SUPPLIER SELECTION PROCESS SUPPORTING SUSTAINABLE DEVELOPMENT - USING ANALYTIC HIERARCHY PROCESS TO DETERMINE PRIORITY FACTORS

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Abstract

The present study was conducted to identify simultaneously economic, environmental and social conditions that should be considered when deciding to cooperate with the supplier. This integrated approach allowed, besides identifying the validity of individual criteria, noting the relationship among a group of economic, social and environmental criteria. The importance of particular criteria was designated with the help of AHP method (Analytic Hierarchy Process). The research was done among experts from international enterprise of industrial automatic control line. The "Economic" group got the highest importance. The second place was taken by "Environmental". The least importance was achieved by the "Social" category. It should be noted importance of social and environmental criteria that affect the economic dimension. The research results show that sustainability does not exist if a company is not profitable. A proper balance between economic, social and environmental perspective is needed to be successful in long and short run and sustainable development.

Keywords: Supplier development, supplier selection, supplier selection criteria, sustainability

1. INTRODUCTION

At present, enterprises more often concentrate their activity on marketing and creating the mark, ordering the production to subcontractors.[1], [2] It is connected with the necessity of controlling suppliers and also with influencing on customers in the range of sustainable management of supply chain. Sustainable supply chain can be define as such net of connections (relations) in which management of raw materials and services from suppliers to manufacturer/from service provider to customer and back with improvement of the social and environmental impacts.[3] He choice of suppliers implementing sustainable development in supply chain gained the rank of the strategic importance. We can find, in the literature, sets of criteria, measurers of assessment of the sustainable suppliers. However, the researchers mainly concentrate on one of the aspects of sustainable development e.g. economic, environmental or social. Seuring and Muller [4] provided a review on sustainable supply chain management taking 191 papers published from 1994 to 2007 into account. Only 20 papers focused on the social dimension, and a further 31 papers were classified as sustainable, as they integrate environmental and social issues. This reveals a clear deficit in supply chain management and purchasing literature on social issues as well as on the amalgamation of all three dimensions of sustainable development. As the authors state, future research on these topics would be one of the clear recommendations towards researchers in the field. Additionally, we are still unknown how these dimensions relate to each other. The majority of papers point at win-win-(win-) situation(s), which are frequently observed in environmental and sustainability management literature but still trade-offs between the three dimensions are brought up many times.[4] It indicates knowledge gap in this field. Hence, in response to these facts, the main aim of the article is identification of economic, social and environmental criteria which should be considered while making decision about cooperation with the supplier. Such integrated attitude allowed, besides identification of criteria, noticed the dependants among the group of economic, social and environmental criteria.

The problem of choosing the supplier requires making the decision on the basis of many criteria, thus it multiple-criteria decision. In the range of solving multiple-criteria problems we can find many different methods in the literature. To the most common we can add, among the others: ELECTRE (ELimination and Choice

Expressing REality) I i II, III, IV, PROMETHEE I i II, CBR (Case-based Reasoning), AHP (Analytic Hierarchy Process), ANP (Analytic Network Process). Each mentioned method has its advantages but also some its restrictions.[5] The supplier selection problem involves both qualitative and quantitative criteria. AHP can handle adequately the inherent uncertainty and impression of human decision making process. It can provide the robustness and flexibility needed for the decision maker to understand the decision problem. AHP provides an easily understandable and defensible approach to practitioners. It allows practitioners to be involved in the analysis and actually to guide the decision more effectively. This managerial transparency and lack of complexity allow for greater acceptance by both researchers and practitioners.[6] Using AHP as a supporting tool for decision making will help to gain a better insight in complex decision problems. It allows structure the problem as a hierarchy. It forces to think through the problem, consider possible decision criteria and select the most significant criteria with respect to the decision objective. The method also allows “translating" subjective opinions, such as preferences or feelings, into measurable numeric relations.[7]

2. SUPPLIERS CRITERIA SUPPORTING SUSTAINABLE DEVELOPMENT

Supplier supporting sustainable development is one of the conditions of responsible supply chain management (RSCM). RSCM can be defined as an economic, social and environmental management influencing the supply process.[8] Sustainable development can be analyzed on the macroeconomical and microeconomical level e.g. enterprise. Operationalization of sustainable development on the enterprise level is connected with the fall of energy consumption, material consumption, the rise of productivity of environmental resources, reduction of pollution level, reduction of harmful emissions, reducing the consumption of hazardous materials, reduce the frequency of accidents and all of that with simultaneous meeting the expectations of interest groups. Supplier supporting sustainable development is such one, who plans and put into reality activities in order to reduce the harmful effects on the environments: natural and social, whereas there is no deterioration in economic results.[9] If you assume that the aim of RSCM is formation, protection and development of economic, social and environmental value for all stakeholders engaged in the supply process, it means that final criteria of evaluation of suppliers supporting sustainable development should fall into one of three categories e.g. (1) economic,(2) social, or (3) environmental. Gathered, on the basis of literature, examples of criteria for suppliers assessment are presented at the Table 1.

3. THE RESEARCH METHOD

The research works were done at the international production firm offering solutions in the field of industrial automation and dedicated IT solutions for its products. The enterprise implements supporting solutions of sustainable development on every stage of the production process. The company covers substantially the whole world and its actions are divided among the individual regions: Asia, Pacific countries, North America, Latin America, Europe, Middle East and Africa. There are two production plants in Poland. Strategic Purchasing Department in Poland is responsible for servicing the suppliers applying Europe, Africa and Middle East. The company operate according to an Engineer-to-order (ETO) strategy. The suppliers are required the maximum level of flexibility and communication. Of course, there is also a significant part of materials and semi-products (bought on component markets) characterised by regular consumption and the high level of availability. Strategic purchasing department concentrates, in such cases, mainly on component markets. This is due to the greater control demand, easiness in finding alternative suppliers, high competitiveness among suppliers, bigger sensitivity to market factors, large volume of buying. The importance of particular criteria was appointed with use pairwise comparisons e.g. (Analytic Hierarchy Process, AHP).

Table 1 Examples of criteria used to evaluate of suppliers

Category	Evaluation criteria	Source
Economic	Price, quality, logistic costs, terms of payment, financial situation, delivery time, timeliness of delivery, time of launching new products on the market, communication and IT systems, abilities in R+D, or production abilities and capabilities, management and organization abilities, implemented management systems.	[3], [10], [11], [12] [13], [14]
Environmental	Safety, respect for human rights, improvement of labour standards, ethical behaviours, philanthropy, employment of minors, slavery labour	[10], [15], [16], [17]
Social	Possessed certificates of environmental management, environmental protection policy, reducing the use of toxic preservatives in the product, recycling, package recycling, trainings of employees, trainings of the employees raising awareness of the need and ways to protect the environment, taking advantage of the ecological technologies, reducing of consumption of resources	[16], [18], [19], [20]

AHP method is an heuristic approach combining the elements of mathematics and psychology. It makes optimal decisions easier by the reduction to the series of pairwise comparisons which is performed by the experts. Finally, it allows determination of a numerical measure of the value of the analysed criteria.[19] The aim of the first stage of the AHP method is structuring the problem and presenting it in a hierarchical form. It starts with the general presentation of the problem dividing into smaller and simpler components. The second stage is based on the generating rating of mutual comparison of selection criteria (global preferences) and considered variants (local preferences). Specification of criteria is done by comparing them in pairs. The importance of criteria indicates their influence on accomplishment of the main aim. Estimation is formed in accordance with nine-levels scale introduced by Saaty.[21] Values 1,3,5,7,9 adequately means: equal importance, moderate importance, strong importance, very strong or demonstrated importance, and extreme importance. Even numbered values will fall in between importance levels. On the basis of achieved comparisons the matrix eigenvector and eigenvalue are calculated. Matrix eigenvector is a weight criterion. Maximal eigenvalue helps to calculate consistency ratio (*C.R.*). *C.R.* is calculated by using the consistency index (*C.I.*) which was described by Saaty as follows:

$$\mathrm{C.I.} = \frac{\lambda_{max} - n}{n-1} \tag{1}$$

where:

λ_{max} - principal eigenvalue,

n - a number of compared characteristics.

C.R. consistency ratio is calculated as a percentage quotient of the consistency index *C.I.* and random index *R.I.*:

$$\mathrm{C.R.} = \frac{\mathrm{C.I.}}{\mathrm{R.I.}} \tag{2}$$

Random index *R.I.* is the average *C.I.* for the large number of comparisons from the matrix of dimensions *n x n* (table values). If the coefficient ratio (*C.R.)* is lower or equals 0.1 it is assumed that this coefficient is accepted.[22]

AHP model was created on the basis of the literature analysis and with the help of five experts working at the Strategic Purchasing Department. Two of the experts were at the post of managers, two are from lower level of management and one was an operating employee. Each of them had at least five years experience in selection and estimation of suppliers. From the list of 89 criteria, after two hours meeting experts chose the set of criteria limited to 41, and grouped them into main categories on three levels. (Table 2) The web application by Klaus D. Goepel was used for building the model.[7] Web application was used by the others in their research works.[24],[25]

4. RESULTS AND ANALYSIS OF THE RESULTS

Finally, the criteria of estimation of suppliers supporting sustainable development were allocated to one of three categories: economic, social and environmental (Table 2). AHP model was implemented in application BPMSG AHP Online System.[20] With the use of the same application comparison in pairs was done and on the basis of conducted estimation, comparative assessment of five experts was provided. In Table 2 each of the criteria shows partial local weight values. Last column shows the global value of each criteria. Experts were at least agreed with assessment of the criteria from the “Economical" (compatibility of about 70%). In the category of social and environmental criteria compatibility was on the level of 86% and 87%. Global consistency rate *C.R.* was at acceptable level 0.07. In case when *C.R* <0.1 comparison of characteristics is considered as consistent. What is more, on each level of AHP the *C.R.* value of coefficient did not exceed 0.1. The highest priority was assigned to criteria *E1*, it means the price of a product 9.8% but a little less 9.1% gained the criteria *E7*. The functional resources of risk management. Also remaining places were taken by criteria from the group “Economical”, it means *E2* Logistics costs achieved the weight of 6%, and punctuality of delivery 5.9%. It should be noticed that criteria connected with launching new products were of minor importance. Criteria *E17* (focusing on innovation), *G7* (re-projecting the product due to environmental requirements), *G10* (designing for recycling) or *E10* (time for launching a new product on the market), should be explained by the lack of cooperation with suppliers on the level of organising sub-groups. In the analysed company suppliers get final projects or trade components are bought. Components from the group “Economic” got the highest importance (with weight of 0.6803). The second place was taken by the criteria Environmental with the weight of 0.1707. Costs criteria are also seen with the high values of weight criteria of environmental criteria. The highest weight in this group was gained by criteria which can directly influence lowering the costs of product. The highest values were achieved by such criteria as *G1* Energy consumption 4.2%, *G3* solid wastes 1.7% or *G4* sewage 1.2%. The least importance 0.149 was achieved by the criteria of social category. Among them were the highest rated criteria related to safety, safety of culture, and the ethics of supplier. Also in this case we can see appreciating attributes of suppliers (outside ethics) which can have a direct influence on the costs of delivery of components. A big importance of attributes in social and environmental categories which influences economical dimension, brings the questions: what relations are among economic, social and environmental categories? Are these relations of a type trade-off or win-win? The low importance of criteria in the “Social” category in experts opinion affirms the results of previously led research. Seuring et al. (2008) state that organizations have just started to implement in the system estimation of suppliers or other logistic activities, integrated sets of criteria of sustainable development.[25] Despite the fact that many corporations worked out different kinds of liabilities of sustainable development, guide-books for suppliers etc., so according to Ehrgott et al. (2011) implementation of sustainable development is difficult to be reached because it depends on many factors such as: customers’ requirements, employees requirements, economical-financial condition of an enterprise, obligatory legal regulations in a given country.[26]

To sum up, then, sustainable supplier should be less susceptible to disturbances, with a big awareness of possible, unexpected and unwanted occurrences in the process of production and supply of raw materials including these which can increase the pollution of natural environment. Besides, it should support safety, occupational safety and health, work out and follow the ethical rules of business.

5. CONCLUSION

We can find, in the literature, sets of criteria, measurers of assessment of the sustainable suppliers. However, the researchers mainly concentrate on one of the aspects of sustainable development e.g. economic [e.g.12, 13, 22], environmental [e.g. 6] or social [e.g.15, 20]. The present study was conducted to identify simultaneously economic, environmental and social conditions that should be considered when deciding to cooperate with the supplier. This integrated approach allowed, besides identifying the validity of individual criteria, noting the relationship among a group of economic, social and environmental criteria. The "Economic" group got the highest importance (with weight of 0.6803). The second place was taken by "Environmental" group (0.1707). The least importance (0.149) was achieved by the "Social" category. This indicates that firms in developing countries (e.g Poland) tend to reorder their priorities in supply management sustainability practice by stressing the importance of the economic as opposed to the environmental or social value. The findings are quite different from Orji's findings.[27] The differences indicate knowledge gaps in this field. Further research is necessary to consider case studies in different sectors, developing countries versus developed ones or different economic condition (e.g. prosperity versus economic downturns).

A big importance of attributes in social and environmental categories which influence the economical dimension brings a question: what are the relations among economical, social and environmental categories? The research results show that sustainability does not exist if a company is not profitable. Decisions about environmental or social issues are thus very pragmatic and organizations should keep sight of the fact that they must be both economically, environmentally and socially sustainable. The managers need to be careful in choosing appropriate sustainable criteria since those dimensions need to be compatible with each other and with a firm's overall strategy.[28] Organization wants to generate more profit but consideration of only economic perspective may give good results in short run. A proper balance between economic, social and environmental perspective is needed to be successful in long run and sustainable development. Therefore, the question for managers is not simply whether to use environmental and social factors. It is rather what kind of these factors is suitable for a specific firm's strategy. Additionally, the results suggest that different forms of firms sustainable orientation are not only beneficial for sustainable improvements, but could be considered as a tool for firm performance improvement. This study has limitations that could be addressed in future work. First, the findings were worked on one case study (buyer and suppliers operate on industrial automation market). Second, AHP model is highly dependent on the judgments of the experts. Thus, it is needed statistical analysis on a broader sample to confirm presented results.

Table 2 Criteria for evaluation of suppliers to support sustainable development

	Economic criteria		Code	Weight
	Main criteria	**Specific criteria**		
Economic criteria 0.68026	Cost 0.2678	Price of product 0.5381	**E1**	9.8%
		Logistic costs 0.3298	**E2**	6.0%
		Terms of payment 0.1321	**E3**	2.4%
	Quality 0.3792	Claim conditions 0.1766	**E4**	4.6%
		Product durability 0.1251	**E5**	3.2%
		Product performance/efficiency 0.1805	**E6**	4.7%
		Uncertainties and risks management systems 0.354	**E7**	9.1%
	Delivery 0.1359	Delivery time 0.2281	**E8**	2.1%
		On time delivery 0.6377	**E9**	5.9%
		Time to market 0.1341	**E10**	1.2%
	Technological capabilities 0.0895	Communication and information systems 0.1955	**E11**	1.2%
		Develop innovation and R & D skills 0.228	**E12**	1.4%
		Production skills and abilities 0.5765	**E13**	3.5%
	Potential 0.1276	Financial situation 0.2227	**E14**	1.9%
		Implemented quality management systems 0.4541	**E15**	3.9%
		Sharing information level 0.2041	**E16**	1.8%
		Focusing on innovative solutions 0.119	**E17**	1.0%
	Social criteria			
Social criteria 0.149083	**Main criteria**	**Specific criteria**		
	Social justice 0.2849	Sex discrimination 0.2879	**S1**	1.2%
		Gender equality 0.4464	**S2**	1.9%
		Forced labour 0.2657	**S3**	1.1%
	Health and Safety 0.5435	Mortality 0.0885	**S4**	0.7%
		Higiene 0.3464	**S5**	2.8%
		Creating safety culture 0.2774	**S6**	2.2%
		Safety 0.2877	**S7**	2.3%
	Ethics 0.1716	Supplier ethics 0.8037	**S8**	2.1%
		Preached standards.values in business 0.1963	**S9**	0.5%
	Environmental criteria			
	Main criteria	**Specific criteria**		
Environmental criteria 0.170657	Effect on environment 0.4658	Energy consumption 0.5289	**G1**	4.2%
		Emissions of harmful air pollutants 0.1078	**G2**	0.9%
		Solid. chemical waste 0.2141	**G3**	1.7%
		Sewage 0.1492	**G4**	1.2%
	Control over the environment 0.2015	Buying environmentally friendly materials 0.501	**G5**	1.7%
		Using of environmentally friendly technologies 0.2528	**G6**	0.9%
		Products redesigning 0.1338	**G7**	0.5%
		Awareness raising among workers in the field of environmental protection 0.1124	**G8**	0.4%
	Design for environment 0.1592	Using eco-friendly materials 0.6065	**G9**	1.6%
		Design for recycling 0.2482	**G10**	0.7%
		Life Cycle Assesment 0.1453	**G11**	0.4%
	Competence in environmental Protection 0.1735	Ability and potential to reduce pollution 0.1558	**G12**	0.5%
		Clean technologies availability 0.0897	**G13**	0.3%
		Competence in logistics returns: goods. waste and recyclable materials 0.2383	**G14**	0.7%
		Environmental certificates np. ISO 14000 0.5161	**G15**	1.5%

C.R.=0.07

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