 transport enterprises there is a department dealing with logistics, only 6 companies do not have such a unit within their organizational structure. A major challenge for the enterprise is the ability for efficient and profitable management in the conditions of a competitive environment, saturated markets and the growing globalization of economies. In view of the above phenomena a significant problem becomes skilful logistics management undertaken by the company carrying out investment projects.

Freight exchange enables companies to gain new customers thanks to it lowering costs, e.g. of avoiding empty runs. Out of 109 respondents 104 uses electronic exchanges.

![Figure 4](image)

Figure 4 Structure of the surveyed companies due to their knowledge of logistics instruments
Source: own study

According to the respondents all transport companies know the freight exchanges as one of the instruments of logistics. The second group is the instrument JIT known by 80 companies, instrument QR known by 61 companies and instrument ECR is known by 58 companies. The awareness of instruments is helpful in guiding activities in the transport market. A great interest among companies is given to solutions such as ECR and QR.

Most transport companies believe that the knowledge of logistics instruments is important in their functioning. This means that the use of freight exchange gives the benefits of business activities. Only 3 companies think that knowledge of such instruments has no significant impact.

![Figure 5](image)

Figure 5 Structure of the surveyed companies due to the impact of the logistics instruments’ knowledge on their activity
Source: own study
On the basis of the conducted study the largest part of transport companies (91 companies) using logistics instruments recognizes their financial situation as rather good. In contrast, a very good financial situation is confirmed by the 15 companies. The result proves that the knowledge of logistics instruments affects the financial position of transport companies operating in the market.

3. CONCLUSION

The results of the conducted study in the area of Lubuskie Province has identified a process of logistics management. A logistics department is the basis, which a company must have. Transport companies must not only keep pace with contemporary changes, but in many cases be ahead of them, meeting the expectations of their customers. The permanent element of logistics activities has become studying and forecasting changes. This requires, however, not only perceiving new circumstances and new challenges for logistics, but their multifaceted analysis, understanding mutual implementation and impact. A company in order to be noticed in the market and in order to obtain a competitive advantage over other players, must not only care about its image, develop its business and analyse the competition, but also pay a lot of attention to logistics management. A competitive advantage, better meeting customer needs, faster and more efficient operation, more efficient supply chain and its optimal functioning - these are just some of the benefits of maintaining a high level of logistics management in the enterprise, including the use of logistics and marketing instruments.

REFERENCES


EARLY WARNING SYSTEM IN LOGISTICS PROJECT MANAGEMENT

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Abstract

Risk management is a vital process in all complex logistics project management. We discuss the concept of early warning system EWS dedicated to logistics project, which enable management under the conditions of uncertainty and risk. The complexity and uniqueness of the logistics projects as well as the discontinuity of the effects in the environment of goods and services, significantly impact the inability to eliminate the risks and subsequently lead to changes during execution. The introduction into companies and supply chains things such as: principles, methods, mechanisms of knowledge management and project risk, e.g. by implementing into the logistics project management the early warning systems can minimize the impact of unexpected, at the stage of initiation of the project, negative phenomena. Early information concerning risks enables to eliminate effectively later problems, in meeting the logistics project's schedule and budget, simultaneously constitutes a potential source of opportunities to accelerate the project implementation and project implementation below the assumed budget. The model of the dedicated early warning system should help policy-makers (logisticians) at the stage of the logistics project's planning and implementation, enabling undertaking decisions regarding its accomplishment and elaboration of the response plan in the case of appearance of a particular type of risk. Early warning system should aid logisticians with logistics project management undertaken in an company or in a supply chain. The developed approach extends previous work by the authors.

Keywords: Early warning system, weak signals, logistics project, project management, uncertainty, risk

1. INTRODUCTION

The success of a single company and a supply chain results from the skillful use of processes, principles, rules of conduct and resources in response to opportunities and risks that arise, including non-standard processes like logistics projects. Logistics projects play a huge role in improving a company's competitive position [1]. An important challenge in logistics and supply chains is appropriate management of logistics projects [2, 3]. The logistics projects play a significant role in logistics and supply chain [1, 4]. In many cases it is prerequisite for the creation of new business fields and for opening up additional markets and increase effectiveness of logistics systems and supply chains [5]. On the one hand companies and supply chains are nowadays seeking different approaches to cope with uncertainty and risk [6]. In order to cope with uncertainty and risk they undertake new groups of task i.e. logistics projects. Logistics projects can be used to improve logistics practice and supply chain practice [1, 3, 4]. Logistics projects are, by definition, a kind of projection of an intended future state, play a pivotal role in shaping, building, and delivering the future of companies and supply chains, and are by nature delimited by uncertainty. On the other early warning system EWS as a tool is concerned with looking into the future of the process or project including logistics project or companies, which is always uncertain, and discussing what it might mean for decision-making in the present or in the future [7]. The ability to react in real-time to hazards and disturbances, especially within time-critical processes, becomes more and more important for many companies and supply chain [6, 8]. In this context the availability of real-time data concerning current events in the logistics and supply chain of logistics project execution is essential. Therefore research in the field of early warning system of logistics project management is becoming more and more important.
This paper aims to identify how early warning system in the context of logistics project management and its value to the logistics and supply chain management and project management practice. This paper presents an overview of the concept of early warning systems in the literature. The authors present approaches to the EWS including logistics projects and explains how they can be utilized as an early warning signal for avoiding failure in logistics project management.

2. LITERATURE REVIEW

A logistics project (type of specific project) can be defined as a planned set of interrelated tasks to be executed over a fixed period, limited by budget and time, which is carried out in order to improve the efficiency and effectiveness of product flows and of the associated information in companies, supply chains or spatial systems [2]. This is a non-routine set of tasks characterized by a timeframe, costs and organization, the aim of which is to perform a singular and unique action that sets out to optimize a specific logistics process [1].

Planning and implementing projects, including logistics projects, always involves a certain level of uncertainty. This is due to the fact that these projects are often innovative and unique and it is difficult to predict the direction of implementation in uncertain situations. This uncertainty is the result of not having full access to information regarding a project type, and can be defined as the probability that the objective will not reach its planned target value [9]. The internal and external conditions of logistics project are full of uncertainty, which stems from changing customer requirements, resource utilization, personnel mobility, economic turbulence, weather conditions, etc. Under such conditions, company and supply chains have to manage several different logistics projects. A multi-project context is common in contemporary companies and supply chains. Companies and supply chains increasingly use multiple logistics projects in their daily work to achieve their aims [1, 3, 4]. However, most logistics projects are either over budget, late or are simply not good enough [10] and still different people claim that those projects have been successful. In that context, the early warning system of logistics project has to be taken into account.

The ability to react in real-time to disturbances of undertaken logistics projects in companies and supply chains, especially within time-critical processes, becomes more and more important in order to achieve success. Therefore research in the field of early warning system in logistics project management is becoming more and more important.

The concept of the early warning systems is an instrument of strategic management [11, 12, 13]. Until now, this concept has referred exclusively to business management. In the few works dealing with project management, one can find a reference to the concept of Ansoff's weak signals [14]. Professor Igor Ansoff introduced concept of weak signal which appears to contain the kind of anticipation of surprising future events in the business. If Ansoff’s thoughts on the uses of vague or inexact information can be applied to project work, there may be good possibilities of developing the sought-for tools for project leaders [7], including logisticians - logistics project leaders. The aim of any early warning system, including system in logistics project management is to deliver the right information product, in the right format, at the right place at the right time and to the right people; this is customer demand driven. Information of each logistics project execution are an important component of any early warning system in logistics and in supply chain management, delivering warning messages to designated recipients in time with appropriate information in the required quality and format. An important challenge in planning, execution and control of the undertaken logistics project in intra-and cross-company in supply chains is the capability to react to unforeseen deviations and disruptions. The basic functionality of early warning systems consists of detecting the event and quickly warning the users.

At present, the literature on early warning system especially in research of project and project management is very few [7, 15]. According to research made by Nikander [16], very little existing literature deals explicitly with the early warning system in projects and project management. The same conclusion was made by Klakegg [15] addressing that early warning systems in project and project management are under researched. The
problems of early warning systems in project and project management are mainly addressed through production projects, meteorological phenomena, natural phenomena, not through logistics projects. The literature of logistics project management includes some indirectly statements that are possible to interpret as examples of early warning system.

The approaches to early warning detection directly and indirectly mentioned in the project management literature are presented in the Table 1. The first column presents the early warning sources directly discussed in the literature with some examples of paper. The second column presents potential of early warning sources discussed indirectly in the project management literature. It includes such approaches as: stakeholder analysis, maturity measurement, extrapolation from earlier projects, cause and effect analysis, gut feelings, and interface analysis.

Table 1 Approaches to early warning systems in project and project management

<table>
<thead>
<tr>
<th>Early warning sources directly discussed in the literature</th>
<th>Potential of early warning sources discussed indirectly in the literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk analysis</td>
<td>Stakeholder analysis</td>
</tr>
<tr>
<td>Project assessment methods</td>
<td>Cause / effect analysis</td>
</tr>
<tr>
<td>Project success / failure models</td>
<td>Maturity assessment</td>
</tr>
<tr>
<td>Earned Value Method EVM</td>
<td>Interface analysis</td>
</tr>
<tr>
<td>Decision support model of early warnings</td>
<td>Extrapolation from previous projects</td>
</tr>
<tr>
<td></td>
<td>Gut feelings</td>
</tr>
</tbody>
</table>

Source: [7]

A broad range of the project management literature points to early warning signs through the treatment of risk management as one important part of the early warning system [16, 17]. An example of the research done on the link between risk and early warning signs is the research done by Niwa [17]. The author outlines an approach based on the use of computer-based expert system. The developed concept of risk alarm was introduced as an advance warning of emerging problems. Another approach to early warning signals is Earned Value Method (EVM) [18]. The EVM system relies on a set of metrics that measure and evaluate the general state of a undertaken project [19]. According to paper [20] the EVM is a good forecasting or an early warning tool that enables project managers to plan and control projects proactively. Another large body of literature in the project management field deals with so-called project success factors, or sometimes their inverse, project pitfalls can be treated as approaches to early warning signals. This topic was also extensively researched by Nikander [16]. Many researchers and practitioners consider performance, effectiveness, and success as synonyms [21], which means that effectiveness is a synonym of success. It can be treated as the degree to which objectives are achieved [21, 22]. Various aspects of success were assessed: project efficiency (measured by the project management triangle), the project’s impact on the client (measured by client satisfaction level), organization success (measured by the actual impact of project outcomes on the organization), as well as future-proofing (measuring how well project outcomes were aligned with the strategic goals of a company) [23]. Nevertheless, to date success has in principle been measured by business results. Today, we can note an evolution of project success concepts. Project effectiveness is synonymous with project success. It is measured or assessed in terms of the degree to which project objectives are achieved.

Another approach to early warning detection directly discussed in the literature of project management are various project assessments. They have also been discussed as a way to identify areas that should be addressed by EW monitoring. Project assessments go by many names, some of which are project reviews, PHCs, benchmarking, post project evaluation and project audits [15]. Assessments can take place during the project initiation stage and up to the project mandate stage, when the go / no go decision is made and even post-project completion. In the literature of the project management an we can find some relevant material on
project problems or pitfalls for example in [13, 16]. These approaches have been directly mentioned in the project management literature as early warning identification approaches. The compilations of typical project problems were presented in these papers. Another paper [24] presents cause-and-effect (cause-and-problem) chains in projects.

3. TOWARDS EARLY WARNING SIGNALS IN PROJECT MANAGEMENT IN LOGISTICS AND SUPPLY CHAIN

In the area of logistics and supply chain management we can find very few research addressing to early warning signals. Genca et al. [8] focus on presenting an early warning system for production in supply chains and evaluating its benefits regarding logistic objectives by using discrete event simulation. Quing [25] discusses the risk which business faced by the logistics system on the impact of corporate targets. He used the methods of knowledge management to establish the logistics risk early warning system. Wächter et al. [26] present aspects of the architecture of tsunami warning systems in general, including design criteria, information flows and main architectural building blocks. The authors of papers [28, 29] developed a database model as an architectural base layer of information logistics for geospatial EWS to disseminate customized messages in a multilingual environment, providing a generic approach to be applied to each EWS. In the paper [29] the concepts of generic information logistics was developed for the distant early warning system (DEWS). The tool is not limited to specific hazard types, languages or other deployment specifics. It enables the generation of user-tailored warning messages that account for specific needs, individual requirements, different levels of understanding, distinct perceptions and varying personal abilities. The presented system provides several filter mechanisms to avoid unintentional message flooding in emergency situations. This system is completed by a reusable graphical user interface component, which provides functionality to generate warning messages in compliance with the Common Alerting Protocol (CAP) standard to leverage inter-operability among early warning systems [29].

Another research [1] presents an approach to evaluating the effectiveness of logistics projects. The purpose of the study was to identify the critical factors determining the success of logistics projects and develop a model of logistics project effectiveness. The approach can be treated as an approach to early warning detection approaches. The study carried out by the authors had the form of questionnaires. The authors used a case study to validate the model of fuzzy decision-making system dedicated to estimate the level of logistics project effectiveness. The paper [5] presents a new approach for the evaluation of logistics service effectiveness, along with a specific computer system implementing the proposed approach - a sophisticated inference system, an extension of the Mamdani probabilistic fuzzy system. The paper presents specific knowledge concerning the relationships between effectiveness indicators in the form of fuzzy rules which contain marginal and conditional probabilities of fuzzy events. An inference diagram is also shown. A family of Yager’s parameterized t-norms is proposed as inference operators. It facilitates the optimization of system parameters and enables flexible adjustment of the system to empirical data.

The limited research on possible approaches for identifying early warning system in logistics project management, the application of early warning identification approaches in logistics practice and supply chain practice and possible barriers against responding to them can be seen as research gaps. This paper is the one of first individual publication addressed to early warning systems in logistics projects.

4. CONCLUSION

The challenge for logisticians is to create an early warning system, which would allow the company and supply chain to transform incoming weak signals into useful information used in knowledge management of logistics project. The response, of the management to the quality of the flowing information into the early warning systems, may be the use of the weak signals concept, because it is assumed that every event, every change
is preceded by a series of information which, even though they are difficult to obtain (weak signals, as unstructured and incomplete) allow to undertake actions securing the enterprise against the consequences of change (or at least give time for the appropriate response). The model of early warning systems dedicated to logistics project management can serve as a tool to identify potential opportunities and threats in the life cycle of logistics project. The success of the logistics project accomplishment may depend on, among other things, the ability to respond in advance to potential opportunities and threats, avoiding strategic surprises that disorganize the implementation of the project. The accomplishment of particular logistics projects, completed successfully, influence the improvement of the company’s competitiveness, as well as supply chain. This tool can be a valuable source of knowledge for logistics project managers in decision-making processes. An early warning system must provide information about relevant changes in the internal area, in the environment of the logistics project and make them available to analyze it. The introduction into the companies and supply chains things such as: principles, methods, mechanisms of knowledge management e.g. by implementing into the logistics project management the early warning systems can minimize the impact of unexpected, at the stage of initiation of the project, negative phenomena. The model of the dedicated early warning system should help policy-makers (logisticians) at the stage of the logistics project’s planning and implementation, enabling undertaking decisions regarding its accomplishment and elaboration of the response plan in the case of appearance of a particular type of risk and / or opportunity. An effective aid of the early warning systems can be seen as a computer tool utilizing knowledge. In the processing of qualitative information, poorly structured, knowledge systems are useful. In the problems of the early warning, the knowledge system should help, among others, to integrate various methods and concepts of the early warning, to manage numerous collection of diverse information, to explain and interpret various information. As already mentioned, it is crucial to reduce the mistakes made while identifying weak signals. With regard to the early warning systems in the logistics projects, it is necessary to maximize the correct assessment and minimize incorrect assessment resulting from the analysis of signals. While designing early warning systems, achievements of the diagnostics theory should be used. Information flowing into such a system would have a post of diagnostic signals, which are the values of individual numbers or aggregated indicators or images obtained by measuring certain quantities: economic, technical, social, psychological and other.

REFERENCES


MEASUREMENT OF THE CUSTOMER SERVICE IN LOGISTICS

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Abstract

Logistics is increasingly seen as an integrated management system of the circulation structure of goods, products and information in the conditions of expanding the scale of company operations, extending the logistics chain, intensifying competition and the growing importance of customer service. Today's companies need to combine the efficiency and competitiveness of business in the global market with sensitivity to the needs of local customers. To provide it, logistics companies need to look for new solutions, which aim to constant control and improvement of the customer service process. Their key task is the measurement of the quality of customer service.

In practice survey of customer satisfaction is most often used. However, the observation of practice shows many disadvantages of such a solution. Customers often do not want to get involved in the assessment mainly from a lack of conviction of their impact on changing treatment by the company. Often obtained information is accurate only in cases of negative experiences with the cooperation of the logistics company.

This paper proposes a system for measuring the quality of customer service dedicated to logistics companies. It is based on a set of indicators of the most important areas of customer service. They enable rapid and constant control of the customer service process. In the presented solution pays particular attention to indicators related to the strategic objectives of the company. The implementation of the presented solution leads to increase the quality of customer service and improve its competitiveness on the market.

Keywords: Key Performance Indicators, measurement of customer service

1. INTRODUCTION

Changes in today's markets have a large impact on the logistics, especially in crisis time [1]. Logistics is increasingly seen as an integrated management system of the circulation structure of goods, products and information in the conditions of expanding the scale of company operations, extending the logistics chain, intensifying competition and the growing importance of customer service. Presently companies need to combine the efficiency and competitiveness of business in the global market with sensitivity to the needs of local customers. Strong competition and the globalization of markets forces innovation, which primarily manifests short time of process realization, excellent quality of customer service and offering additional services.

Companies use many different methods to achieve better effectiveness [5], [7], [8]. Currently, the effectiveness of logistics companies depends on the ability to gain a competitive advantage in the market. The most important element of a competitive advantage is an efficient, high-quality customer service. To provide it, logistics companies need to look for new solutions, which aim to constant control and improvement of the customer service process. In this situation, the key task of logistics companies is the measurement of the quality of customer service.

In practice survey of customer satisfaction is most often used. However, the observation of practice shows many disadvantages of such a solution. Customers often do not want to get involved in the assessment mainly from a lack of conviction of their impact on changing treatment by the company and sometimes a lack of time.
Often obtained information is accurate only in cases of negative experiences with the cooperation of the logistics company. In cases of average or good evaluation, many customers fill the questionnaire automatically, without enough reflection, imprecise, often without thinking about the exact meaning of the questions. These actions affect the unreliability of the data contained in the surveys and a little credibility. In addition, in many cases, a negative impact on the quality of the data contained in the questionnaires is the wrong way to distribute surveys and inadequate, badly trained staff who are engaged in conducting surveys.

This paper proposes a system for measuring the level of customer service quality which is dedicated to logistics companies. It is based on a set of indicators of the most important areas of customer service. They enable rapid and constant control of the customer service process. In the presented solution pays particular attention to indicators related to the strategic objectives of the company. The implementation of the presented solution in the logistic enterprise leads to increase the level of customer service quality and improve its competitiveness on the market.

2. A ROLE OF THE CUSTOMER SERVICE IN LOGISTICS COMPANIES

Very fast development of logistics enterprises followed the Polish accession to the European Union. This development was due to the following factors [2]:

- rapidly progressive globalization;
- the development of information technology;
- abolition of barriers to movement of people and goods;
- the possibility of using funds from the European Union, which allows a significant improvement of road infrastructure;
- increasing popularization of outsourced logistics services.

The recent economic crisis caused a sharp decline in both the number of logistics companies, and their revenues [2]. In this situation, logistics companies need to increase the efficiency of the operation and strive for the rapid implementation of strategic objectives, which will increase their competitive advantage and stay in the market.

Logistics companies in Poland, as well as in the European Union, mainly belong to the sector of micro, small and medium-sized enterprises. In this type of companies a key factor in gaining competitive advantage is the level of customer service. For this reason, one of the most important and the most common strategic objective of logistics companies is to improve the quality of customer service. Customers expect personalized, flexible offers supported by high standards of services provided [2]. Fast, professional service and price are the factors that most often determine the choice of the operator. Logistics companies must also increase the efficiency of economic activity. This is facilitated by well-articulated strategy that takes into account the current situation on the market and can gain a competitive advantage [6]. Therefore, there is a legitimate need to seek solutions that quickly enable the measurement, evaluation and continuous monitoring customer service in logistics companies and at the same time will be oriented towards the future strategy of the company.

Contemporary conditions of the logistics companies in the market are related to the strong pressure to reduce the cost of logistics and shorten the execution time of all processes and operations in the company. Although thanks to the development tools, it is possible to process a lot of data and the use of very sophisticated databases, companies do not have the time to analyze and control such a large amount of information. This is the ensure high quality customer service, it must be objectively assessed on the basis of a well-designed measurement system, based on carefully selected criteria and set targets to be met at exactly the right time. The company must identify clearly what aims and what exactly will be called improving the quality of customer service.
Properly identified needs and requirements of the client play an important role in this matter. The questions then arise as follows:

- What to measure?
- What aspects of customer service are the most important?
- How to evaluate the level of customer service and ensure constant monitoring and control of the customer service process in logistics enterprises?

F. J. Beier i K. Rutkowski suggested four factors that determine the level of the customer service [3], which are presented in Table 1. In contrast, M. Fertsch presented a set of measures from the point of view of the customer, to which he included [4]:

- orders received on time;
- orders executed completely,
- orders delivered without damage,
- orders properly executed,
- orders accurately invoiced.

**Table 1** The set of criteria to measure the quality of customer service by F. J. Beier i K. Rutkowski [2]

<table>
<thead>
<tr>
<th>Criterion for assessment</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>delivery time</td>
<td>time from order to delivery to the customer transfer</td>
</tr>
<tr>
<td>Reliability</td>
<td>associated with the correctness of the order</td>
</tr>
<tr>
<td>communication</td>
<td>a dialogue way between the transport company and the buyer of the service, which allows controlling the execution of the order and inform each other about changes and disturbances</td>
</tr>
<tr>
<td>Convenience</td>
<td>simultaneous willingness and ability of the transport company to meet additional customer requirements, such as the volume of deliveries, select the type or types of transport, packing method, frequency of delivery, terms of taking orders and deliveries, etc.</td>
</tr>
</tbody>
</table>

An interesting set of criteria to measure the quality of customer service offered P. Romanow [9]. These criteria are described in three levels: as part of the pre-trade, transactional and post-transaction, as shown in Table 2.

**Table 2** A set of criteria to measure the quality of customer service by P. Romanow [9]

<table>
<thead>
<tr>
<th>Level</th>
<th>The criterion for assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-trade items</td>
<td>convenience in contacting the client company</td>
</tr>
<tr>
<td></td>
<td>organizational structure</td>
</tr>
<tr>
<td></td>
<td>flexibility provider understood as the ability to quickly adapt to individual customer needs</td>
</tr>
<tr>
<td></td>
<td>delivery</td>
</tr>
<tr>
<td></td>
<td>response time to inquiries</td>
</tr>
<tr>
<td>Elements of the transaction</td>
<td>duration of the transport service</td>
</tr>
<tr>
<td></td>
<td>indicator of the order realization</td>
</tr>
<tr>
<td></td>
<td>timely delivery</td>
</tr>
<tr>
<td></td>
<td>indicator transport damage</td>
</tr>
<tr>
<td>Elements of the post-trade</td>
<td>complaints</td>
</tr>
<tr>
<td></td>
<td>service returns</td>
</tr>
</tbody>
</table>
3. MEASUREMENT OF THE LEVEL OF CUSTOMER SERVICE QUALITY

A strong competition in the market of logistics services causes that logistics companies have subjected to strong pressure to reduce costs for many years. For this reason a key aspect of competition is the level of customer service quality. Logistics companies often have significantly raise the level of customer service quality in order to stay in business. Therefore, there is a need to implement solutions that will quickly raise the level of customer service quality and to measure, evaluate and control its level.

The main objective of the study was to develop a system for measuring the customer service quality dedicated for logistics companies. After a thorough analysis of existing tools it was decided that an universal set of indicators that can be used to gauge the level of customer service quality in logistics companies, and also control and monitor the planned increase in the level of customer service quality is sought as a part of this research.

The use of Key Performance Indicators (KPI's) is proposed in the presented solution. KPI's are oriented for future of the company. It is a very important advantage. KPI's should be very clearly linked to business strategy and relate to the key areas. The company should measure and control only what confirms their efforts and its strategic direction. The main objective of determining the KPI's is to show the workers why the strategy is important and help in understanding these areas. The indicators are used for organizational learning and development and presentation of the strategic direction of the company in a more understandable manner, and above all the use of indicators to improve working and correction operations, allowing organizations to refocus their efforts in the fight for results. KPI's allow enterprises to determine the stage of development at which the organization is to determine whether the adopted goal is achieved in an appropriate manner and to indicate when it will be achieved [11].

Properly selected KPI's should be: precise (relating to the organizational goal); measurable (to assess the level of realization); achievable (realistic in the business environment); binding (connecting activity directly with measures); and conditioned by time (define the specific terms of achieving objectives) [12].

The essence of KPI's is to select the most important indicators to rationalize and simplify decision-making, paying attention to the strategically most important areas of the customer service. KPI's help to define and measure progress toward organizational goals and make the management of enterprise easier. KPI's not only relate to items that are easy to measure (e.g. participation, number, frequency, etc.), but also allow areas which are difficult to measure (such as organizational culture, the potential for cooperation, quality of relationships with customers, etc.) to be controlled. These activities cannot be measured, but can be evaluated using any scale (e.g. the description of KPI's in the form of number of activities, that relate to intangible assets). KPI's should be used to measure the current state; evaluate effectiveness; plan improvements; monitor changes and progress and motivate staff.

Main areas of particular importance for high-quality customer service have been selected based on a detailed analysis of the literature, the many observations made in logistics companies in Lubuskie district and used interview techniques among the customers of these companies:

- delivery time;
- reliability;
- communication;
- convenience (flexibility).

Then, for those areas indicators by which to measure and evaluate the level of customer service quality were formulated. Based on the study and careful analysis measures were highlighted, which are presented in Table 3.
### Table 3: Measures to assess, control and monitor the customer service quality in logistics companies (compare [10])

<table>
<thead>
<tr>
<th>Criterion for assessment</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>delivery time</td>
<td>Timely delivery - percentage of timely deliveries within a period T</td>
</tr>
<tr>
<td></td>
<td>The percentage of deliveries, which have been prepared for shipment within 24 hours of placing an order</td>
</tr>
<tr>
<td>reliability</td>
<td>The percentage of deliveries in which the ordered product range was consistent with the order</td>
</tr>
<tr>
<td></td>
<td>The percentage of deliveries in which the entire range was delivered without any damage</td>
</tr>
<tr>
<td></td>
<td>The percentage of deliveries in which all goods have been delivered in terms of their usefulness</td>
</tr>
<tr>
<td>communication</td>
<td>The percentage of deliveries, where the level of implementation of the client could monitor</td>
</tr>
<tr>
<td></td>
<td>The percentage of deliveries in which the client has received notification after each stage of the order</td>
</tr>
<tr>
<td></td>
<td>Time availability of customer service staff in the period T</td>
</tr>
<tr>
<td>convenience, flexibility</td>
<td>The percentage of deliveries, which until shipment could change the ordered product range</td>
</tr>
<tr>
<td></td>
<td>The percentage of deliveries in which the client can choose more than one type of packaging</td>
</tr>
<tr>
<td></td>
<td>The percentage of deliveries in which the customer can specify a different frequency of the supplied goods</td>
</tr>
</tbody>
</table>

### 4. CONCLUSIONS

In the paper a new efficient and practical system for measuring the quality of customer service dedicated to logistics companies is proposed. This system consists of a set of universal Key Performance Indicators that enable fast measurement, monitoring and control of the main areas of particular importance for high-quality customer service according to conducted research: delivery time; reliability; communication; convenience (flexibility).

On the basis of these measures the quality of customer service can be evaluated, but also the degree of improvement of the quality level of customer service in logistics companies can be monitored and controlled. This solution also has yet another very important advantage. It is possible to assess the extent to improve the quality of customer service. In the presented solution pays particular attention to indicators related to the strategic objectives of the company. The implementation of the presented solution leads to increase the quality of customer service and improve its competitiveness on the market.

### REFERENCES


LEAN TOOLS INFLUENCE ON THE LOGISTIC PROCESS IN PRODUCTION COMPANY

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Abstract

The paper presents identification of problems during the implementation of lean concept in enterprises in Poland. On the case, the manufacturer of semi-trailers car there was assessed the influence of lean tools for logistics processes in the production area. Based on studies compilation of problems in the implementation and operation of selected lean tools were presented. Additionally statement of effectiveness of selected tools in the analyzed company was developed.

Keywords: Lean manufacturing, logistic, tools, Muda

1. INTRODUCTION

The concept of Lean is a systematic approach to identifying and eliminating waste through continuous improvement of processes in production and logistics processes related to the delivery of the product according to customer requirements. Lean tools can be used in improving the logistics operations in the production process and assembly as well as in the processes of inventory management. As in Lean manufacturing philosophy and so in logistics processes you should focus on eliminating waste, in this are helpful soft and hard Lean tools. The result of this approach was the appearance in the literature of the concept of Lean logistic, which in the current reasoning can be called logistics without waste [1÷3,7,8].

Lean manufacturing from Lean logistic differs only in area of application of tools. In both cases we are dealing with the concept of MUDA (waste) and the instruments used for its elimination and processes improvement e.g. 5S, OEE, 8 step Practical Problem Solving (PPS) Method, Pareto Analysis, Kaizen, Setup Time Reduction, Process Mapping, Value Stream Mapping (VSM), Quick & Easy Kaizen, SPC / Control Charting, 5 Whys, 5W2H, Continuous Improvement, Continuous Flow, Visual Controls, Design for Six Sigma (DFSS), Cellular Manufacturing, Production Levelling, KANBAN / Line Balancing, VOC (Voice Of The Customer), Jidoka, ANOVA, Work Standardization, Work Simplification, Fishbone diagrams Six Sigma, Takt Time, QFD and Poke Yoke / mistake proofing. Typical, published results from the implementation of Lean concepts logistic in enterprises are suspending the efficiency of shipping by 30%, reduced inventory by 15% and further reduction of made qualitative errors by 30% and increase of the level of security also about 30% [4÷6,9,12].

The question arises whether you should use all mentioned tools? What will be their effectiveness and whether the culture of the organization as well as the workers themselves are prepared to work with the tools of Lean?

In the Lean organization must be precisely defined rules of cooperation independently whether it will be a production worker or operator of means of transportation. In Lean logistic all participants need to know that they are the source of knowledge about how to eliminate waste and from their involvement will depend to what extent they will contribute to its elimination. The efficiency of logistics processes in the production system depends on the use of methods and techniques which improve materials flows namely will eliminate waste. The article is an attempt to assess what is the impact and what is the effectiveness of the Lean tools to improve logistics processes.
2. IDENTIFICATION OF WASTE IN LOGISTICS PROCESSES

The aim of Lean tools in production is to fight against waste in case of logistics processes (supply chain) waste takes on new meaning. When analyzing the impact of Lean tools on logistic processes there were carried out identification of the waste in the aspect of implementation of logistics processes [4,10,11].

- In the case of Muda - overproduction in relation to the logistic processes in the majority of identified cases we are dealing with the improper priority of tasks and improper scheduling of means of transportation.
- In case of expectations we should divide the problem into two areas. The first concerns the external expectations associated with delays related to handling inbound deliveries, slow inventory replenishment is so called unbalanced work. In case of the internal expectations the problem concerns expectation (in the analyzed company) on the corresponding assembly components in assumed time window on given assembly station. There happens also problem of providing improper component in given time window for a given assembly station. What in consequence causes waste of transport and generates unnecessary costs.
- Waste of movement is pure logistics process associated with improper storage, poorly laid out releases and admissions zone. We also cannot forget about the wastefulness of traffic associated with the search for relevant components of production, transport containers or finally production tools.
- Waste of inventories is a maladjustment of the size and time of delivery in relation to the real needs in a given time interval. Consequently, this can lead to a slow-moving inventories (here also occurs a waste of capital - the frozen financial resources). Possession of surplus stocks allows to mask problems in the company, among others, product quality, unreliable suppliers and poor technical condition of the machines.
- Waste of space associated with lack of storage space optimization but also with the inadequacy of the size of the production containers to the dimensions of transported parts. Another manifestation of the space waste is non-optimized storage of tools for the tool magazine but most of all sub-optimal storage of tools in the area of workstations.
- Waste of defects - these are not only defective products but all the processes which because of resulting errors must be repeated. From the viewpoint of logistics these can be e.g. errors in transport documents, wrongly classified and labelled materials and manufacturing containers or damage to the logistics carriers.

![Figure 1 Assumptions of using Lean tools in logistics processes](image-url)
Figure 1 shows the general principles of the use of Lean tools in logistics processes.

3. RESEARCH METHOD

Research concerning the effectiveness of application of Lean tools and their impact on the logistics processes were carried out in the company belonging to the leading manufacturers of car trailers and semi-trailers as well as truck bodies for trucks. The number of staff employed in the audited company exceeded 1000. The study was limited, however, to the management and employees of one production hall. The study was conducted in two groups, to the first group was qualified management team including the leaders of processes in particular auxiliary areas and areas of direct production. To the second group was qualified operating personnel. The study was conducted in the form of survey supported by direct interview as well as own observation of realized processes in evaluated production cycle carried out after receiving the results of a survey in order to verify them. Subsequently from the obtained research there were separated responses of the staff responsible for the execution of logistics processes and compared with the remaining group of employees. For research was qualified 115 correctly completed questionnaires and filled in sheets from direct interview. Respondents had to answer questions concerning ten selected Lean tools. The questions concerned the level of knowledge of methodology of instruments use, the effectiveness of the action (impact and effectiveness assessment on the improvement of realized processes), and the type and duration of completed trainings in the field of Lean if such took place. Test results are provided in the form of weighted averages for each tool. Each of the respondents had to answer to what extent he agrees with the statement e.g. use of 5S (OEE, SMED, etc.) influences the improvement of logistics processes.

4. RESULTS AND DISCUSSION

Questionnaire survey was conducted in the first quarter of 2016, the study included responses of 115 respondents who responded on 10 selected instruments of Lean (Table 3). For each instrument, the respondent had to choose a scale from 1 to 5. The results for the question whether you agree with the assertion that the elimination of Muda influences the improvement of logistics processes are shown in Table 1.

Table 1 Respondents’ answers on the impact of the elimination of MUDA on the logistics processes

<table>
<thead>
<tr>
<th>Answers</th>
<th>Number of respondents</th>
<th>Percentage share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Strongly Disagree</td>
<td>2</td>
<td>1.75</td>
</tr>
<tr>
<td>2 - Disagree</td>
<td>3</td>
<td>2.61</td>
</tr>
<tr>
<td>3 - Normal</td>
<td>6</td>
<td>5.22</td>
</tr>
<tr>
<td>4 - Agree</td>
<td>29</td>
<td>25.22</td>
</tr>
<tr>
<td>5 - Strongly Agree</td>
<td>75</td>
<td>65.22</td>
</tr>
<tr>
<td>TOTAL</td>
<td>115</td>
<td>100</td>
</tr>
</tbody>
</table>

Conducted research indicated that according to the respondents the most important influence on implemented logistical processes has the elimination of waste. On very strong influence (5) on elimination of MUDA on the logistics processes indicated 75 respondents representing 65% of the respondents to the strong influence (4) 25% of respondents that totally is 90% of respondents. Analyzing the results with division on the management staff and leaders of processes and production workers 100% of management staff responded that the elimination of MUDA has very strong impact on the improvement of logistics processes. All employees in both research groups underwent adequate training on issues of MUDA elimination. According to the employees it is precisely the elimination of waste has the greatest impact on improving logistics processes, as instruments with the least impact on the improvement of logistics processes employees pointed 8 step problem solving Method, OEE and balancing of production (Hejunka). Table 2 summarizes responses about the impact of 8
step problem solving Method, which in the opinion of the respondents has the least impact on the improvement of logistics processes.

**Table 2** Respondents’ answers on the impact of 8 step problem solving Method on the logistics processes

<table>
<thead>
<tr>
<th>Answers</th>
<th>Number of respondents</th>
<th>Percentage share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Strongly Disagree</td>
<td>35</td>
<td>30.43</td>
</tr>
<tr>
<td>2 - Disagree</td>
<td>37</td>
<td>32.17</td>
</tr>
<tr>
<td>3 - Normal</td>
<td>14</td>
<td>12.17</td>
</tr>
<tr>
<td>4 - Agree</td>
<td>14</td>
<td>12.17</td>
</tr>
<tr>
<td>5 - Strongly Agree</td>
<td>15</td>
<td>13.04</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>115</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The results of respondents for 8 step problem solving Method indicate small effect of this instrument on the improvement of logistics processes, only 35% of respondents indicated a significant impact on the improvement of logistics processes and 65% of respondents indicated that there is no significant impact. In both research groups similar distribution of results was observed. The study excluded employees who did not have training from a given instrument that is why to the study was included only 115 sheets of questionnaires.

**Table 3** summarizes the results obtained for all the 10 analyzed Lean instruments. In the studies was used weighted arithmetic (\(W_{av}\)) mean in order to determine the rank of a given instrument according to the formula.

\[
W_{av} = \frac{W_1 \cdot X_1 + W_2 \cdot X_2 \cdots W_n \cdot X_n}{W_1 + W_2 \cdots W_n}
\]

Where:

- \(W_1 \ldots W_n\) - weight
- \(X_1 \ldots X_n\) - The number of respondents responding (Strongly Disagree…… Strongly Agree)

**Table 3** Ranking of the impact of selected Lean elements on the improvement of logistics processes

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Instruments</th>
<th>Weighted arithmetic mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Elimination of Muda</td>
<td>34.47</td>
</tr>
<tr>
<td>2</td>
<td>5S</td>
<td>32.35</td>
</tr>
<tr>
<td>3</td>
<td>Process Mapping</td>
<td>30.02</td>
</tr>
<tr>
<td>4</td>
<td>VMS</td>
<td>29.80</td>
</tr>
<tr>
<td>5</td>
<td>Kaizen</td>
<td>28.54</td>
</tr>
<tr>
<td>6</td>
<td>Pareto-Lorenz</td>
<td>27.34</td>
</tr>
<tr>
<td>7</td>
<td>SMED</td>
<td>25.49</td>
</tr>
<tr>
<td>8</td>
<td>OEE</td>
<td>24.23</td>
</tr>
<tr>
<td>9</td>
<td>Heijunka</td>
<td>20.04</td>
</tr>
<tr>
<td>10</td>
<td>8 step problem solving Method</td>
<td>18.80</td>
</tr>
</tbody>
</table>

From the analysis of obtained results of weighted average (Table 3) for individual instruments we can conclude that, in the opinion of employees the greatest importance for the improvement of logistics processes has Elimination of waste (weighted average 34.47) in next step 5S (weighted average 32.35), process mapping
(weighted average 30.02) and value stream mapping (weighted average 29.80). Fifth place in the ranking takes Kaizen with weighted average at the level of 28.54. It should be emphasized that the first four Lean instruments we can directly link to the improvement of logistics processes, in case of Muda we eliminate waste associated with the logistics processes (Lean logistic). 5S also refers directly to this area and is the guarantor of maintaining order within the hall, stores as well as maintain order means of transport. Next, we have the instruments related to the exploitation of technical means namely OEE and methods of fast retooling. In the opinion of employees and management staff has rapid setup of machines and equipment. Respondents indicated that the least impact on production processes has balancing production (which was somewhat surprising) and use of 8 step problem solving Method. Analysis of the reasons for such a low assessment of the impact of balancing production on logistics processes had its cause in lack of understanding of the concept of Heijunka despite conducted training in this field. This indicates again on the role of relevant practical training in improving competencies of employees.

5. CONCLUSION

The article presents a small part of research related to the analysis of the impact of Lean instruments on implementation and improvement of logistics processes of various industries. For analyzed research object was taken into account only 10 tools associated with carried out training and knowledge of these tools by employees. Carried out research has clearly indicated the positive effect of Lean tools on improvement of logistic processes in the area of improving the flow of the supply chain both internal and external. This is confirmed by the high assessment of the impact of the elimination of MUDA and 5S, as well as instruments used for processes mapping and the flow of added value. The use of one of the first five evaluated instruments will have in a short period of time a large impact on improving the productivity of logistics processes.

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REFERENCES


MAPPING OF THE QUALITY STREAM IN THE PRODUCTION PROCESSES WITH THE USE OF THE BPMN

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Abstract

The article depicts the use of the BPMN (Business Process Model and Notation) in the graphic presentation of the quality flow in the production processes. The main purpose of this project was to conduct a validation of the material flow in the separated production subsystem as well as the identification of the areas which generates the biggest quality loss. The BPMN enables the realization of business processes’ maps and the use of software tools can help with building the model and conducting the validation processes. In further steps there is also a possibility to run a simulation in the different conditions. In the article author focuses on the first step of modelling - the mapping of the representative production process including quality aspects.

Keywords: Production system, improvement of flow continuity, productivity

1. INTRODUCTION

Mapping of the processes has a broad usage in the service and production sectors. Mapping is mainly used whilst analyzing the flow of material, information, capital and value stream (for example: VSM method - Value Stream Mapping [10]). Processes’ mapping is a graphic presentation of correlations between the objects. Depending on the method used, the purpose can differ. It can be modelling of the stream processes, validation of model’s compatibility, verification of correctness, analysis (of efficiency, productivity or anything else) as well as the implementation of the supporting systems (like IT). Mapping has a broad usage because it can easily show the relation between objects. In the analysis of dynamic systems it is very important to reflect the relations between objects. Identification of the source of the incompatibility and creation of analysis of systems is as hard as the complexity level of the system. System’s complexity depends on the amount of the components. It also depends on the level of complexity of the relations between objects and on the level of relations between the system and its’ surrounding [5]. Complexity of system is influenced by the purpose’s function. According to the Klir’s definition we can present basic systems and complex systems [6]. Other authors [9] use definition of “big system” whilst analyzing the object made of many components (with a lot of relations between them). Verbal description of the complex system is quite hard and take a lot of time. It is also hard to understand it by listener. Graphical form is easier to adopt, and by using icons we are able to present the model with a certain order and go through the consecutive steps of the process. The map is the most popular of graphic presentation of the models. Mapping of the processes can concern the identification of the current status of the process. On this step, there are flows presented in the real structure. Identification of the current status predates the mapping process of the next status. On the map of the next status there is the presentation of the structure of the optimal flows and objects for the targeted status and also there is a need to make an improvement plan. In this plan it is necessary to set the certain tasks and designate people responsible for exact tasks, but also point the deadlines for the exact actions. In the last step there is a need to conduct the verification of the results and it have to be stated if the provided changes brought assumptive effects. If the results are not valid - there is a need to conduct the identification of the causes to be able to correct modeled system to achieve improvement. If results are valid - it is important to control following results on the daily basis.

Mapping of the systems may be executed on the three different levels: 1 - visual mapping, 2- analytical mapping, 3 - executive mapping [3]. Visual map reflects to the strategical level and it presents the most
important streams, objects and the main purpose. On the visual map there are rarely presented the elements of the transaction subsystems. Analytical map pertain to the tactical level, and in comparison with the visual map - it is more detailed. There are some subsystems included (Loop, Multi-Instance, Ad-Hoc, Compensation) and there are every kind of events enlisted. Executive mapping pertain to the operational level and it is a map which includes all the possible events and flows possible. The executive map is the most detailed map and its' implementation in the informatics’ system can help whilst verifying the correctness of flows, actions and the order of the tasks. Making a detailed map and using IT tools (for example. ADONIS) can help with conducting the efficiency analysis in a certain unit of time. Modelling of the processes enables monitoring, recording and interference (in case of delays, loops) as well as elimination of the errors.

The main purpose of this article is to present the first step of the mapping process of the quality stream with the use of BPMN. In this publication the quality stream is consist with the requirements, which is achieved by the consistency of the crafting process in the separate steps of the production process. The quality is the inherent set of the hierarchic consistency from the consecutive production steps. The level of the rating indicator is influenced by: the quality of the consecutive processes, the quality of stocks and components of the crafted product. In this case - quality term is non-deterministic random variable of the single events in the simultaneously considered list of stochastic processes which occur in certain time.

2. BUSINESS PROCESS MODELLING NOTATION (BPMN) - INTRODUCTION

Business Process Modelling Notation (BPMN) is a graphic tool which can be used whilst mapping and modelling the business processes. Business process is a straight sequence which can lead to execute a certain good - material (for example product) or immaterial (like information). BMPN is used in correlations and implementation of the service and production processes for the IT language. BPMN is a standard evolved by OMG (Object Management Group). The final version of the notation which is BPMN 2.0 has been published in the January 2011 [2, 3]. It is a standard which enables description of the processes in the understandable way and it allows to present them in the very specific and certain way. This duality is really important nowadays because in a lot of organizations it is important to use human, machine and IT resources in the most productive and efficient way. The quality of optimization depends on the quality of modelling of the real systems [3]. Meaning of the proper modelling is equal to the complexity of studied object. Modelling on the first step is based on the identification of lack of efficiency - in the lean philosophy there is an identification of 3M waste (muri, mura and muda). It is a diagnostic step which is a base for optimization or re-engineering of the processes. Proper rating of the current status has significant influence on potential implementation for the improving solutions.

In the quality area there are some tools used: 8D sheets, Ishikawa diagrams, Pareto, quality houses, Shewhart's control cards and some others [4]. However these do not have vital mechanism which can support reduction of generated incompatibilities. Nowadays the most popular form used to define flows is graphical form which can be transformed into the IT language to conduct system’s validation. BPMN is a standard which is helpful whilst creating the visual definitions of flows and processes. It is easily recognizable on the operational stage as well as the tactical and strategic stages. Moreover, creation of the flow and processes map whilst using BPMN icons and transferring gathered data to IT platform enables conducting simulation and monitoring. Research and verification of the objects’ statuses using the IT tools is not as risky as implementing changes to the “live” organization. Validation of proposed changes using the virtual object is less risky than using the real object. Using IT tools also enables to estimate what resources do we have and what human, finance, material, machine and energetic resources we need. It is also possible to enlist the KIP (Key Performance Indicators) to a process and then study its’ values. All of those values made BPMN popular in making the map of quality stream in the certain production subsystems.
3. DEFINING OF THE MAPPED PRODUCTION SYSTEM

Analyzed system is a convergence setup in which there are some sets of basic streams of components, stocks and energy. In the model there is not analysis of “know-how” stocks or human resources. There is only an analysis of machines and relations between product and quality. On the first step of the building process there are not aspects caused by limitation of efficiency. It is important to have enough stocks of expected efficiency.

Analyzed production system \( SP \) is defined as a set:

\[
SP = \{ E, A, X, Y, R \}
\]

(1)

where: \( E \) - set of \( SP \) stocks; \( A \) - stocks' attributes \( SP \); \( X \) - parameters of \( SP \) input; \( Y \) - parameters of \( SP \) output; \( R \) - relations between: \( E, A, X \) and \( Y \) in the \( SP \) area.

Moreover:

\[
E = \left\{ \left\{ E_1^1, E_1^2, \ldots, E_1^N_1 \right\}, \left\{ E_2^1, E_2^2, \ldots, E_2^N_2 \right\}, \ldots, \left\{ E_N^1, E_N^2, \ldots, E_N^N_N \right\} \right\}
\]

(2)

where: \( E_i^j \) - elements of the \( i \) set (machine) which has been assigned in according to the executive technology process, for example cutting - set \( N_1 \) - amount of cutting machines, \( E_2^j \) - elements of the \( 2 \) set, for example \( N_2 \) - amount of the edge press.

\[
A = \left\{ \left( a_{1,1}, \ldots, a_{1,N_1} \right) \left| y_{M,N}^K \right. \right\} \left. \left( a_{2,1}, \ldots, a_{2,N_2} \right) \right\} \left| y_{M,N}^K \right. \ldots \left. \left( a_{n,1}, \ldots, a_{n,N_n} \right) \right\} \left| y_{M,N}^K \right. \right\}
\]

(3)

where: \( a_n \) - attribute dependent on \( E_n^N \) whilst using the element (or set of elements) from \( y_{M,N}^K \).

\[
X = \left\{ D^K, K \mid D^K, D^S, S \mid D^K, D^P, P \mid D^K, R^X \right\}
\]

(4)

where: \( D^K \) - suppliers of the input components; \( K \) - input components dependant on \( D^K \); \( D^S \) - suppliers of the input stocks; \( S \) - input stocks dependant on \( D^K \); \( D^P \) - suppliers of the Energy; \( P \) - stream of Energy dependant on \( D^P \); \( R^X \) - relations between \( X \) set.

\[
Y = \begin{bmatrix}
  y_{1,1} & y_{1,2} & \ldots & y_{1,N_1} \\
  y_{2,1} & y_{2,2} & \ldots & y_{2,N_2} \\
  \vdots & \vdots & \ddots & \vdots \\
  y_{M,1} & y_{M,2} & \ldots & y_{M,N_M} \\
\end{bmatrix}
\]

where: \( y_{M,N}^K \) - single final product for which \( K, M \) and \( N \) indexes are: different size, different models and destination and also variety of the additional options. Moreover, \( y_{M,N}^K \) is a single column matrix which consists of the elements of the Bill of Materials structure.

Presented production system \( SP \) has been used whilst the mapping process of the quality stream in compliance with BPMN. On the first step, addition of the values to the final product \( y_{M,N}^K \) there has been a visual map projected, just to be able to set the amount of the points in the quality control.
In the production process there are about 600 different kinds of final products. Production process is customized and dedicated for the only one client at the same time. Due to great variety of final products, there is no “stockroom” production. There are three groups of criteria for division of the final products: size, destination (and model), additional options. There are about 450-650 different subsystems which make one final product. About 15% of these are the components delivered by the suppliers. Components are not processed in the production process. These are only edited on the certain step of the production process. The rest of 85% are the elements which are produced whilst analyzed system of stocks. By the stocks sets we understand: wires, steel plates, gaskets bought in the mb, different kind of the powder-paints and others. Production process takes place in 9 different nests. Each of the nest is responsible for the different process of production. Main production processes are: cutting process, edging process, weld process, isolation process, painting process, edit process (electrical and refrigeration). On the final phase there is six-steps process of editing of the final product. Streams of components and stocks have been mapped and details of the production process has been ignored.

4. DESIGNATION OF THE CRITICAL QUALITY STREAM

Visual map presented on the graphic shows the scale of the quality problems in the certain example. We can notice that in the analyzed system there are five independent streams which joins with each other on the final editing step of production process. Because of the fact that the system meets the terms of the complex system [5] there is a need to disintegrate for the components of the stream flows. On the assigned, single stream flows on the next step there has been conducted the analysis of critical path. This analysis is based on the gathered historical data and it allowed to set the sub-stream of the value in which there was the biggest loss caused by
incompatibility. **Ad hoc** processes (which are the serial-parallel production systems) in the analytical view are the systems between repeated tasks (processes and measurements). If there is a repetition of the measurements for the same variable value (in different conditions or in different time) - a factor is repetitive as well. In the example provided for the ad-hoc processes there are a lot of the same events (processes, measurements) made on the same elements (machines, semi-finished products). These are creating the group of the “factors of repetitive events”. Moreover - provided events are in relation with each other. Interpretation of the final results and interactions between them is not dependent on the “difference between factors between groups” or “factors of repetitive events”. To make the step of exuding the critical path easier, it has been decided to ignore the effects of the interaction between single ad hoc processes. Ignoring the interaction has been based on the Fisher idea. Ineffectual combinations of levels were not considered in the model. This kind of model has been named “hierarchical system” in which the classification criteria is determined by the transition path. Due to the formula (6) for each and every path there is a need to set the amount of expenses generated by quality incompatibilities. The highest value of the costs will set the stream in which quality losses are the biggest burdens.

\[
X_S = C_{B^1} \cdot B^1 + C_{B^2} \cdot B^2 + \ldots + C_{B^n} \cdot B^n
\]  

(6)

where: \(X_S\) - is the sum of expenses which are a result of the occurrence of \(B^n\) quality errors in the path \(S = 1; 2; 3; 4; 5\) when \(S = 1\) for the first path; \(S = 2\) for the second path etc. \(B^n\) - the amount of n-error in the \(n\) point of control. \(C_{B^n}\) - single value of the \(B^n\) error, when the value of the cost which results from the occurrence of \(B^n\) errors is a constant random variable with \(f_{X_S}\) density. Then:

\[
P(X_S \leq x) = P\left(C_{B^1} \cdot B^1 + C_{B^2} \cdot B^2 + \ldots + C_{B^n} \cdot B^n \leq x\right)
\]  

(7)

\[
P(X_S \leq x) = \int_0^x f_{X_S}(x)dx
\]  

(8)

It is possible to indicate the predicted value of the expenses incurred for the errors in the certain path of the formula (9):

\[
EX_S = \int_0^x x \cdot f_{X_S}(x)dx
\]  

(9)

The greatest expected value for \(S = 1; 2; 3; 4; 5\) will indicate the critical path which will be under decomposition in the next step of the quality improvement in the certain process.

5. **CONCLUSION**

The main purpose of “projecting for quality” is creation of optimized system of tasks in the area of projected product, projection of the production line and projection of the crafting quality [7]. Producer is responsible for all these areas of organization. That is why the producer is responsible for the general quality of the product. This quality should be accepted by the customer. Lean production focuses mainly on the elimination of muda, mura and muri losses. Majority of the lean toolbox focus on the improvement of efficiency of processes and crafting systems. Quality in lean manufacturing is one of the analyzed parameters in the production process. In the real production objects, quality analysis are mainly deterministic and there are no relations between the influence of the efficiency (increase or decrease) changes for the dynamic of these changes (for the process or the product). In the [8] publication there is a presentation of the analysis of the efficiency’s increase (10%)
in the chosen stream of production with the decrease (47%) of the probability of achieving the constant quality level. Basing on the calculations published in [8] we can notice that the diagram of relations between efficiency and quality is not a linear function. Analysis of the quality parameter without the parameters of analyzed production system is incompatible with the general theory of complex systems [5, 6]. Proper validation of the models which are the reflection of the reality should consider all the influences and main relations [11]. Presented model of the real object is a graphical presentation of the system of convergence. The map made of the elements compatible with BPMN has a visual role and is a first step in the building of analytical map. On this step there is a detailed definition of all input streams possible and there are some mathematical models created to rate the quality of the defined input components. Use of the set (9) allows to determine the path in which the biggest costs are generated. In the next step there will be an analytical map developed for the designated path. In other words - next step of the mapping process will be executed (accordingly to the BPMN).

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RELATIONAL CHARACTER OF THE DATA IN THE CONTEXT OF FUNCTIONAL MODULES OF THE SYSTEM SIMMAG 3D

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Abstract

Nowadays, decision support systems play an increasingly important role. On the one hand, they allow for complex design taking into account several boundary conditions. On the other hand, they reduce the risk of making mistakes that can have more or less serious consequences. One of these tools is the system SIMMAG3D developed under a project financed by the NCBR. The tool allows for designing and visualization in 3D of warehouse facilities. The article presents the functionality of the system SIMMAG3D and need for data of its individual elements. Due to the large amount of data and the fact that they come from different subject areas, the most convenient tool for their collection are databases. The article presents the concept of the database for the system with its structure and catalogs, from which will come data to the work of individual modules. In addition, we discussed relational character of data between different functional modules.

Keywords: SIMMAG 3D, databases. Technical specifications, warehouse facilities, designing

1. INTRODUCTION

Majority of currently implemented research projects are based on information systems. They are basis of banking systems, reservation systems, administrative systems, systems of civil registration, logistics, and systems for design supporting (including warehouses and warehouse processes designing), etc. The most commonly used tool for designing various types of information systems are database systems [6], [15]. They consist databases and database management systems.

Therefore, development of a modern tool for modelling and visualization warehouse facilities in 3D requires the development of specific databases. The major aim of this tool is to improve process of warehouse designing. It will allow to develop design procedures, estimate values of economic and technical indicators for various types of warehouse.

Database presented in paper is based on analysis of information system needs (information system to support modelling warehouse facilities), as well as analysis of information resources for visualisation in 3D. At designing that database it is important to consider selection of appropriate database model and system to its manage.

2. SIMMAG 3D AND ITS FUNCTIONS

The SIMMAG3D system which is developed within the project has many uses and functionality. Its main use is to support the management of storage facilities after connection with WMS. On the other hand, it is a powerful tool for storage facilities designing.

The SIMMAG3D system architecture was designed based on dedicated mathematical models, dedicated algorithms and optimization modules (e.g. the location of storage facilities), dedicated simulation module (simulation and analysis of selected warehouse processes). Providing data for the calculation lies with the
integrated database containing catalogues of internal and external transport, equipment of storage facilities or for example architectural solutions. The database includes libraries for objects graphic visualization. The module of graphic presentation in 3D - helps to identify the critical areas of storage facilities.

Therefore two main functions of the system SIMMAG3D are support in management of storage facilities and support in storage facilities designing.

Carrying out the above system functions results from the needs of real objects and real application, but also in research and teaching field. It follows the need to equip the system with advanced functional modules. Among them can be distinguished graphical user interface (GUI), interface WMS>SIMMAG3D, database (catalogues and 3D library), 3D visualizer, optimizer along with a simulator (and data generator). The overall diagram of the SIMMAG3D system is shown in Figure 1.

The graphical user interface (GUI) is a base layer program. GUI consists of two main parts. One concerns the use Visualizer 3D, while the second refers to the part related to the optimization and simulation of warehouse processes. The visualization and optimization modules are integrated via an interface for data exchange which is done through the database. The interface WMS>SIMMAG3D contains tables of data exchange needs of transfer structures and data from WMS database. This allows for visualization and analysis of the current object or its reorganization, modification and finally allows for simulation to verify the improvements. The database is the layer that connects all components of SIMMAG3D system and is designed to store all input data, libraries, as well as the performance of the user. More information about database will be discussed later in the article.

The Visualizer 3D module is responsible for the visualization of the warehouse facility. It is possible to display the object mapped in the WMS and the object projected on the basis of the optimization and simulation module. The visualizer allows to graphical formation of the functional zones, sectors and whole areas of the warehouse. This is done by using the implemented structural model built on the catalogues. Visualizer also presents the functioning of the object in terms of state changes of its resources.
The simulator and optimizer is a module consisting a series of solutions for the design of new facilities, as well as reorganize and modernize existing ones. For the purpose of this module was implemented data generator which results from reason that the decision maker does not always have a complete set of data, especially in the design of new facilities. As the main elements of this module can be identified:

- warehouse facilities location [13], [14], [18] - in addition to the location of the object there can be adjusted the number of objects and material flows through the object, and also allows to specify some of the facility operational cost,
- warehouse process construction [8], [11] - mapping of processes occurring in objects having a time, the number and nature of the transformation, resources,
- scheduling and shaping [10], [12] - assign tasks of mapped process to increase the lead time of the object, determining the number of devices, people and evaluation of some indicators,
- warehouse processes simulator [16] - module based on the simulation mechanisms that allows to study different solutions in the system, for example the study on process time changes for different strategies of storage assignment,
- multi-criteria evaluation [7], [9] - support the user in performing multi-criteria analysis of investment (modernization) options and choose the most beneficial.

The functioning of each module required to provide relevant data. The system assumes the possibility of manually data insertion for each module. However, more important is the use of real data, as well as from the calculations and simulations performed by other modules of SIMMAG3D system. The needs for data are shown in the next section of the article.

3. SIMMAG 3D NECESSARY DATA

The selected SIMMAG 3D modules presented in the Figure 1 require many input data conditioning their functioning [4], [17]. The first SIMMAG 3D system module refer to warehouse location. In order to locate the warehouse in the logistics network it is necessary to identify the warehouse suppliers and customers. Other characteristics that are required refer to the storage time and storage volume. The materials' technical parameters are important for the storage space definition.

Another module is the storage facility shaping module. The warehouse space shaping requires data about the possible land locations and the land costs as well as the warehouse building technical limitations. Warehouse designing also depend on the material flow volume, assortment structure, storage technology and the warehouse transport technology.

Similar data is required by the warehouse process shaping module. The basic data is related to the scope of the material flow transformation according to the customers' orders. Warehouse process designer also has to know the orders structure, the number of inventory items, physical and commercial characteristics and the material flow volume.

The module for the warehouse process dimensioning generally requires the tasks identification. To develop the warehouse process' schedule it is necessary to determine the allocation of people and equipment to the tasks at a time. Also the tasks limitations and unitary tasks costs are required.

Evaluation of the warehouse and the processes inside is the module which helps to decide which variant of the designed warehouse should be selected for the implementation. To perform such an evaluation, many warehouse parameters have to identified. After that each parameter is assigned with the weight to allow their importance. From the point of warehouse designing view these parameters should refer to technical and quality indicators such as efficiency, performance. The quantitative parameters refer to the warehouse cost and expenditures.
The visualization of the warehouse processes will require the historical data obtained during the simulation process. Moreover, the assortment allocation and its stock will be uploaded from the warehouse management systems WMS.

4. DATABASE FOR SIMMAG 3D SYSTEM

Due to the large amount of data coming from different subject areas, the most convenient tool for their collection are databases [1], [2], [3]. In this tool data are stored according to strict rules, which allows for their complete processing. Database tools allow for sorting of the data according to specific criteria and searching for specific information in a particular place.

The concept of a database for the SIMMAG 3D system shown in Figure 2 [4], [17].

![Figure 2](image)

Figure 2 The concept of a database for the SIMMAG 3D system

The basic data sets stored in the database, which was developed for the system SIMMAG 3D are:

- data from the WMS (Warehouse Management System) - For proper operation of the system for designing and visualization of warehouse facilities in the 3D there are necessary data, which document the process of cargo flow in the Logistics facility. These data provide WMS systems,
- data necessary for designing and visualizing of the warehouse process [5] - in order to properly preparation the warehouse process in the logistics facility it is necessary to introduce a number of input data for which the most convenient form of storage are database,
- data necessary to carry out the simulation - system for modeling and visualization carrying out stimulations will allow to assess whether designed logistics facility allows for carry out tasks.

The second group of data are the results of work of individual system SIMMAG 3D modules. The result of the work of individual modules are values which should be stored. The best place to perform this task is also the database. Using this tool, we can not only store the results, but also make it available as input data needed for operating other program modules. As an example of such data we can indicate the results of the warehouse process and simulation.

An important group of data, which also will be located in the database are parameters. They concern two groups of issues. The first is the location of a storage facility in the logistics network. For this issue, it is necessary to introduce a number of parameters. The second group of issues are directories of internal transport, external transport, non-mechanical equipment and reloading infrastructure. Each of these objects has a set of parameters such as load capacity and speed of the drive with the load.
The last group supplying database in specific values are data generators. In the case that impossible or very difficult is to obtain data concerning the problem, e.g. in the field of supply structure and characteristics of the assortment (especially in terms of actual data from the warehouse management systems WMS) it is necessary to generate them. This will help to carry out stimulations of the warehouse process, which will allow from the one hand on checking the operation of the system SIMMAG 3D, and from the other hand on the presentation of the functionality of the program.

Data from the database supply various program modules (see point 2) in the necessary data to their work. Figure 2 shows the general concept of database. While Figure 3 shows the structure of the database in the field of exchange technology of data between modules.

Data in the database are powered by the effects of the implementation of specific project task (Figure 3): Furthermore, the individual tasks 1-4 "exchange" data - the results of work of the task can be used as input data to another task or input to the second task can also be input data for the third task. Data from task 1 feed the work on the realization of the task 2 and 3. Data of the task 2 supply work on a task 3. Data from task 4 are necessary to complete the task 2. However, data from tasks 1, 2, 3 and 4 are necessary to complete the task 5. Data from the task 5 supply directly the SIMMAG 3D system and store the data, which are the result of its work. Described structure corresponds to the relational data model, which is implemented in the system for modelling and visualization of warehouse facilities in 3D - 3D SIMMAG

5. SUMMARY AND CONCLUSIONS

The main result of the project (an element of which is database discussed in paper) is an innovative tool for efficient designing warehouse models with pre-defined objects, as well as its graphical presentation in 3D. Catalogues and database, prepared by the project (containing parameters and characteristics of warehouse facility equipment) allow to optimally design warehouse facility or (if they already exist) to appropriate organize and rationally use its work resources.

Development of databases containing such detailed information will affect small and medium-sized design companies. Companies, that will be use the SIMMAG3D tool, will be able to implement more projects without increasing human resources. This will significantly affect the financial results of these companies.
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REFERENCES


THE RELATIONSHIP OF LOGISTICS AND MARKETING IN THE FIELD OF CUSTOMER SERVICE

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Abstract
The paper presents the problem of customer service as the field of the relationship of logistics and marketing. Mutual completion, dependencies and discrepancies of logistics and marketing potentials in the area of customer service have been reflected in the presented logistics and marketing processes in a traditional approach to customer service, the concepts of marketing logistics, logistics marketing or logistics and marketing management.

Keywords: Customer service, logistics, marketing

1. INTRODUCTION
The concept of customer service is one of the least clearly interpreted terms in the theory of enterprise management. While searching for the area of the relationship of the logistics system with the concept of marketing impact on the market, researchers repeatedly come across a range of controversial ambiguities. The consideration of the mutual completion, dependencies and discrepancies of logistics and marketing potentials in the area of customer service is reflected in logistics and marketing processes in a traditional approach to customer service, the concepts of marketing logistics, logistics marketing or logistics and marketing management, presented in the present paper.

2. MULTIDIMENSIONALITY OF CUSTOMER SERVICE
The views of D. J. Bloomberg, S. LeMay and J. B. Hanna [1], M. Cichosz [2], M. Ciesielski and J. Długosz [3], P. M. Price and N.J. Harrison [4], Y. A. Bolumole, A.M. Kнемeyer and D. M. Lambert [5], D. Kempy [6] seem to perceive the area of customer service unanimously. The finding that the multidimensional area of customer service partially includes the field of marketing, logistics and other strategic fields of enterprise management seems to be common for the above authors (Figure 1).

The conceptual approach to customer service as the formed system serves the building of the optimal system of information flows, flows of goods and financial flows between the enterprise and the final customer [8]. The service of the final customer formed in this way constitutes, therefore, the area of the common interest of logistics, marketing, finance and other functional areas of the enterprise [9]. However, logistics customer service is the resultant of the activities taken at each stage of the logistics system, i.e. the stage of procurement, production and distribution, which have indirect or direct impact on customer satisfaction with the level of service. The condition of success is understanding the role of individual elements of the system in creating the level of service and relationship between elements (Figure 2).
3. LOGISTICS AND MARKETING PROCESSES IN A TRADITIONAL APPROACH TO CUSTOMER SERVICE

The relationship of the logistics system with the concept of marketing impact on the market is apparently united by the problem of customer service. The marketing dimension of the service, as the area of establishing the relationship with the customer by recognizing their needs and making promises, includes the activities aimed at creating demand [11]. On the other hand, the potential of logistics customer service allows for the physical movement and storage of products for customers in a way enabling their takeover in the right quantity and quality, which allows for obtaining benefits from their delivery at the right place and time [12]. Therefore, the relationship of marketing and logistics is frequently regarded in distribution as an instrument of marketing-mix.
via elements directly oriented to customer service (Figure 3). Some authors, among others J. J. Coyle, E. J. Bardi and C. J. Langley Jr. [13], P.M. Panayides [14], A. Mesjasz-Lech [15], acknowledge the indicated position of distribution in logistics and marketing processes as a traditional approach to the area of customer service in the enterprise, considering the current approach towards the issue described below.

Figure 3 The relationship between logistics and marketing
Source: [16].

4. MARKETING LOGISTICS

In the opinion of many authors, among others, F. J. Beier and K. Rutkowski [17], J. Bendkowski and M. Piertucha-Pacut [18], P. Blaik [19], J. Witkowski [20], the intersection area of the distribution sub-system and the procurement sub-system constitutes the structure of marketing logistics.

The relationship of logistics and marketing is included in the concept of marketing logistics interpreted as “the system of planning and operational activities ensuring that the goods that have been ordered will be delivered at the right time and place, using the most appropriate means of transport, in the shortest route and at the lowest possible cost”[21]. According to S. Krawczyk [22], this definition specifies more the range of distribution logistics while requiring completion by adding “the optimization of transfer of raw materials, materials and components flowing into a specific business entity, optionally, along with their flow through power cells”.

According to T. Barciński [23], the aforementioned views on marketing logistics express the manifestation of the superiority of marketing over logistics. The confirmation of this thesis is the definition of the term by J. Krulis-Randa [24] as “the integrated function of marketing, which, while regulating the flow of products and information, supports the implementation of its objectives in the area of purchase and sales” or the one by R.L. Chapman, C. Soosay and J. Kandampully [25] as “an instrument rationalizing the operation of the whole system of the enterprise, allowing for an increase in the overall efficiency of this system - maximization of profits in a long term by minimization of global costs at the accepted level of customer service”. M. Christopher and H. Peck [26] indicate three main elements underlying marketing logistics: rapid response to customer’s needs, reliability of the service and appropriate relationships.
5. LOGISTICS MARKETING

The analysis of the relationship of logistics and marketing, as opposed to the above, has been conducted by S. Abt [27]. The author replaces the term of marketing logistics with the concept of logistics marketing identified with "the look at distribution channels through the prism of likes of customers and capabilities of manufactures and distributors". While underlining the superiority of logistics in management of distribution channels, marketing must gain logistics characteristics, i.e. it should serve the strategy understood broader than the marketing activity brought to the products and their maintenance on the market [28]. A similar concept is expressed by M. Szymczak [29], who claims that the marketing activity is a component of logistics and, at the same time, "an element supporting logistics in achieving the level of service expected by customers".

Apart from the hierarchy in the logistics and marketing relationship, M. Christopher [30] pays attention to the mutual interweaving and complementarity of the elements of both areas. Some specific interdependence of marketing and logistics activities, presented in the form of the multiplier effect in Figure 4, determines marketing efficiency. The illustrated impact of the level of customer service and logistics management in three links of the logistics system (suppliers - intermediaries - customers) is aimed at achieving maximization of marketing efficiency.

6. LOGISTICS AND MARKETING MANAGEMENT

The consideration of the mutual completion and dependence of logistics and marketing potentials of the enterprise is reflected in the concept of logistics and marketing management, also known as the marketing and logistics concept. The integration of both orientations and their management as the integrated whole in order to achieve the synergy effects is found an optimal solution, among others, by I D. J. Bowersox, D. J. Cross and O. K. Helferich [31], M. Chaberek [32]. The area of the greatest cooperation of logistics and marketing is customer service as a multidimensional effect of logistics, occupying the central position, right next to the elements of marketing, and constituting the bridge towards new opportunities for an increase in benefits in the enterprise and the whole system of market relations.

According to P. Blaik [19], logistics and marketing management constitutes a type of linkage of two concepts:

1) logistics - as the management concept sectionally oriented to the flows;
2) marketing - as the concept of enterprise management oriented to the market.

Both concepts, as the main and equal functional areas of the enterprise ‘meet’ on the market, creating the strategy of sale and procurement.

The concept of marketing and logistics management, proposed by F.J. Beier and K. Rutkowski [17], D. M. Lambert and J. R. Stock [33], combines customer satisfaction with the profits of the company at the integrated
marketing and logistics activities (Figure 5). The authors assume that full customer satisfaction can be achieved by - apart from the coordinated marketing activities concerning the product, price, promotion and distribution - the utility of place and time, offered by logistics, which allows for maximization of profits in a long term [34] whereas the achievement of the accepted level of profits by the enterprise is determined by reduction in global logistics costs, achieved, however, with the assumption of the maintenance of the specific level of customer service. The integration of activities understood in this way, through eliminating or weakening the conflicts between individual elements of the discussed system, is the source of essential synergy benefits [32].

![Figure 5 The concept of marketing and logistics management](source: [33].)

7. DIFFERENCES IN THE RANGE OF MARKETING AND LOGISTICS SERVICE

Customer service consists of the elements of all three stages of the process of exchange of goods and services, i.e. the elements of the pre-transaction, transaction and post-transaction stage, however, in logistics, the greatest attention is paid to transaction elements. At this point, there runs one of the most visible dividing lines of interests in customer service in marketing and logistics [6]. Whereas, in traditional terms, the whole of the issues associated with customer service in marketing is seen as creation of demand, in the circle of logistics competencies there is to satisfy this demand. The differences in the range of both areas of the activities of the company are in detail presented in Table 1, however, the approach does not cover an extensive problem of the selection and division of the components. The reason is the lack of a universal list of qualitative elements of customer service due to the need to diversify the applied solutions depending on the dynamically changing conditions of the operation of enterprises.
Table 1 Elements of marketing and logistics service

<table>
<thead>
<tr>
<th>Group of elements</th>
<th>Marketing</th>
<th>Logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td>- complaint reception time</td>
<td>- order placement time</td>
</tr>
<tr>
<td></td>
<td>- complaint investigation time</td>
<td>- order processing time</td>
</tr>
<tr>
<td></td>
<td>- returns acceptance time</td>
<td>- transportation time</td>
</tr>
<tr>
<td></td>
<td>- opening hours</td>
<td>- loading, reloading time</td>
</tr>
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<td></td>
<td>- waiting time for the service at the counter</td>
<td>- load unit forming time</td>
</tr>
<tr>
<td></td>
<td>- customer service time</td>
<td></td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>- punctuality of the opening of the company</td>
<td>- stock level in a warehouse</td>
</tr>
<tr>
<td></td>
<td>- competences of the staff</td>
<td>- timeliness</td>
</tr>
<tr>
<td></td>
<td>- resolving the complaint</td>
<td>- load transport safety</td>
</tr>
<tr>
<td></td>
<td>- possibility of obtaining information in a</td>
<td>- load storage safety</td>
</tr>
<tr>
<td></td>
<td>specially dedicated service point</td>
<td>- correctness of order fulfillment</td>
</tr>
<tr>
<td></td>
<td>- availability of assortment</td>
<td>- correctness of completing documents</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>- distribution of promotional newsletters</td>
<td>- cargo tracing</td>
</tr>
<tr>
<td></td>
<td>- product tracking</td>
<td>- providing information on the order</td>
</tr>
<tr>
<td></td>
<td>- politeness of the staff</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- information on shelf life on the packaging</td>
<td></td>
</tr>
<tr>
<td><strong>Comfort</strong></td>
<td>- certain number of people available to the</td>
<td>- placing phone, fax or online orders</td>
</tr>
<tr>
<td></td>
<td>customer</td>
<td>- selecting transport sector</td>
</tr>
<tr>
<td></td>
<td>- possibility of online payment</td>
<td>- offering logistics service portfolio</td>
</tr>
<tr>
<td></td>
<td>- providing information over the phone</td>
<td>- logistics consulting</td>
</tr>
<tr>
<td></td>
<td>- telephone booking services</td>
<td>- night deliveries</td>
</tr>
<tr>
<td></td>
<td>- payment in installments</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own study based on [7].

8. CONCLUSION

In the light of the above considerations, in spite of a broad spectrum of disaggregation and classification of logistics systems, all their aspects identify an inseparable component which is customer service and its functional relations in the enterprise. The concept of customer service is multidimensional in nature since it combines logistics and marketing aspects, which provides great opportunities for its interpretation. It constitutes the area of integration of marketing and logistics and, from the point of view of the former one, includes the processes associated with sale, the operation of the warranty and post-warranty service, reception and acknowledgement of the complaint [35]. As a manifestation of the capabilities of the logistics system to satisfy customer needs, their "logistics service should constitute the foundation for each logistics system and guide the implementation of all logistics processes" [3]. While integrating all the elements of communication with the customer, it is the crowning of the process accomplishing the final objective of the logistics system which is customer satisfaction with its goods and services.

In the subject literature, there is no agreement as for the perception of the mutual relations and ties between logistics and marketing. The concepts of marketing logistics, logistics marketing or logistics and marketing management, while indicating the superiority of logistics or marketing or their equality underline the mutual antagonisms. At the same time, in the analyzed area of customer service, as the common area for logistics and marketing, the essence of the listed concepts, most of all, refers to supporting the processes coordinating...
the fulfillment of some specific assumptions in relation to the area of service. Simultaneously, all the listed concepts strengthen the marketing and logistics dimension of customer service, placing the strengthening of customer relationships beyond boundaries.

REFERENCES


