Strategic sourcing for an order-related single-part manufacturer

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Abstract
In times of Lean Management and holistic approaches towards value creating networks, sourcing decisions have gained importance for all companies. Especially in an order-related single-part production, which is characterized by sporadic orders, long lead times, high value parts and complex processes, a standardized decision-making process is required to select the best sourcing strategy for A-parts. This paper builds on the Analytic Hierarchy Process and derives criteria, subcriteria and alternatives to guarantee optimal provision of input factors.

Keywords: sourcing strategy, single-part production, Analytic Hierarchy Process

Introduction
The goal of this paper is to contribute to theory and practice by developing a standardized process to change, simplify and finally to standardize the sourcing process of A-parts and supplier selection. To illustrate the approach, a real-world problem, namely that of company S is analyzed. In the future, this single-part production company wants to buy their A-parts from global suppliers in a highly competitive manner. Up to now such sourcing decisions were made without the support of a formal decision-making process. To generate such a standardized process, this paper first identifies sourcing goals and alternatives through a case study with company T, a leading company in a similar industry. Second, the findings will be verified and amended through literature review. The order-related single-part production company T uses the cost benefit analysis to decide on the source of supply, thus communication between different levels of decision-making becomes easier. In this respect, defining of criteria weights is problematic and seems rather subjective. This paper examines if Multi Attributive Decision-Making approaches are better suited for the sourcing decisions of A-parts in an order-related single-part production company. Furthermore, it analyzes if the developed model can be transferred to company S and if it could be helpful in deciding on their new sourcing strategy. Additionally, the impact of the current economic crisis on the sourcing decision will be discussed. Note that the intention of this paper is to understand the selection of a suitable sourcing strategy in

company T and if the proposed framework is transferable to company S. It is not the intention, however, to derive representative results for any company.

Analytic Hierarchy Process (AHP)

Deriving a sourcing strategy requires consideration of multiple criteria (McIvor, 2000; Sydow, 2004). Moreover, the method used needs to be structured, be comprehensible, guarantee optimal results and be applicable in practice. The Analytic Hierarchy Process (AHP) developed by Saaty (1994), is a Multi Attributive Decision-Making approach recognized in both, theory and practice and has been used to make a variety of decisions (for examples see Yang & Lee, 1997). It helps the decision-maker to select a suitable option and is not a black box that only presents the best option. It proposes a standardized decision-making process that describes the complexity of the problem, measures criteria-conformance and ranks several alternatives (Bhushan, 2004). To this end it first decomposes the complex decision into a number of smaller problems, which are solvable by pairwise comparisons. It allows quantitative as well as qualitative criteria. Structuring the partial problems as a goal-hierarchy and synthesizing the results accordingly, makes the process comprehensible and helps to select the best alternative. Thus, the AHP is suitable for selecting a sourcing strategy for an order-related single-part production.

The approach of this paper can be described as an interactive, five-step process. It is interactive in a sense that interviewer and interviewee constantly interact. In the *first step*, an open interview with a sourcing executive of company T was conducted. The expert first named sourcing goals, criteria and subcriteria and was then able to arrange them in a goal-hierarchy. The expert selected three alternatives, each a combination of three dimensions, and compared their criteria-conformance in pairs (Bhushan, 2004; Harker, 1989). In addition, the inputs from a literature review were also used to describe the characteristics of each alternative. As a *second step*, the decision-maker evaluates the (sub)criteria pairwise. Since it was also a goal of this paper to assess if criteria weights changed in an economic crisis, the decision-maker was asked to make such a distinction. The software package Expert Choice was used to support the interview process (Vincke, 1992). Pairwise comparisons can lead to difficulties in determining the ratios that best represent the real-world system. Saying that one option is between three to five times better than another is not allowed in the AHP. It demands the decision-maker to decide whether it is exactly three, four or five times better than the other option (Wang, Chu, & Wu, 2007). Using the Eigenvector approach (Saaty, 1994), local priorities can be obtained from the preference matrices that are then aggregated to global priorities. The result is then presented to the decision-maker. Note that inconsistencies in the preference matrices are allowed to a certain degree (Saaty, 1994), they point out problems and give the decision-maker the opportunity to revise their decision (Harker & Vargas, 1987). Adding new alternatives is not allowed, lowering the possibility of rank-reversal, which is discussed in AHP literature (Dyer, 1990). During the *third step*, the decision-maker chooses an alternative. It is possible to choose a different alternative than proposed by the framework. The AHP helps the decision-making process; it does not select a strategy automatically. The *fourth step* examines if the proposed framework, can be applied to company S as well. To test the applicability of the framework, a sourcing expert from this company is asked what their most relevant criteria and subcriteria were. If required the hierarchy, is adjusted accordingly. Then this interviewee is also requested to evaluate criteria and subcriteria pairwise for both situations, in a normal economic environment and during an economic crisis. Based on the characteristics of alternatives derived in step 1 and the criteria weights

derived in step 4, the framework then proposes an alternative to company S. Finally, *step five* requires the decision-maker to select an option for company S.

The following two sections present the results from step 1, by introducing criteria and alternatives.

Sourcing strategy goals and criteria in order-related single-part production

Selecting suppliers is one of the most fundamental and important decisions of an enterprise. In particular, it can develop into one of the most difficult and critical decisions (Joseph & Srinivas, 2002). First, the sourcing goals should be obtained, in order to objectively and strategically select a supplier. Ideally sourcing goals follow company goals, with the purpose of achieving company-wide goal conformity (Friedl, 1990). In recent years, the cost objective has been seen less as the only criterion pursued in the strategic selection of suppliers. Other criteria need to be considered simultaneously, in particular when deciding on permanent co-operation with suppliers in the context of Lean Management and Supply Chain Management (Joseph & Srinivas, 2002). Hence this paper not only analyzes the impact of cost on the overall goal, but also the significance of quality, dependability, flexibility, service and socio-political criteria. Reaching the overall goal "optimal provision of production factors" can be assured by selecting a sourcing strategy which scores the highest in these six criteria categories. Figure 1 also shows which subcriteria were chosen to evaluate the main criteria.

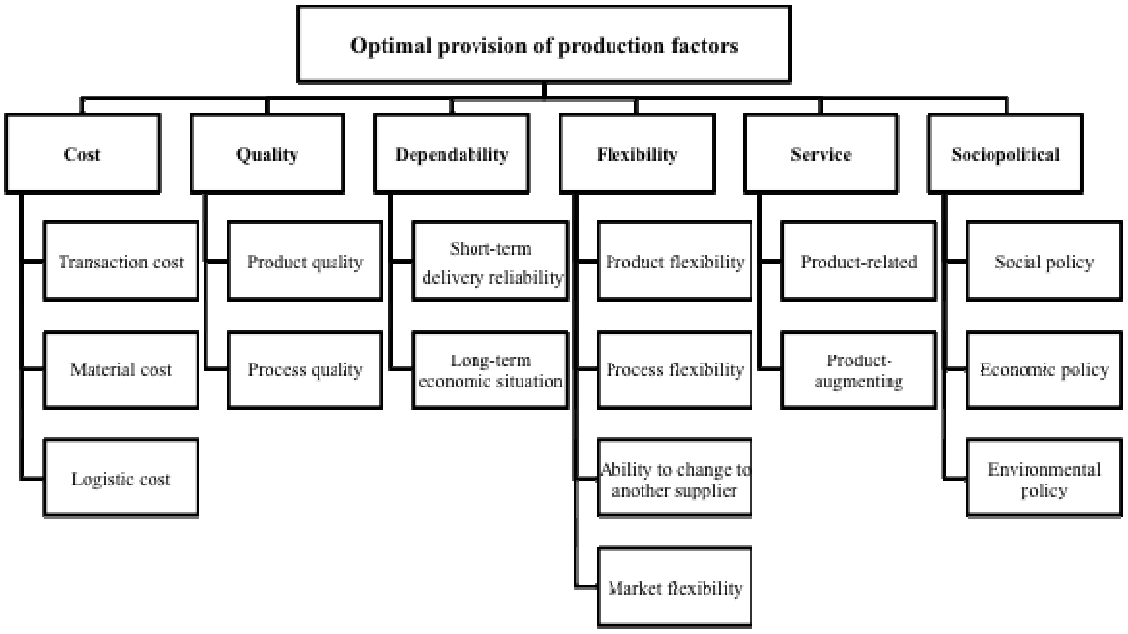

Figure 1 - Proposed hierarchy of criteria and subcriteria.

In this hierarchy, the main goal refers to the procurement of A-parts for an order-related single-part manufacturer in mechanical engineering. This paper defines an *order-related single-part manufacturer* as a company that creates customized products with the lot size being one. Additionally, only incoming orders trigger the engineering, sourcing and manufacturing processes necessary to create the end product. The following section mentions the peculiarities of such an order-related single-part manufacturer in respect to the proposed criteria and subcriteria.

For an order-related single-part manufacturer conditions exist, which affect the pursued criteria in an explicit way (cf. in the following: Mai 1982; Koppelmann 2000; Ernst 2002; Riffner & Weidelich 2001; Backhaus & Voeth 2009). Above all, the sporadic nature of incoming orders affects the entire value chain's planning as well as its procurement. As a result, high quantitative fluctuations of incoming orders may arise at a given point in time. Furthermore, due to the uniqueness of many A-parts, it seems hardly possible to negotiate framework agreements or quantity discounts with suppliers. The cost of a project is difficult to measure, mostly because of the long duration of projects. The long project duration mainly depends on long delivery times of A-parts. It becomes obvious, that affecting the *cost* criterion positively can be very challenging for an order-related single-part manufacturer.

Characterized by high technical complexity and extreme size, *quality* assurance of the A-parts that need to be procured can be complicated, outlining another characteristic of single-part production. On the one hand, high quality is very important because of the strategic significance of A-parts for the final product. On the other hand, the parts' high monetary value entails a high significance of component quality. Further specific requirements for procurement arise as a result of high delivery times. The *dependability* of the supplier, and in particular supply security, is of great importance for an optimal provision of A-parts. It may even be the most important criterion of all.

In the case of no, late, wrong or defective supply, the company usually has limited possibility for short-term replacement shipment. This often leads to an abrupt stop of production. But also, if A-parts get delivered too early, high capital freeze costs develop due to the high value dimension of the parts. A know-how gradient between the construction department and the purchasing department is just as characteristic as the high complexity and enormous extent of the parts mentioned above. Therefore the criterion of *flexibility* is difficult to achieve. However, if a supplier is able to offer an excellent level of flexibility, it can gain competitive advantage.

Combined with the high technical complexity, *service* offerings such as extended warranties, integration into the research and development process as well as the ability and willingness to innovate can be advantageous for a prospect supplier. Also, the high value dimension of A-parts furthers the importance of service offerings. In particular the product-augmenting services play a special role. Based on the high value dimension and high lead times, individual financing can increase the attractiveness of a supplier, since it allows preserving the liquidity of the company.

The outlined characteristics for an order-related single-part manufacturer result in high technical, high economic and high political risks for the enterprise.

Socio-political criteria are hardly affected by the characteristics of the order-related single-part manufacturer. These may gain ever more significance, however, in times of economic crisis.

Furthermore, it can be stated that the high value dimension as well as the technical complexity of the individual orders, substantiate the most crucial differences between the goals of the order-related single-part manufacturer and mass production.

The following paragraph will outline the dimensions and alternatives which will be further used in combination with the derived criteria to build the AHP model. This in turn will be used to aid selecting a suitable sourcing strategy. First, the dimensions of a sourcing strategy will be introduced; secondly they will be combined into alternatives.

Alternative sourcing strategies

The dimension *intensity of relationship with suppliers* consists of two parametric values: "cooperative" and "competitive". The characteristics of cooperative

relationships include long-term contracts as well as a close, trusting commitment between customer and supplier. A short-term contract and tougher negotiations are typical for competitive relationships. In alignment with the resource-based-view of the firm (RBV), the intensity of the relationship usually increases with rising strategic importance of the product or service. It follows that in cooperative relationships only one or two suppliers for each product or service will be employed, whereas competitive relationships draw on several suppliers simultaneously (Arnold, 1997).

The second dimension is the *degree of internationalization* of the supplier base, with the two extremes "local sourcing" and "global sourcing". The level of internationality increases with the geographical distance between supplier and customer. As a result of globalization more sourcing opportunities arise. Global sourcing demands a careful selection and very exact evaluation of suppliers. The evaluation and the selection should always be done in accordance with the business objectives (Vahrenkamp, 2007; van Weele, 2010).

The *degree of vertical internalization* is characterized by two poles: "make" and "buy". If "make" is chosen, a company produces products and services in-house, whereas "buy" postulates sourcing activities from economically and legally independent suppliers. Both, the transaction-cost-theory and the RBV explain when to choose "make" rather than "buy". The RBV states that if an activity is scarce, not imitable, not substitutable and of value to the firm, it should be made rather than outsourced (Child, 2005). Therefore activities relevant to the business' core competencies and competitive advantages shall never be bought-in.

Combining these three dimensions results in eight alternatives, which are shown in figure 2.

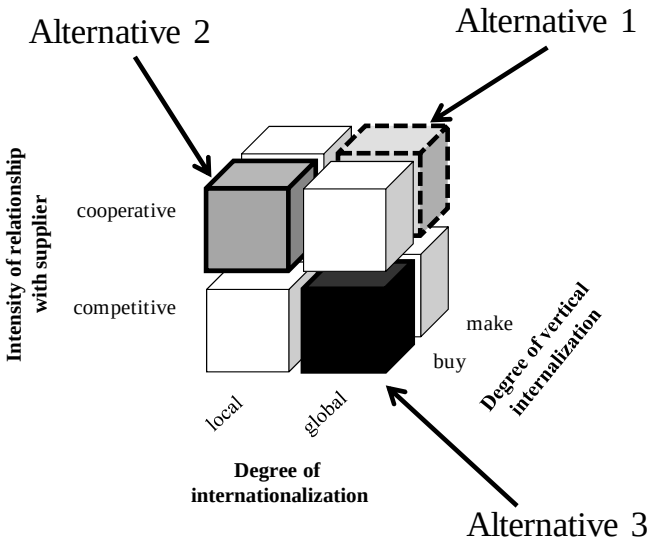

Figure 2 - Putting the three dimensions together to form eight possible alternative sourcing strategies. Three of which are investigated using the AHP.

It is important to note that the possibility to make or buy products exists in cooperative and competitive, as well as in global and local relationships. Organizational units can practice internal competitive relationships, for example, in the case of center organizations which compete with other independent companies (Friedrich, 2003). In contrast, the characteristics of in-house cooperative relationships are coordinated

processes and close, trusting commitments between the different organizational units. A global in-house manufacturing is usually executed by multinational companies.

Because this paper concentrates on the sourcing process of A-parts for order-related single-part production, suitable alternatives will be chosen and their most important strengths and weaknesses will be revealed (cf. in the following: Arnold, 1997; Ernst, 2002; Krokowski, 1998; Schulte, 2001; van Weele, 2010; Vahrenkamp, 2007).

According to *alternative 1* the A-part is cooperatively made in-house, in great geographical distance to the customer. As a result of lower labor costs abroad, currency fluctuation and higher choice amongst possible suppliers, material costs may decrease. Information is shared within the same company, thus the search for information is simpler and more transparent. This results in better planning reliability, more dependable processes and lower transaction costs. Principal-agent problems become less important, because of long-term contracts and a stronger loyalty to the company. However, differences in mentality, culture and education can complicate communication and collaboration between the organizational units. They may also cause higher transactions costs and endanger product quality. The long-term contracts, the close commitment, the specific know-how as well as high loyalty all benefit transaction costs. In international companies this is supported by sharing the same standards, analog processes, common instructions, one production system and similar hierarchies. Caused by a lot of huge and heavy components, single-part production has special transportation needs. Because of this, locating production closer to the customer could reduce logistic costs and therefore total costs. Great distances also imply risk and endanger short-term delivery reliability as well as process flexibility. In contrast the certainty of the long-term economic situation of the supplier is higher because relevant information can be gathered easier within the same company. Because of the cooperative relationship a short-term change of the supplier is more difficult. On the other hand, the close collaboration with the supplier offers the possibility to break into new markets with the supplier's help. Because production is conducted in-house, little competition and great distances between production facilities, product-related services could be at risk. Conversely product-augmenting services could be an advantage of alternative 1, because of the cooperative collaboration within one company. But for the same reason the service could become worse over the years, if no competition exists. In case of in-house production, sociopolitical goals may be easier to achieve. This could be based on the assumption that compensation schemes and employment relations can become more transparent and controllable. But global sourcing may weaken the position of the local economy and could avoid local environmental requirements.

Alternative 2 proposes to buy A-parts from local suppliers, while emphasizing cooperative relationships. Although initially transaction costs for buying products are higher than those of in-house production, they could be reduced because of long-term contracts, similar mentality, same language and similar ways of working. The long-term contracts also offer the possibility to standardize and establish common processes benefiting product quality and process quality. For A-parts product quality is very important and demands an early integration of the supplier into the engineering process, to guarantee a smooth production flow. The interdependence between supplier and customer can also be an advantage, because both can grow together and help each other, e.g. in times of crisis. Furthermore, the short distance can benefit process flexibility as well as product-related services. In contrast to product-augmenting services, product-related services can suffer, due to the long-term character of the cooperative relationship. This alternative seems to fulfill the sociopolitical criteria in the best way. Because of the local surrounding and the close relationship, sociopolitical aspects are

easier to encourage and to control. Also the local industry can be supported and local environmental standards are more transparent. Public opinion may also help to enforce sociopolitical goals.

Alternative 3 proclaims to globally buy A-parts within a competitive relationship. This uses the advantages of competition and potentially leads to lower material costs. Probably transaction costs are higher, however, caused by the short-term competitive relationship and the globally located suppliers. Long lead times and great distances could be a risk for short-term delivery reliability and process flexibility. Since a great variety of global suppliers exists and contracts are short-term, product flexibility and the ability to change to other suppliers are high. The short-term relations may not allow for high product-augmenting services, however, other criteria may be more important. With regard to sociopolitical goals, this alternative poses potential threats. Local jobs, the local economy and environmental goals could be endangered.

The derived criteria and alternatives were tested in expert interviews. The following section provides the results.

Results

The proposed multi-criteria decision-aiding framework has not been rejected by either expert. Moreover, it was described as better suiting their needs than currently employed methods. The approach was comprehensible for the experts and included the most important criteria for both companies. Although, the decision-maker from company S initially did not identify the subcriteria for flexibility, the sociopolitical criterion, logistic costs and product-augmenting services when asked for relevant criteria, he nevertheless accepted them when suggested by the framework. All other criteria were mentioned from the beginning. He further emphasized the importance of engineering costs and agreed that they should be considered by determining overall material costs. Thus the derived criteria, subcriteria and alternatives with company T can also be applied to company S.

In regards to the goals pursued by the two order-related single-part manufacturers four statements can be made. First, with a more than five percentage-points lead, both companies ranked quality as the most important criterion. This matches the expectations, since it clearly reflects the characteristics of an order-related single-part manufacturer, such as the high complexity and high value dimension of A-parts. Second, the sociopolitical criterion was found to be the least important (less than 5%). Considerations to strengthen the local economy were found to have little impact on the decision, whereas the importance of social objectives was accepted. Third, company T is relatively product-oriented while company S stressed the importance of processes. For company T product quality, product flexibility and product-related services are important criteria. Company S acknowledged the importance of process flexibility, while ranking product quality and process quality equally. Moreover, the significance of product-related and product-augmenting services was found to be the same. According to company S, good processes at the supplying company are required to leverage its own process insufficiencies. Forth, transaction costs play a minor role for both companies (6.7%).

Table 1 shows the results for the two companies. Applying the derived criteria weights on the proposed alternatives, Alternative 2 is found to best suit company T (42 %). The second-best option is Alternative 3 (29.2%), while option 1 is considered to be marginally inferior (28.9%). Since the criteria and alternatives had been developed with company T, the suitability of the proposed framework is confirmed by the fact, that the actual sourcing strategy chosen by company T is Alternative 2. The framework

proposes Alternative 2 (45%) for company S, followed by Alternative 1 (29.3%). It is interesting that company S originally preferred Alternative 3 as their new sourcing strategy, which did not reflect the company's goals sufficiently as the results show (25.7%).

Table 1 - The results for company T and company S

	Company T			**Company S**		
	Alt. A	**Alt. B**	**Alt. C**	**Alt. A**	**Alt. B**	**Alt. C**
Optimal provision of production factors	28.9%	42.0%	29.2 %	29.3%	45.0%	25.7 %
Cost	24.4%	25.9%	49.7%	24.4%	25.9%	49.7%
Quality	41.6%	47.6%	10.8%	38.9%	50.7%	10.4%
Dependability	24.2%	54.9%	21.0%	24.2%	54.9%	21.0%
Flexibility	22.9%	36.5%	40.4%	29.3%	47.9%	22.8%
Service	16.6%	37.5%	45.9%	21.0%	43.0%	36.1%
Sociopolitical	36.8%	52.9%	10.3%	38.7%	51.2%	10.1%

During the course of the interview, few inconsistencies in the preference matrices appeared and were reduced to a just acceptable level (<.13) by pointing them out to the interviewee.

The conducted sensitivity analyses showed stable results for company S. For company T the evaluation of Alternative 2 is also robust. For the quality criteria, however, a 3.2% increase leads to a priority shift from Alternative 3 to Alternative 1. Decreasing the importance of costs by 7.5% or decreasing the weight of flexibility by 8.8% can obtain the same results. The interactive approach of the proposed framework can be of advantage when analyzing the problems shown by the sensitivity analysis. Confronted with the results, company T claims not to rank Alternative 3 better than Alternative 1. Option 1 would better suit company T because product quality is taken as granted and it would not even consider an alternative if it cannot guarantee the required product quality level. If quality were assumed as equal across alternatives, material costs would also need to be the same for all options. Furthermore, company T ranks the importance of ex-ante services higher than that of services spanning the whole life-cycle of the product. Cooperative supplier relationships could help this end. Considering those comments in the framework, the ranking of Alternative 1 (29%) and Alternative 3 (27.9%) is reversed.

Table 2 - Comparing normal with abnormal economic circumstances

	Company T			**Company S**		
	Normal	**Crisis**	**Difference**	**Normal**	**Crisis**	**Difference**
Cost	19.9%	21.8%	+1.9	20.2%	38.1%	+17.9
Quality	27.5%	26.8%	-0.7	25.4%	14.0%	-11.4
Dependability	20.7%	20.0%	-0.7	17.6%	21.3%	+3.7
Flexibility	22.7%	22.7%	+0.0	20.1%	15.2%	-4.9
Service	5.2%	4.8%	-0.4	11.9%	7.2%	-4.7
Sociopolitical	4.1%	3.8%	-0.3	4.8%	4.2%	-0.6

The recent global economic crisis has dissimilar impacts on the sourcing strategies of the two companies. Even though the decision-aiding framework still suggests selecting Alternative 2 for either company, Alternative 3 is able to narrow the gap between the best alternatives to less than 10 percentage-points. Company T has changed its sourcing strategy towards a more short-term oriented approach. The relative weight of the subcriterion “ability to change to another supplier” soared from 34.8% to 53.8% and that of “short-term delivery reliability” from 50% to 83.3%, leading to a better ranking of Alternative 3. Since the weights of the quality subcriteria remained unchanged, company T is not willing to compromise on this point. The relative significance of cost also remains equal.

Having increased from 20.2% to 38.1%, the cost criterion is of the utmost importance for company S under difficult economic circumstances. Apparently the company is willing to compromise on quality, flexibility and service to achieve lower costs. Interesting, however, is the fact that the relative weights of social goals and long-term economic situation of the supplier increase. Company S explains this with its extra long production duration and the implied risk of losing a supplier during a project.

A contradiction follows for each company. The one for company T is to simultaneously achieve an acceptable level of costs and quality, while emphasizing short-term reliability and the flexibility to change partners. The contradiction of company S is to emphasize costs boldly on the one hand, while requesting long-term economic stability and social adequateness from partners on the other. Both companies trust Alternative 2 to solve them.

Conclusion

The fundamental aim of this work was to support strategic sourcing decisions by using a formal decision-making process.

First, a case study with company T was conducted. It became clear that multi-criteria decision-making models could be used for sourcing decisions concerning A-parts of an order-related single-part manufacturer. It was shown, in particular, that deriving weights could be improved by using pairwise comparisons. Second, as it became clear in a further interview with company S, the developed model is also transferable to that order-related single-part manufacturer. Thus the proposed model can support the decision-making process for future sourcing strategies for that company. Furthermore, it became obvious that only expert knowledge was extracted to build a decision-making framework, rather than formulating generally applicable results, suitable for any company.

This leaves room for further studies in this field. First, discussing the parametric values of the used dimensions is desirable, since it remains unclear if they are, as the proposed framework suggests, discrete or if they are rather continuous. A distinction between the “end” of local sourcing and the “beginning” of global sourcing, for example, may remain vague. Second, it would be worthwhile applying the proposed decision-making process to sourcing decisions of other companies, in order to produce more generalizable results. Third, the shown impact of an economic crisis on the strategic sourcing decision for A-parts can be a starting point for future research.

References

Arnold, U. (1997), *Beschaffungsmanagement*, Schäffer-Poeschel, Stuttgart.

Backhaus, K. and Voeth, M. (2009), *Industriegütermarketing*, Vahlen, München.

Bhushan, N. (2004), *Strategic decision making applying the analytic hierarchy process*, Springer, London.

Child, J., Faulkner, D., Stephen, B.T. (2005), *Cooperative strategy: Managing Alliances, Networks and Joint Ventures*, Oxford University Press, Oxford.

Dyer, J. S. (1990), "Remarks on the AHP", *Management Science*, Vol. 36, No. 3, pp. 249-258.

Ernst, M. (2002), *Beschaffungsmanagement eines Anlagenbauers in globalisierten Märkten*, Shaker, Aachen.

Friedl, B. (1990), *Grundlagen des Beschaffungscontrolling*, Duncker & Humblot, Berlin.

Friedrich, R. (2003), "Centeransatz zur Führung und Steuerung dezentraler Einheiten", in Bullinger, H.-J., Warnecke, H.J. and Westkämper, E. (Ed.), *Neue Organisationsformen im Unternehmen – Ein Handbuch für das moderne Management*, Springer, Berlin, pp. 1153-1183.

Harker, P. (1989), "The art and science of decision making: The Analytic Hierarchy Process", in Golden, B., Wasil, E. and Harker, P. (Ed.), *The analytic hierarchy process applications and studies*, Springer, Berlin, pp. 3-36.

Harker, P. and Vargas, L. (1987), "The Theory of Ratio Scale Estimation: Saaty's Analytic Hierarchy Process", *Management Science*, Vol. 33, No. 11, pp. 1383-1403.

Joseph, S. and Srinivas, T. (2002), "A Model for Strategic Supplier Selection", *The Journal of Supply Chain Management*, Vol. 38, No. 1, pp. 18-28.

Koppelmann, U. (2000), *Beschaffungsmarketing*, Springer, Berlin.

Krokowski, W. (1998), *Globalisierung des Einkaufs – Leitfaden für den internationalen Einkäufer*, Springer, Berlin.

Liu, L. B., Berger P., Zeng A. and Gerstenfeld A. (2008), "Applying the analytic hierarchy process to the offshore outsourcing location decision", *Supply Chain Management: An International Journal*, Vol. 13, No. 6, pp 435–449.

Mai, A. (1982), *Lieferantenauswahl: Die ziel- und bedingungsorientierte Gestaltung der Beschaffer-Lieferanten-Beziehung*, Thun, Frankfurt am Main.

McIvor, R. (2000), "A practical framework for understanding the outsourcing process", *Supply Chain Management: An International Journal*, Vol.5, No. 1, pp. 22-36.

Riffner, B. and Weidelich, R. (2001), *Professionelles Lieferantenmanagement : so arbeiten Kunden und Lieferanten erfolgreich zusammen*, Deutscher Wirtschaftsdienst, Köln.

Saaty, T. L. (1994), „How to Make a Decision: The Analytic Hierarchy Process", *Interfaces*, Vol. 24, No.6, pp. 19-43.

Schulte, G. (2001), *Material- und Logistikmanagement*, Oldenbourg, München.

Sydow, J. and Möllering, G. (2004), *Produktion in Netzwerken - Make, Buy & Cooperate*, Vahlen, München.

Vahrenkamp, R. (2007), *Logistik – Management und Strategien*, Oldenbourg, München.

van Weele, A.J. (2010), *Purchasing and Supply Management*, Cengage Learning, London.

Vincke, P. (1992), *Multicriteria decision-aid*, Wiley, Chichester.

Wang, L., Chu, J., and Wu, J. (2007), "Selection of optimum maintenance strategies based on a fuzzy analytic hierarchy process", *International Journal of Production Economics*, Vol. 107, No. 1, pp. 151-163.

Yang, J. and Lee, H. (1997), "An AHP decision model for facility location selection", *Facilities*, Vol. 15, No. 9/10, pp. 241–254.