DIFFERENTIATION POINT OF METAL SHEET IN THE DISTRIBUTION CHANNEL - CONTEXT OF THE RESILIENCE

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Abstract
The identification and assessment of the frequency and the power of the influence as well as the results of disruptions, are essential problems noticed both by practitioners and theoreticians of flow management in supply chains. They are part of a widely discussed problem of the resilience of a supply chain. The sensitivity to disruptions of supply chains is growing along with the growth of the customization of products. Customization of products, moved from the manufacturing company to the distribution channel, is a chance of reducing disruptions resulting from the uncertainty of orders. Consequently, research into strategies of strengthening the resilience of the supply chain is important and up-to-date. This paper discusses the strategy of strengthening the resilience through production postponement and building network relations with subcontractors and participants of distribution channels. Two variants of this strategy were considered and their limitations were indicated: customization in trading company and customization in logistics service provider. Due to the aim of the research, attention was focused on the material decoupling point of the supply chain: assemble-to-order. The adopted research procedure consists of the following stages: the identification and the analysis of disruptions (the diary method, the statistical analysis of the obtained results), analysis of the effects of disruptions, evaluation of the reliability of logistics processes and sensitivity analysis of policy options to fluctuations in demand (simulation modelling in the technique of dynamics of systems). Empirical studies concerned the flow of the chosen smelting product - sheet in coils.

Keywords: Dynamics of systems, assemble to order (ATO), postponement production, disruptions, strategy

1. INTRODUCTION

Distribution channels are subject to continuous evolution which is a result of both the technological development (e.g. omni-channels resulting from the development of internet technologies) and changing customers' needs. For many years now, it has been indicated that one of the key determinants of the final goods flow is product customization [1]. Product differentiation, which is a response to this megatrend can be realized both in industrial and commercial enterprises, and sometimes even in logistic ones. The differentiation is a precondition of postponed production in which finishing of every product is realized at the last stage of the manufacturing process postponed until real orders are placed [2]. However, not every differentiation requires the strategy of postponed production. Secondly, an alternative solution involves modular products which can be configured in the distribution channel from modules indicated in the customer's order. Therefore, the needs and product designing are key factors decisive about the production system and the structure of the supply chain. The characterization of the value chain and product variants (the differentiation degree) indicate the type of the production system and the type of the organization of material flows.

Based on a review of the literature [3], the following variants of product differentiation can be indicated:

- differentiation (adaptation) of the option of deliveries for standard products (logistic differentiation),
- creating products which can be differentiated at different stages of creating the value added (productive differentiation),

- differentiation of delivery points, including intensive distribution, many various participants of distribution channels and the differentiation of methods of sale stimulation (marketing differentiation).

The fulfilment of product differentiation in a chain link of the distribution channel, according to the variant of postponed production realized in the distribution channel, which is analysed in this paper, can require network relations from this chain link. This results from the need to increase the potential of complementary resources because the more strongly differentiated the product is in the distribution channel, the more difficult it is for a distribution enterprise to provide the required flexibility of resources which will enable execution of all tasks of postponed production, especially that usually the execution of tasks of postponed production is not a key competence of a distribution enterprise.

The degree of product differentiation significantly affects the decision about subcontracting of tasks of postponed production, increases the network of distribution channels. The growth of the number of tasks executed in cooperation is a potential generator of new disruptions in material flows. Consequently, decisions about the width of the distribution network must be confronted with the resilience of this system to disruptions. Both the degree of product differentiation and the position in a supply chain in which the differentiation is realized, affect the sensibility of a supply chain and consequently the choice of variants for strengthening resilience. Consequently, it can be acknowledged that investigation into the thresholds of product differentiation, taking into account the degree of differentiation perceived by the customer as essential (thus allowing gaining the competitive advantage) with relation to the overall costs connected with both the manufacturing and the logistic process required in product differentiation, are and will be one of the key directions in the area of management of a supply chain.

Adopting this direction of research, the authors of the paper analysed two variants of the differentiation of sheet metal in the distribution channel. In the first variant the sheet metal is differentiated at the level of a service centre. In this model, the distribution enterprise possesses flexible resources which allow and builds relations with subcontractors in order to increase the complexity of offered services. The degree of the differentiation of the form of a product was defined in this model as large but the degree of logistic differentiation as low. In the second variant differentiation proceeds in a logistic enterprise. The organization has resources of not very large flexibility, allowing exclusively cutting sheet metal in circles. However, a strong differentiation can be noticed in the organization of logistic processes connected with both the stock and transport management. In this range, the organization builds network relations with subcontractors. In both organizations differentiation processes were analysed from the perspective of the system flexibility, the authors measured disruptions in the finished products flow and analysed variants of strengthening the resilience.

2. THE FLEXIBILITY OF DISTRIBUTION SYSTEMS

The flexibility of a distribution system is indicated in the literature generally as a strategy of strengthening the resilience [4,5] and the authors consider it as a sort of limitation of negative impact of demand fluctuations on the performed processes. The flexibility of resources becomes critical to ensure the implementation of changing recipients' needs. In the research presented in the literature it can be noted that the more competitive the market, the more investments in flexible resources are present. Therefore, the enterprises must constantly modify and alter the product, which is difficult when having dedicated resources. On the other hand, strong competition within the sector does not favour sourcing resources by way of co-opetition.

When analyzing the literature in terms of partial flexibility in manufacturing and logistics systems, it must be noticed that originally it focuses mostly on manufacturing flexibility [6,7]. It is expressed in several dimensions, such as flexibility of machinery usage, usage of human resources and manufacturing capacity or the manners of particular components production [8]. Flexibility is also analyzed in the context of flow management inside the enterprise and from the point of view of engagement of particular functions (for example, marketing, research and development). Modern research in the scope of manufacturing and logistics flexible systems

formation underline the importance of network relations as a key resource influencing the configuration of flexibility components. Therefore, flexibility should be considered in a wider scope, in reference to supply chain or distribution networks, sourcing networks or production networks.

Flexibility of a supply chain is the ability of an enterprise to manage its processes, deliveries and customers in such a way that will allow responding effectively to sudden changes in deliveries, product and demand [9]. Within this meaning, several components of flexibility are specified, each of which refers to different type of hazards to which the supply chain is exposed [10]: operational flexibility is understood as the ability to adjust the chain resources to the changing customer demands, ,arket flexibility covers the ability to build various relations with customers and to develop a new product with them by way of partnership, logistic flexibility that is to ensure efficient product supply in case of changes to recipients and suppliers' localization, in view of globalization and deferring strategy, supply flexibility; it is manifested by apt reconfiguration of upper supply chain depending of the customers' need and changes in demand, organizational flexibility is about such adjustment of company's structure and shaping employees' abilities that will allow to successfully meet the customers' demands, information systems flexibility means designing these systems for them to meet the demands of supply chain in terms of information exchange and data sharing about current sales.

The variety of possibilities to form the flexibility of distribution systems leads to accepting the assumption that there is not one solution which universally strengthens the resilience of supply chains of products with delayed differentiation. The indicated potential threats, connected with formation of the flexibility through a surplus of network relations, connected with generating additional disruptions, are examples which indicate the need for detailed analysis of each variant. Disruptions, understood as events causing effects in the form of deviations in the performed processes, should be measured systematically and analysed not only in the expression of the frequency of appearance but also the effects on the executed processes.

This study adopts a methodology involving measurement of disruptions in each object based on the diary method (questionnaires for measuring disruptions by workers every day in real time for 3 months, together with indicating their reasons and effects), a statistical analysis of the diary research findings, a simulation analysis of variants of strengthening the resilience for both models of differentiation. The aim of the simulation analysis was to assess the sensibility of the investigated distribution systems on demand fluctuations.

3. THE RESILIENCE OF DISTRIBUTION SYSTEMS OF SHEET METAL

The designed model is a system comprising interrelated elements that influence one another over time and that are subject to demand uncertainties and disruptions in flow, therefore, one can identify elements of the model and its dynamics (changeability over time). The market dynamics causes that even the best selected components of the strategy and their rational interrelations are not permanent [11]. In accordance with the logic of management system dynamics, elements of a comprehensive system, which is a system composed of organizations cooperating within a network, create relations that strengthen or diminish the effects of events disrupting the system operation by way of feedback or relations' complexity.

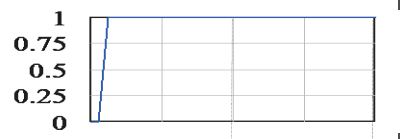
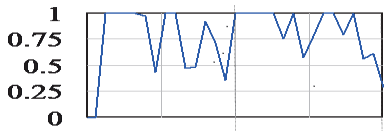
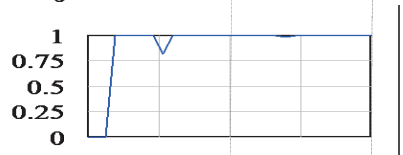
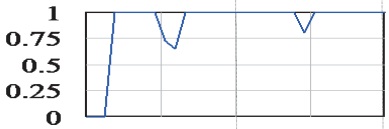
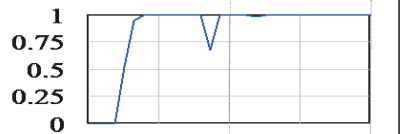
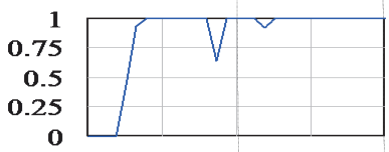
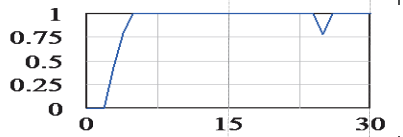
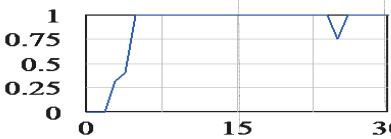
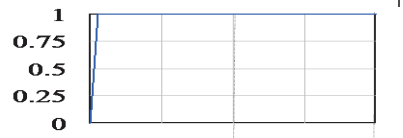
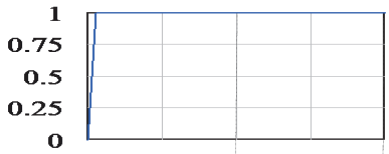
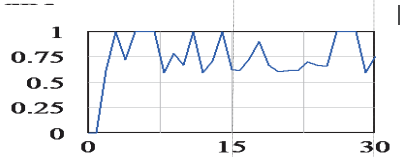
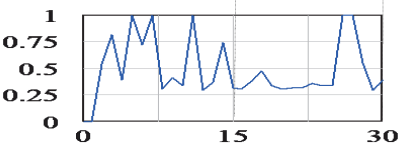
Table 1 presents the collective results of simulation experiments for demand fluctuations up to 20% and above 20% in a model with a distribution centre and in a model with a service centre.

The model with a service centre takes into account 4 product variants: Product variant CS1 - product after operation 1, product variant CS2 - product after operation 1 and 2, product variant CS3 - product after operation 1-2-3, product variant CS4 - product after operation 1-3. Each product variant is characterized by a different demand characterization, moreover, the limited resource 1 is used in each variant. Subcontracting concerns solely operation 2 and 3.

In the distribution network configured according to model 2 (the distribution centre), 2 product variants are sold: variant CL1 - the base product, on which postponed production tasks are not executed, and variant CL2 - execution of an operation identical with operation 1 in a model with a service centre. This model includes a

limit of resource connected with the execution of the postponed production strategy. Due to the fact that the distribution centre did not established network relations as regards the scope of the execution of postponed production tasks, orders exceeding the production capacities of the resource are not fulfilled punctually and completely.

Table 1 The results of simulation experiments

Fluctuations Delivery reliability indicator (ICD)	**Product variant**	**Up to 20% (stable demand)**	**Over 20% (unstable demand)**
Service centre	Operation 1 (product variant CS1)		
	Operation 1-2 (product variant CS2)		
	Operation 1-2-3- (product variant CS3)		
	Operation 1-3 (product variant CS4)		
Distribution centre	Base product (product variant CL1)		
	Operation 1 (product variant CL2)		

A rational selection of flexibility level assumed that having high level of reliability indicator (above 0.75), a key criterion deciding on the variant selection are logistic costs. Efforts were made to choose decisive variant that ensures the lowest costs and reducing the level of orders implemented inconsistently with the agreement.

This research indicates a higher resilience of distribution system configured on the basis of the model with a service centre despite its bigger complexity. As regards demand with slight fluctuations, both the first and the second model, with all product variants, maintain the appointed reliability standard, not falling below 75% of orders realized completely and punctually.

The strategies of strengthening the resilience proposed by those two subjects are different and result from the network maturity of those organizations in the distribution sector of metallurgic products. The centre service,

which is a commercial enterprise carrying out the process of selling metallurgic products, participated in changes in the distribution sector of metallurgic products from the beginning of the restructuring of the Polish metallurgy. This organization strengthens the resilience through flexible resources allowing combination of different tasks of postponed production and formation of relations with subcontractors of postponed production tasks. Network relations are unusually essential for this organization. These are both relations formalized by cooperation contracts and informal ones, based on trust strengthened by long-term cooperation in the network.

Relations with transport enterprises are a definitely weak aspect indicated in this particular case. It is so because disruptions which arise at the last stage of product delivery to the customer directly result in worsening of customer satisfaction as there are no chances to suppress their results. In the case of disruptions such as unpunctual delivery of the base product (appearing with the greatest frequency), the results are not so serious as in other disruptions because both the strategies of the surplus of the reserve of the base product and the strategy of the surplus of network relations successfully allow compensating disruptions inside the service centre. The network is not strongly developed, which translates into a high reliability of executed disruptions. The strategy adopted in this manner increase the flexibility of the system and allows responding to exogenous disruptions. Disruptions in flows between the service centre and subcontractors are not dominant and are compensated by the service centre.

The distribution centre realizes the strategy of the surplus of the base product and simultaneously forms its network relations with transport enterprises. This variant is compatible with one of the strategies of strengthening the resilience - flexible transport networks. The strategy adopted in this manner allows very good compensation of disruptions in the variant of selling the product which is not personalized (in the investigated organization such orders involve over 70% of all orders). For products customized through cut, flexible transport networks do not sufficiently compensate disruptions in the conditions of strong demand fluctuations. Consequently, such a state translates into an increase in the number of orders fulfilled incompletely and unpunctually. It must also be stressed that the investigated organization is a relatively new participant of the distribution network of metallurgic products and has a considerably smaller network maturity than the service centre. Simultaneously, this is an enterprise offering logistic services regarding storage and completion of orders and this range is a key competence of this organization.

4. CONCLUSIONS

Product customization in distribution channels requires flexible systems that are resilient to disruptions and consistent in reliable delivery of product indicated by the customer to the right place at the right time.

The strategy of the service centre provides higher product flexibility and the strategy of the logistic centre ensures higher quantitative and temporal flexibility. As regards the service centre, the surplus of network relations is an essential strategy of suppressing such disruptions as those indicated in the analysis: lack of accessibility of products with parameters determined by the customer, incomplete delivery of the base products.

The indicated results induce to continue and deepen research into the sensibilities of both models to disruptions in material flows because network ability is still an essential competence of distribution enterprises, however, it is determined by the atmosphere of cooperation. Research will be continued in this area soon.

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