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Cross-Functional Decision Support Systems for a Supplier Selection Problem

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Abstract

In supply chain management, how to determine appropriate suppliers has been a key challenge in strategic decision making. Supply chain managers need to explore options in selecting suitable suppliers that best fulfil the requirements in a competitive environment. This article focuses on how the supplier selection process can be delegated to different organisational levels and to different functional or divisional units within a company. We demonstrate how this de-centrally executed selection process can be supported by a new type of decision support system (DSS) platform, in which cross functional decision making on different managerial levels can be supported. We demonstrate the effectiveness of this type of DSS for supplier selection using a widely used multi-attribute utility approach. The applicability of such an approach will be demonstrated using a subset of sample data from a real-world project.

Keywords: Decision Support Systems; Supplier Selection; Supply Chain Management

1. Introduction

Supply Chain Management (SCM) can be defined as 'a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements' (Simchi-Levi, Kaminsky, and Simchi-Levi, 2007). SCM often stresses the intensive and long-term character of customer-supplier-relations that lead to win-win-situations (Lambert, 2008). It is also important to maintain long term partnership with a list of suppliers, however, utilise fewer of them as reliable and responsible one (Ho, Xu and Dey, 2010). Therefore, selecting the appropriate suppliers requires extra care to decide within a wide range of quantitative and qualitative factors rather than just scanning a series of price list.

In supply management (a sub-domain of SCM), sourcing decisions are identified as critical decision problems as they require cross-functional orientation to achieve holistic outcomes in decision making effects (Moses and Ahlstrom, 2008). Cross-functional decision making involves operational level decision makers with corresponding knowledge to make the sourcing decisions (Leenders, van Engelen and Kratzer, 2003) and the functional diversity within the cross functional team is the key for innovation (Moses and Ahlstrom, 2008). Accordingly, Moses and Ahlstrom (2008) recommended that cross-functionality has become the method of choice for high technology organisation (Keller, 2001). Our key motivation in this article is to address this significant issue in the context of supplier selection by introducing a decision support system approach that enables sourcing decisions with multi-levelled cross-functionality options, in which decision makers both from different levels and functions can be involved.

Within this context, one task supply chain managers are managing is to select one or more suppliers for a specific material or part. One aspect of the supplier selection problem is to decide if to select only one supplier or to choose two or more suppliers; however, the decision on a single or multiple sourcing will not be discussed in this article; see, for example, Burke, Carrillo, and Vakharia (2007) or Inderst (2008). Instead, we assume, that the company prefers a single sourcing approach, i.e. will have only one supplier for a specific material or part. This assumption holds true for many situations within supply chains, especially when the focus lies on important, complex and/or high-value parts. Often, these are modules or (sub-) systems that are exclusively designed by the supplier for a single business customer. In such a development, systems suppliers' role is not only to deliver the required products, but also to provide solutions to the customer's business and to manage some of the customer's processes (Helander and Möller, 2008).

In this situation, the challenge for the supply chain manager is to identify the best supplier out of a number of potential suppliers, as defined. In addition, selecting the best supplier has a great influence on a company's performance, as shown by Kannan and Tan (2006). This significant task can also be applied to the current set of suppliers, when a company decides to move from a multiple sourcing approach (i.e. many suppliers for a specific part) to a single sourcing approach; see Faes and Matthyssens (2009) for an analysis of reasons for changing to a single sourcing strategy and Goffin, Szwejczewski, and New (1997) for further empirical results on supplier base reduction.

Most research in the area of supplier selection focuses on the methodology used for the selection process. Also, extensive research activities focus on the effectiveness of cross-functional teams in supplier selection. However, research on the decision support for different managerial levels is almost non-existent. Therefore in this article, we focus on how the supplier selection process can be delegated to different organisational levels and to different functional units within a company. We subsequently demonstrate how this de-centrally executed selection process can be supported by a new type of decision support system (DSS), a so-called end user enabled design environment (EUEDE) (Described in Miah, Kerr and Gammack, 2009). To demonstrate the effectiveness of this type of DSS, the methodology for the supplier selection will be a widely used multi-attribute utility approach, as for example used by Ng (2007); the procedure is described in detail by Min (1994). Beside the methodology chosen for this article, there exist various different approaches, as compiled and listed by Ho, Xu, and Dey (2010). The proposed DSS approach and its applicability for a multi-level and de-centralised decision making might overcome some of the problems in cross-functional decision making discussed by Moses and Ǻhlström (2008). The applicability of such an approach will be demonstrated using a subset of sample data from a real-world project.

The paper is organized as follows: Sections 2 presents current approaches of the supplier selection DSS. Section 3 describes the problem domain identified for this study. Section 4 provides details of the DSS architecture and its background of technological relevance. Section 5 gives an example illustration of the approaches. Finally, section 6 includes overall concluding remarks and presents further outlook and research directions in the study.

2. Previous DSS approaches for supplier selection

Supplier selection in a broader view can be seen as a process in which potential suppliers are evaluated and chosen to be an actor in the supply chain. The selection process requires to evaluate various supplier-specific data, e.g. product prices, additional costing, but also credibility or performance histories. This evaluation is executed not only using quantitative analysis but also through qualitative analysis using different management level's subjective judgements. Various DSS approaches exist for serving the purpose. For the supplier selection DSS, previous studies suggest four main decision models: multi-criteria-based, hybrid-based, group-based and integration-based decision approaches. Several techniques have been proposed to solve the problem in these approaches. They include: analytic hierarchy process, linear programming, case based reasoning, multi objective programming, data envelopment analysis, analytic network process, mathematical programming, neural networks, and fizzy set theory (Guneri, Yucel and Ayyildiz, 2009; Sanayei, Mousavi and Yazdankhah, 2010). The supplier selection using a multi-criteria approach is associated with several limitations such as conflicting factors including in price, quality and delivery (Guneri et al. 2009). Ha and Krishnan (2008) proposed a hybrid approach using the analytic hierarchy process and data envelopment analysis techniques. Wu (2009) proposed another hybrid approach that is based on decision tree and neural network based techniques. These types of approaches can be classified as quantitative approaches especially designed for handling uncertainties. Similarly, integrated approaches aim to handle a high degree of fuzziness and uncertainties in supplier selection problem. Fuzzy set theory is used to implement such approaches. Ghodsypour and O'Brien (1998) suggested an integrated approach using the analytic hierarchy process and linear programming techniques to consider both tangible and intangible input factors. Faez, Ghodsypour and O'Brien (2009) described an integrated approach based on fuzzy case-based reasoning and mathematical programming. Group-based approaches are used in similar techniques; for instance, Sanayei et al. (2010) described VIKOR technique that focuses on ranking alternatives for problems with conflicting criteria.

Most of the existing approaches are based on hierarchical structure, model or mathematical relationship based problem solving techniques. They are sophisticated for achieving quantitative results without considering decision makers subjective preferences as well as cross-functional adjustments for decision making. There is a need to employ a simplified approach in which the decision maker's involvements at different management levels are paramount in the provision of criteria inputs. For example, the inputs can be modified, added, or removed directly to help decision makers to reach a appropriate decision by varying qualitative details of the potential suppliers. Previous studies identified sourcing decisions as critical decision problems, because they require cross-functional orientation to achieve holistic outcomes in decision making effects (Moses and Ahlstrom, 2008). Cross-functional decision making engages operational level decision makers with corresponding knowledge to make the sourcing decisions (Leenders et al. 2003). The functional diversity within the cross-functional team is the key for innovation (Moses and Ahlstrom, 2008). At the same time, knowledge flows from the top management, and their association in decision making is also important for supplier selection. This understanding motivates us exploring requirements of a new approach to address the cross-functional and multi-levels decision making strategies.

3. Problem description

Because the trend to long-term and win-win relationships within supply chains is becoming more and more important, supplier selection does not limit on cost only (Çebi and Bayraktar, 2003). A strong cost focus might still be the case in more transactional-oriented relationships, but since this article focuses on single sourcing relationships, a company could use a variety of different criteria (or attributes) to select the best possible supplier (see for empirical evidence Hsu et. al, 2006). On one hand, this might contain traditionally used criteria as for example the price per unit or transportation cost. This could be extended to a total cost of ownership (TCO) approach, as analysed in depth by Bhutta and Huq (2002). On the other hand, there might also be criteria in use that were established with the rising acknowledgement of SCM, as for example the ability to react fast to changing market conditions or the establishment of risk-robust processes. For a comprehensive analysis of criteria used in supplier selection, see Wu and Weng (2010) or Kannan and Tan (2002). Often, these criteria can be categorised. For example, cost per unit, transportation cost, and inventory cost fall into the category 'cost'. Categorisation of criteria has two positive effects on the selection of suppliers. Firstly, it decreases the overall complexity of the decision making process, since it allows for evaluation of very specific criteria within the categories and for a (final) evaluation on top level. Secondly, the identification and evaluation of the relevant criteria can easily be delegated to different functional units within a company or to the experts within cross-functional teams. For example, the identification of product specific criteria (as, for example, the type of material used by the supplier) can be delegated to the R&D unit, whereas the identification of logistical aspects (e.g. lead time or supply risks) can be delegated to the SCM or logistics unit. This matches recent development in SCM, where some supply and purchasing decisions (including supplier selection) are often executed by cross-functional teams or at least cross-functional collaboration groups (for example, Lintukangas, Peltola, and Virolainen, 2009). However, research also shows that the structure of purchasing tends to move towards a hybrid arrangement, i.e. both centralised and de-centralised structure (Zheng et. al, 2007). The positive impact of decisions made by experts from different units within a company on the company's performance can be high, as Carr, Kaynak, and Muthusamy (2008) identified recently. For the selection of functional experts in cross functional decision making, refer to Muralidharan, Anantharaman, and Deshmukh (2002). The identification of criteria is not necessarily a task on senior management level, but can be delegated to operational management levels.

It is most likely that not all criteria (and categories) are of the same importance to the decision maker. Thus, the decision maker should be able to weight or rank the identified criteria and categories. The weighting could be executed on a senior management level only to incorporate company objectives and to avoid focusing on functional objectives only. However, we assume that weighting will be executed on two levels, if senior management is responsible for assessing the weights for the different categories and possible qualitative values, whereas the weighting of criteria within one category could be executed by operational management levels.

When applying the multi-attribute utility approach to supplier selection, the next step is to estimate utility functions for each criterion. One can argue on what level in an organisation the estimation of utility functions should be executed. In this article, however, we assume that the utility functions for each of the criteria will be estimated on operational management levels, since this should be the level, where detailed information on the specific criteria is existent and the impact of different values can be estimated. Additionally, not much further information is required, except e.g. the company objectives and the company's business-level and functional strategies. In this article, we assume that the utility functions are estimated by a single entity (either a person or a group, for a group decision approach refer to Sanayei et. al. (2008). When focusing on a multi-attribute utility approach, the best supplier will be the one, which has the highest overall utility for the company.

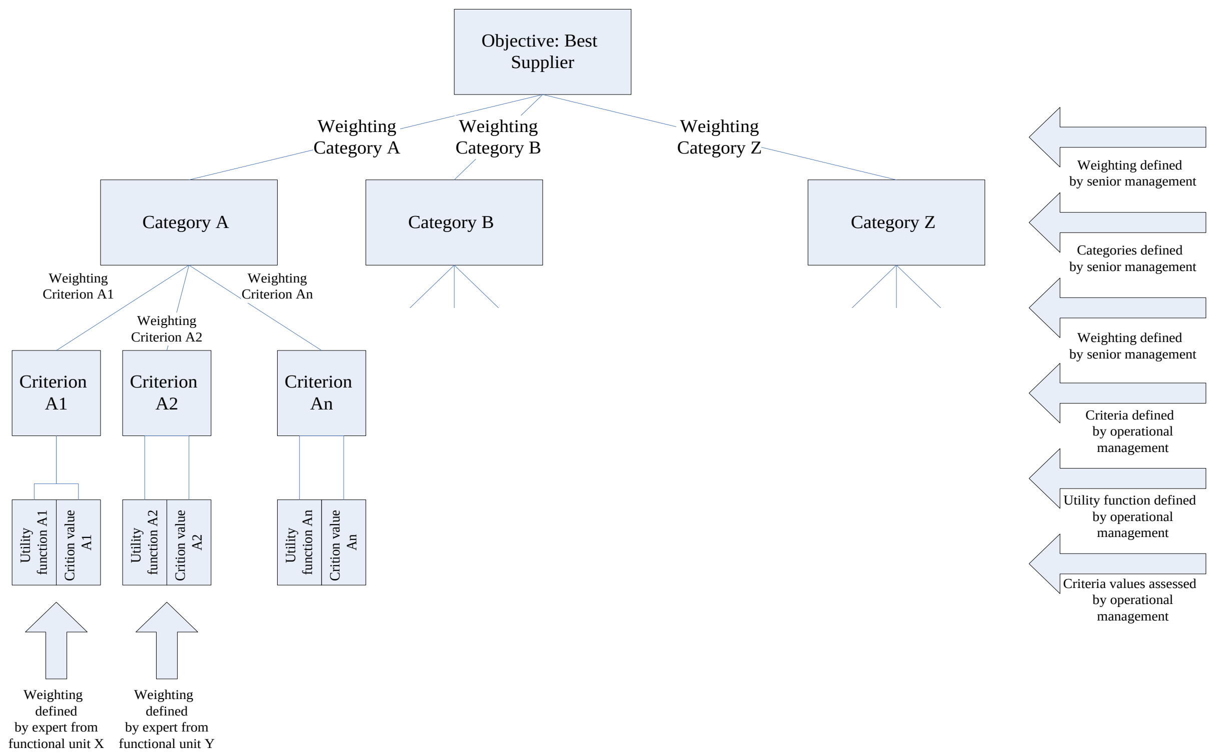

Figure 1: Decision structure for the supplier selection problem using a multi-attribute utility approach

Figure 1 summarises the elements of this multi-utility approach. It also shows, on what organisational level different elements of the approach are specified or assessed. Senior management will define decision categories and the associated weights, whereas operational level management will specify the different decision criteria, their weights as well as the utility functions. Figure 1 also shows, that managers from different functional units can be involved in decision making. Therefore, the proposed approach supports a multi-level cross-functional supplier selection

4. Architecture of the DSS

4.1 Relevance

Many previous DSS development research works have emphasized on design environment based solution mainly on the purpose of collaborative design (Park and Seo, 2006; Bravo and Redondo. 2006; Zhang, Wang, and Esmailzadeh, 2006; Fenves, Rivard, and Gomez,. 2000), multi- agent design (Liu and Tang, 2006; Soo et al, 2006; Nigro et al. 2003), building knowledge based systems (Gennari et al. 2002; Jiang, Ogasaware, and Endoh 2003). However, these types of solution focus on the purpose of technical innovation rather than the general purpose for business users to build solution applications for their own utilisation. For instance, Park and Seo (2006) described an overall framework of a collaborative design environment involving knowledge based approximate life cycle assessment system for product concept development. These types of tools allow product designers to access product data and relevant information of design alternatives including the assessment of environmental impact. Similarly, Liu and Tang (2006) introduced a multi-agent framework of design environment that supports design management extending the design space in a distributed environment. We emphasis the general purpose into development of decision support using business skills and judgments, rather than focusing on the improving technical innovation. A set of expert rules for decision making can be determined from domain experts, which would be used to generate specific decision system according to decision making requirements at lower level although the expert rules are often heuristic and based on 'rules of thumb'. Furthermore, this type of solution can be customizable to specific industry requirements, as problem structures vary to decision requirements and there are various interdependencies between decisions on senior and operational level management.

4.2 Proposed approach

The DSS architecture we used for the solution demonstration in the paper has proven its applicability in improving decision making in the industry context. (Miah et al. 2009) illustrated the DSS design with its generic applicability in a problem situation where different decision makers' associations are significant. Although the illustration has been given for improving decision making in the dairy industries, the solution design has potential for any decision making situations, in which the decision making parameters influence on factors that are contributing to main decision variable (Miah et al. 2009). However, the generic design environment-based DSS, in which a domain expert such as a business manager can provide their expertise for improving lower level management decision making. They can also provide detailed relevant instances around the decision making problems including decision making rules from their practice-based knowledge, to make the design environment ready/fit within a decision making case of a specific business operation (Miah et al. 2009), such as at operational decision making level. Consequently, the solution model could be delivered to end users such as the operational managers who are contributing to the decision making in applying their specific knowledge, e.g. their functional expertise. Now the operational managers use the model for further building of their target specific decision support application in which they can input the details of the parameters. In this design, the DSS system promotes use of domain expertise in terms of key management skills to estimate or establish the required or desired state in current business conditions, utilising practice-based knowledge and negotiation based understanding (e.g. rules of thumb) rather than use of traditional mathematical or statistics based approaches for supplier selections (Wu et. al., 2009; Sanayei, Mausavi and Yazdankhah, 2010). The solution model also can be used in a reversed way for identifying most relevant decision making parameters for any particular type of supplier selection. The developed specific decision support application then contributes to a new way of providing decision solutions as the human expert provides solutions with different classes of problems (Miah et al. 2009). Finally in specific situation for selecting suppliers, the system provides an assessment of the current situation by determining the level of matches for appropriate supplier selection in a target purpose. Figure 2 shows the model of the solution adapted from (Miah et al. 2009).

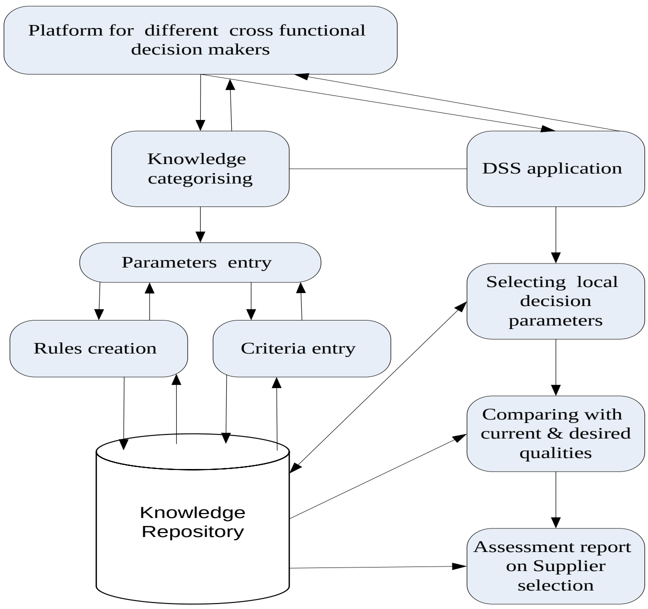

Figure 2: Proposed DSS model for supplier selection (Adapted from Miah et al. 2009)

We employed a rule-based reasoning for decision making in the proposed approach to address the dynamic involvement of knowledge sharing activities. In the process demonstrated in figure 2 the knowledge categorising activities are defined for managers on senior level, so that they can specify their preferred decision criteria set and the associated weights for storing in the knowledge repository for further use in decision making. Senior management also creates rules based on any ‘rules of thumb’ they expect to imply on decision support. The subsequent DSS application activity involved utility functions for managers on the operational level, which they use for evaluation a particular supplier according to the criteria defined by senior management.

5. Example for a DSS-based supplier selection process

The following example focuses on a 1st tier supplier in the automotive industry; the example uses a subset of data from a real-world project. A 1st tier supplier in the automotive sector produces parts, components, modules, and (sub-) systems and delivers them directly to car manufacturers. Often, a 1st tier supplier is a system supplier, which develops and produces complex systems, for example braking systems or gear drives. In our case, the 1st tier supplier produces windshield cleaning systems. One part for the windshield cleaning system which is procured from external suppliers is magnetic disk for the wiper drives. The focused 1st tier supplier intended to switch from a multiple to a single sourcing approach to intensify relationships with the to-be supplier and to realise lower per unit prices through economies of scale.

In a first phase of the selection process, senior management had to identify a list of relevant categories of criteria (as shown in figure 3) and to assign associated weightings. For each category, experts on an operational management level could then be asked to identify single criteria. Within the context of the proposed DSS, senior management is in the role of the domain experts. That is, he or she specifies the different categories and their corresponding weights of importance. The domain expert might also specify the criteria within each of the categories. This data is entered into the DSS on the domain expert level. It specifies the framework for the managers on functional or divisional level, who have certain knowledge in their area, e.g. cost structure or quality aspects. We assume that the operational level managers are responsible for assessing both the weightings and the utility function for each of the specific criteria within a category. The lower level managers cannot change the framework, and neither can they view other specific areas, i.e. decision areas of other functional units. The DSS thus supports a de-centralised decision making, so that each involved party can make decisions only in their specific and defined area.

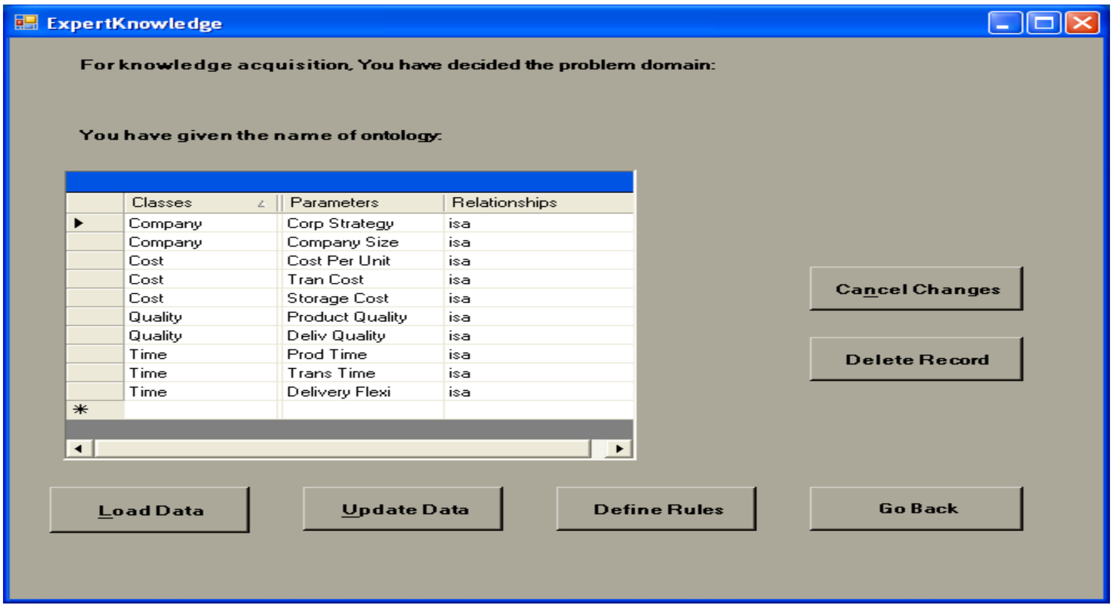

Figure 3: Domain Experts (Senior management) adding the categories for decision making

When all categories, criteria, utility functions and criteria values are entered into the DSS (see figure 4), the system then calculates the overall utility for all assessed suppliers, and suggests the supplier with the highest overall utility as to be selected. This could, of course, also easily be done using available spreadsheet software. However, as mentioned above, what the DSS differentiate from spreadsheet applications is that it allows for a consistent decision making on different managerial level, where the users actually are able to define and specify the relevant elements of the decision problem.

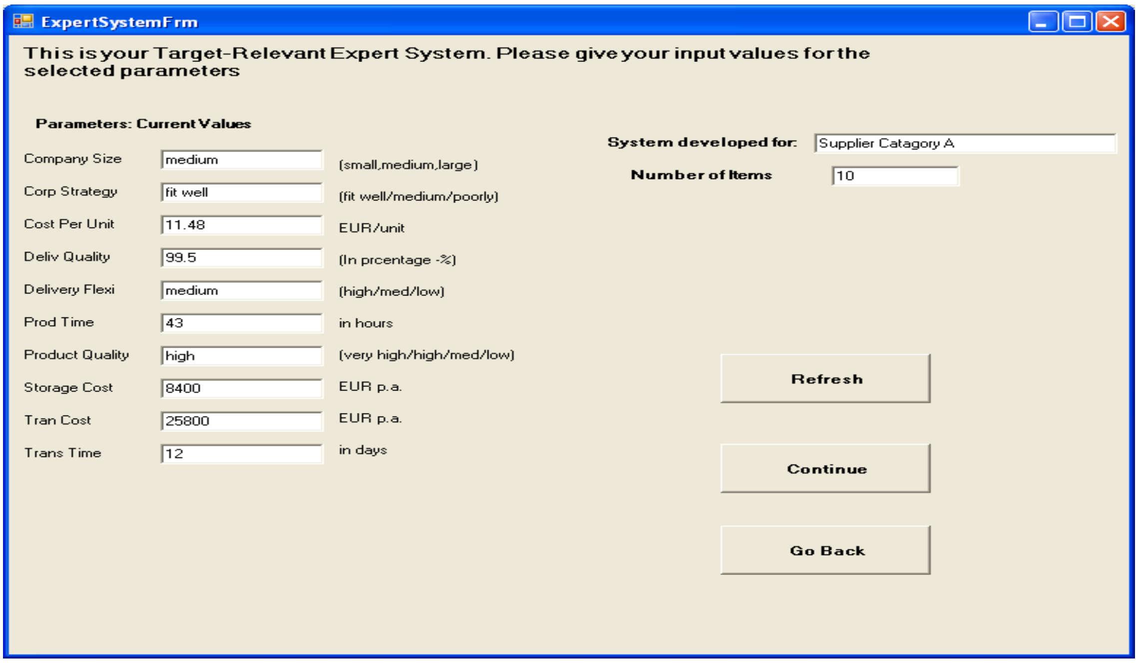

Figure 4: Operational level decision makers giving values on the selected relevant parameters

However, the proposed DSS goes beyond typical spreadsheet applications, not only because it addresses different managerial levels, but also because it allows for a reversed use of the decision model. Often, supplier selection is executed as an iterative process: There might be different stages of selecting suppliers, i.e. a pre-selection and a final selection (see Park et. al, 2010). Within or between each stage, there might also be some kind of negotiation regarding one or more criteria involved. A decision maker then might want to know the criteria for a specific supplier, where the supplier underperforms and where an improvement will have the most impact so that this information can be used in the negotiation. He/she might also want to know, to what extend the supplier should improve its performance in a critical criterion to reach a level which enables it to become a selected supplier. This comparison can focus on both an 'ideal' supplier and the currently best supplier. The proposed DSS can support a decision maker in answering those questions (as the DSS provides a detailed assessment report). The calculation is executed in the 'comparing with current & desired' module, shown in figure 5. The results are then shown to the decision maker using the 'assessment report generation' module (figure 6).

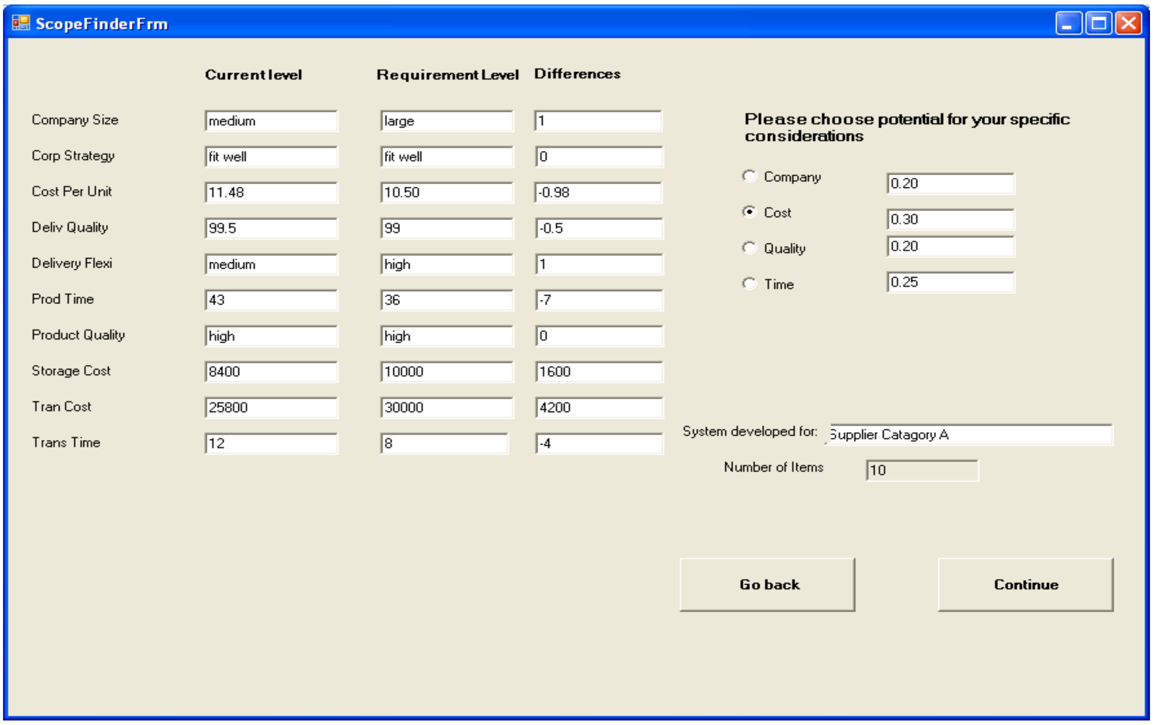

Figure 5: Comparing with current & desired state in the operational management level

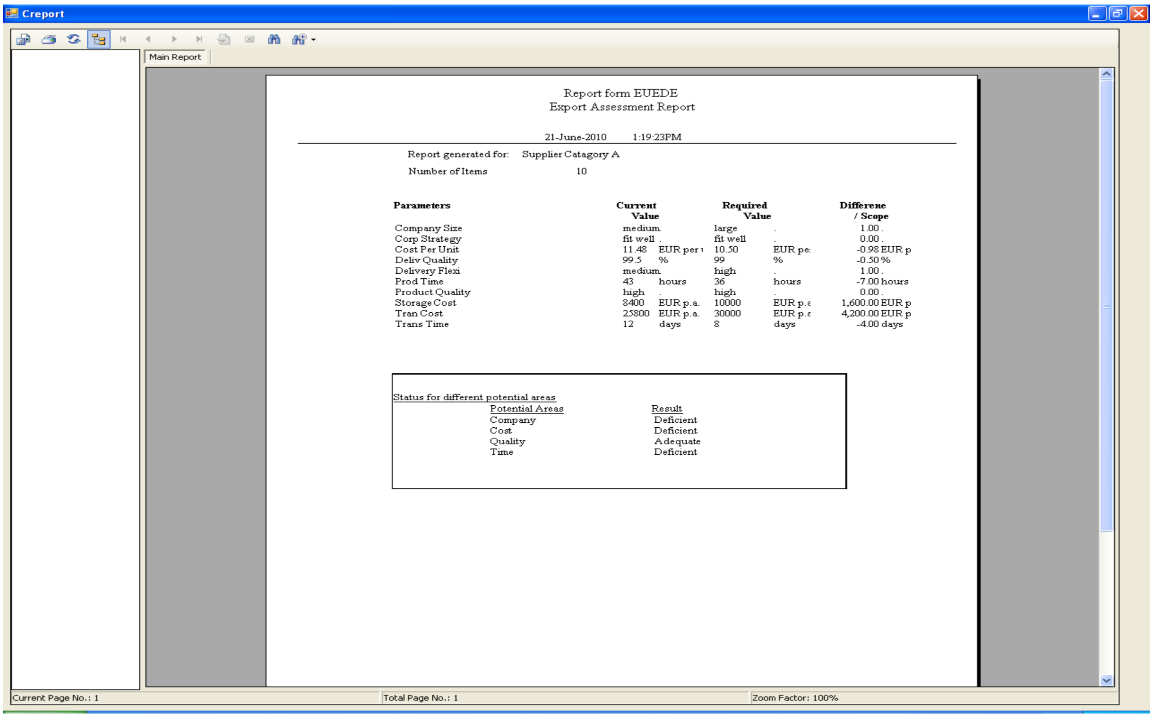

Figure 6: Assessment report generated from the system

6. Summary

Moses and Åhlström (2008) identified various problems that can occur in cross-functional sourcing decisions, and clustered the identified problems into three groups: Functional interdependency, strategy complications, and misaligned functional goals. As aimed in this study, some of those problems can be overcome by the proposed DSS. First, the 'lack of system-support' will obviously not be existent anymore when using the DSS. As described above, the DSS allows for a de-central estimation of utility function and the evaluation of specific criteria; thus, it helps to avoid 'inconsistent basic data for decision-making'. Because only senior managers will have access to the weightings of the main criteria categories, the 'functional imbalance' will also be reduced. Thus, the proposed approach suggests reducing problems in the decision making process and allows for a more consistent and sound supplier selection.

The current status of the model and the DSS is not without limitations. First, the DSS currently supports only a simple multi-attribute utility approach shown in this paper, but does not support other approaches, proposed in the literature. Often, the use of an analytical hierarchy process is suggested (see, for example Bhutta and Huq, 2002). Thus an area of further research will be, how the AHP approach could implemented taking into account the de-centralised decision making process. Second, so far system cannot calculate the TCO for given parameters, so that the TCO have to be calculated separately. This also means, that the TCO cannot be used for a reverse use of the DSS, which would give the decision maker important information for the negotiation phase. Thus, further research and development should also concentrate on offering an option for setting up a cost function for the calculation of the TCO. Also, because of the prototype status of the DSS, support for assessing the weights and the utility functions is not implemented yet; thus, managers have to make those decisions outside of the system. A further step in the development will be additional support for assessing weights and utility functions.

Besides adding further and enhanced features to the DSS as described above, future plans for the use of the proposed DSS head into two directions. On one hand, we intend to include decision support for the assessment of utility functions, since this task is both critical and often overstrengths lower level management. On the other hand, we intend to test this system with more decision making aspects from different industries to further test it for effectiveness.

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