A multi-criteria approach to select suppliers based on performance

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Abstract. Selecting suppliers is a multi-criteria decision-making problem involving both qualitative and quantitative factors. The aim of this paper is to propose a multi-criteria approach that aids to select suppliers based on two interrelated inputs: overall system performance and supplier performance. With this model, enterprises that are collaborating will have a tool to select suppliers not only based on supplier performance but also aligned with their own strategy increasing the quality of the supplier selection process and, therefore, improving the sustainability of the partnership and their competitiveness.

Keywords: performance measurement, collaboration, supplier selection.

1 Introduction

One of the strategies most used to increase/maintain enterprise competitiveness is to establish collaboration relationships with suppliers. Congruent with the need to integrate multiple linked processes in the supply chain, theoretical research advocate that early and extensive supplier involvement results in many benefits, e.g. faster development process, reduced costs, etc. [1]. In this context, selecting suppliers becomes a crucial process for manufacturers.

Various studies about customer-supplier relationships point out the importance of considering the performance measurement of the entire supply chain in order to provide products and services that meet the expectations of end customers and promote improvement and innovation of the whole processes. In [2], Mentzer defines supply chain collaboration (SCC) as *'a means by which all companies in the supply chain are actively working together towards common objectives, and is characterized by sharing information, knowledge, risk and profits'*. For that reason, it is important to define common performance indicators for all the enterprises that are collaborating as they will aid to focus their efforts towards strategic aspects of their business and, therefore, they will support their competitiveness. In fact, it is acknowledged that the way enterprises measure performance shows the organizational culture and the formulation and deployment of their strategy [3]. Thus, it is important for those enterprises to define and use a structured performance measurement framework that

allows managing performance under various perspectives or dimensions that provide a relevant overview of their performance status. One of the most important performance frameworks developed in the academic literature and business applications is the Balanced ScoreCard (BSC) by Kaplan and Norton [4]. In fact, possibly due to this acceptance, the BSC developed initially for managing performance of enterprises has been extended by different authors for interorganizational performance management such as the works by Brewer and Speh [5], Bititci et al. [6], Folan and Browne [7] and Alfaro et al. [8].

In addition, the muti-criteria nature of the process of supplier selection has been widely studied in the literature focusing attention on two main issues: the identification of criteria for the assessment and the application of multi-criteria techniques to pass from the initial criteria to an overall ranking of suppliers [9]. Besides, supplier selection involves considering both qualitative and quantitative criteria [10]. Therefore, selecting suppliers can be defined as a multi-criteria decision-making (MCDM) problem involving both qualitative and quantitative factors.

In this context, it seems reasonable that enterprises that desire to select suppliers need to make their decision based on two main inputs: performance of the enterprises that are collaborating and supplier performance. On the one hand, the enterprises that are collaborating pursue the improvement of the overall system. For that purpose, they should define performance elements (such as performance objectives, performance indicators, etc.) for the whole interorganizational context and select the new supplier that better match those performance elements. In addition, these performance elements are better managed under a structured framework such as the BSC. On the other hand, enterprises need to identify relevant criteria for supplier assessment based on supplier performance as not all the suppliers excel at the same characteristics.

The purpose of this paper is to propose a multi-criteria decision-making approach that aids to select suppliers according to both inputs: overall system performance and supplier performance. With this model, enterprises will have a tool to select suppliers not only based on supplier performance but also aligned with their own strategy increasing the quality of the supplier selection process, its long-term partnership and improving the competitiveness of the whole enterprise association.

The structure of this paper is as follows. First, a literature review of multi-criteria decision analysis methods applied for supplier selection is presented focusing attention on the Analytic Hierarchy Process (AHP) method. Then, the multi-criteria approach to select suppliers is described. Finally, conclusions are exposed.

2 Literature Review

Several methods have been proposed for solving the supplier selection problem such as vendor profile analysis (VPA), multi-objective programming (MOP), data envelopment analysis (DEA) and analytic hierarchy process (AHP) [10]. Evaluation and ranking of potential suppliers involves both tangible and intangible criteria. This is because overall assessment of suppliers should not only consider quantitative performance data but also some other criteria that are critical for successful

partnerships and are not directly quantifiable, e.g. trust and commitment [11]. Therefore, the AHP method developed by Saaty [12] is a useful method to select suppliers as it deals with both types of criteria. In addition, AHP aims at integrating different measures into a single overall score for ranking decision alternatives [13].

The AHP method has been previously used for supplier selection under a wide variety of applications [14]. In [15], it is presented an integrated AHP and linear programming method for choosing the best suppliers and placing the optimum order quantities among them. In [9], it is proposed four different vendor selection systems (VSSs) depending on the time frame (short-term versus long-term) and the content (logistic versus strategic) of the co-operative customer/supplier relationships using an AHP framework. In [16], it is proposed an AHP model for casting supplier assessment based on four groups of criteria: product development capability, manufacturing capability, quality capability, and cost and delivery. In [17], it is applied AHP in the field of project management to select the best contractor to perform the project based on six criteria: experience, financial stability, quality performance, manpower resources, equipment resources, and current workload. In [18], a multi-criteria group decision making model for supplier ranking based on AHP is developed by combining group member's preferences into one consensus ranking. The criteria used to rate suppliers are quality, delivery, price, technical capability, financial position, past performance attitude, facilities, flexibility and service. In [19], an AHP model to structure SCOR (Supply Chain Operations Reference) model metrics to evaluate overall supplier efficiency is proposed. In [20], it is developed a selection model for supplier selection process using AHP. In [21], a multi-criteria supplier selection procedure using AHP is presented. The first level criteria used to compare suppliers involve: supplier, product and service criteria. In [22], it is developed an AHP approach for virtual enterprise partner selection using the SCOR model and the AHP method. In [10], it is presented an AHP approach to select global suppliers according to five criteria: cost, quality, service performance, supplier profile and risk factor.

Regarding the combination of AHP and BSC, in [23], it is developed a model to implement a BSC framework. In [24], it is proposed a model to align the BSC and a firm's strategy using the AHP. In [25], a model for long-term vendor selection based on vendor performance is presented. In [26], a model for selecting performance indicators for supply chain management is presented. In [27], an approach for evaluating performance of IT department in the manufacturing industry in Taiwan is exposed. In [28], it is proposed a decision support system for selecting ERP systems in textile industry by using the BSC.

However, there is not a specific model developed for selecting suppliers that integrates performance information of suppliers as well as the overall system performance. For this reason, the purpose of the remaining of this paper is to present a multi-criteria BSC-AHP model for supplier selection that fills this research gap. With this approach, enterprises that are collaborating and have defined a BSC framework (or desire to do it) will have a tool to select suppliers based not only on specific performance data of suppliers but also aligned to their common strategy and, therefore, have a tool to improve their competitiveness. In addition, supplier performance and overall performance are interrelated as there is probably a supplier that can contribute more than the other suppliers to enhance overall efficiency. With

this approach, both inputs are connected to provide an overall rating of suppliers for decision-makers.

3 The proposed Multi-criteria Approach for Supplier Selection

3.1 Description of the Model

The AHP method structures the decision problem in a hierarchy of levels. These levels are linked by unidirectional dependence relationships. In the upper level of the hierarchy, it is defined the ultimate goal of the decision problem. Then, the criteria that contribute to achieve the goal stand in the second level. In the next levels, intermediate subcriteria and attributes that compose the hierarchical structure are located. Finally, in the last level, the decision alternatives are established. Using levels allows decision makers to focus on a small set of decisions [12]. By making pairwise comparisons and using the fundamental scale of Saaty [12], the AHP method provide relative weights to each element within a level depending on its contribution to an element linked to it that is located on the immediate upper level.

In order to apply AHP, we have defined four phases. In the first phase, the criteria and attributes to improve overall efficiency are defined and the AHP model is composed. Once the AHP model is obtained, the second phase consists of making pairwise comparisons within each level and obtaining the relative priorities. The third phase aims at calculating the overall priorities of the decision alternatives. Finally, the fourth phase deals with sensitivity analysis of the solution provided. It has to be noted that this paper deals with the description of the phase 1.

The multi-criteria model developed for selecting suppliers is founded on two main interrelated inputs: overall performance and supplier performance. Figure 1 shows the hierarchical structure of the BSC-AHP model. The main goal is to select a supplier to improve overall interorganisational efficiency so that this goal stands on the top of the hierarchical structure. In order to manage this goal, different performance indicators are defined. The performance indicators that are to be monitored by the partners are the main criteria of the model as the achievement of the objectives related to these performance indicators will benefit the overall performance. Thus, at this phase, it is suggested to define performance objectives and indicators according to the four performance perspectives of the BSC [4]: financial perspective, customer perspective, internal business process perspective and innovation & learning perspective. In order to support these performance indicators, supplier performance information has to be evaluated under different supplier dimensions. Therefore, there is a direct link between the performance of the supplier and the performance of the overall system. That is the reason why supplier dimensions stand on a layer below overall performance indicators as the performance of the supplier has to contribute to the consecution of the performance of the overall system. In order to define the supplier performance data, the model uses the conceptual framework by Croom [29] for supplier involvement which considers both operational and relational competencies and comprises three dimensions: product, structure and interaction dimensions.

Finally, the last level is composed of the potential suppliers (1, 2, … n). Suppliers will be pairwise evaluated to know which one best performs on the performance dimensions previously defined. Thus, the BSC-AHP model is composed by these four main components: overall goal, performance perspectives, supplier attributes and potential suppliers.

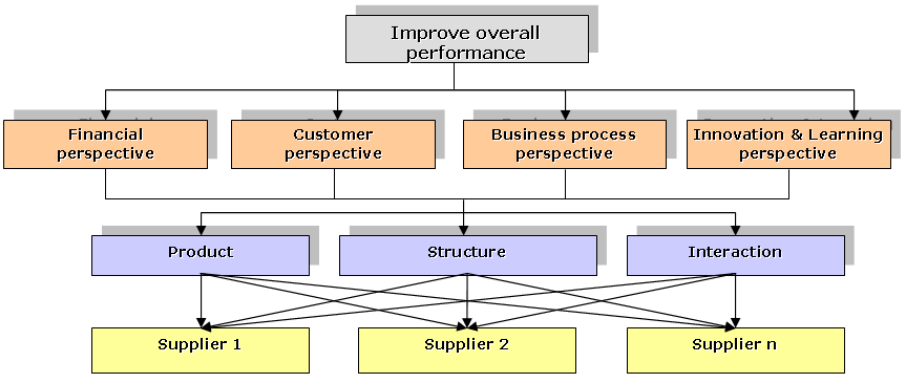

Fig. 1. BSC-AHP model: main components

Figure 2 shows an example of a detailed BSC-AHP model for partner selection. As can be observed, the second level (performance perspectives) is further deployed to show their performance indicators within each performance perspective. Similarly, the supplier attributes within each dimension are also shown. Based on Croom's work, the attributes comprising the dimensions (product, structure and interaction) are described as follows.

The *product* criterion comprises the main attributes that are to be addressed when assessing the product dimension of the supplier. Some relevant attributes of the product dimension include [10, 16, 21]: quality, price, development time, flexibility, and research and development (R&D) initiatives. Quality is one of the most important product attributes. It relates to the historical rejection rate during a period of time of the products delivered by the supplier. Rejection is due to deviations from specifications in the design, manufacturing, or packaging of the product. It also considers deviations from the specified quantities or delivery dates in the customer order. The second attribute is the price of the product as it affects to the bottom-line. Development time refers to the competence of the supplier to design, develop and launch products within the agreed period of time according to the product specifications. Flexibility involves the response time of the supplier when product changes are needed. It also considers the response time to new orders or order modifications during the development and manufacturing stages. Finally, R&D initiatives measure the ability of the supplier to provide support during product development and manufacturing. It is an important attribute as most products, after launching, demand continuous improvement to remain competitive.

The second criterion is *structure*. Structure comprises the capabilities/procedures for developing products and processing materials/components as well as the systems to facilitate control, co-ordination and communication through organizational and

interorganizational systems [29]. The first attribute within the structure criterion is dedicated cross-functional team which assesses the human compromised capabilities of the supplier into the relationship. The second attribute is project management methodology which measures the degree of knowledge and implementation of project management practices in the supplier organization as well as the compatibility with the project management practices of the rest of enterprises. The third attribute is quality methodologies. The fourth attribute is Information Technology and Information Systems (IT & IS). It assesses the extent of technology implementation and interoperability of supplier information systems in order to send/receive and use the information exchanged with the rest of enterprises. The role of the technology is an important attribute as effective collaboration it is highly influenced by seamless communication between supplier and manufacturer. The fifth attribute is process alignment. It evaluates the extent of business process interoperability defined as the *"ability of different processes to work together and exchange information, data, control information, etc."* [30]. The sixth attribute is complementary capabilities. It measures the degree of interdependence on assets as well as the capacity on development/manufacturing so that the collaborative relationship can develop and manufacture higher variety/amount of products to increase the market share. Finally, the financial profile attribute assesses the past and current financial condition of the supplier in order to support/invest in the long-term [10].

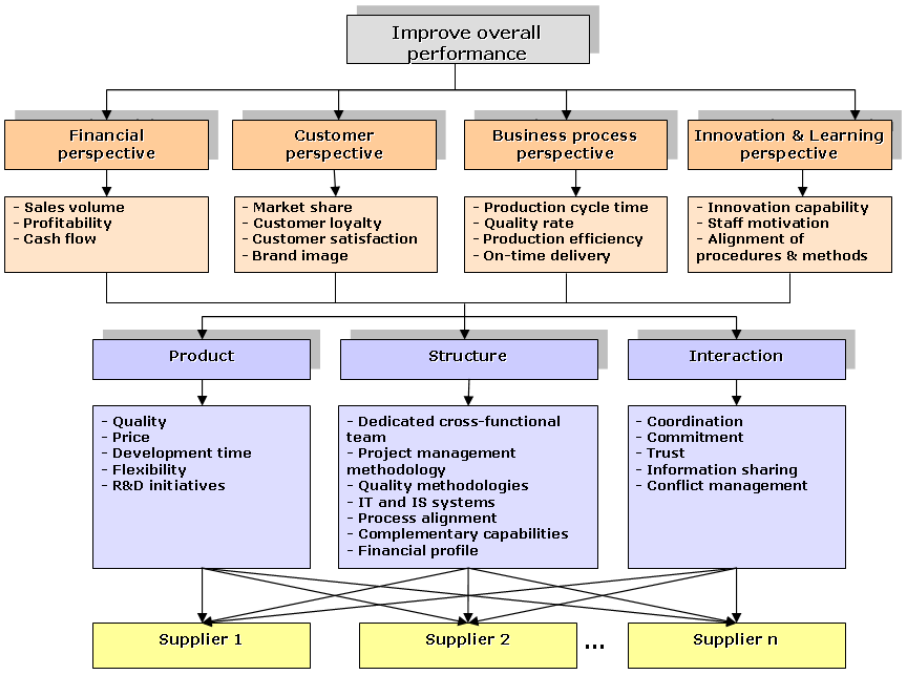

Fig. 2. BSC-AHP detailed model.

The third criterion is the *interaction* criterion which deals with the relational side of collaboration. Based on [11], the relational attributes considered in the AHP model

are: coordination, commitment, trust, information sharing, and conflict management. Coordination involves the tasks that are to be taken for linking activities performed by the different members in a seamless manner. Commitment refers to the willingness of the supplier to perform effort on behalf of the relationship. It is the establishment of the foundation of the relationship and it is based on being supportive in solving problems together. A high level of commitment provides the context for the achievement of individual and mutual goals. Trust is based on the belief that the partner is reliable and will fulfil its responsibilities acting fairly. A partner trusts another partner if considers that decisions made by this last one will be in the interest of both parts. Information sharing considers the timeliness, accuracy, adequacy and completeness of the relevant information exchanged. Finally, conflict management measures the degree of intensity and conflict resolution mechanisms that exist between manufacturer and supplier.

4 Conclusions

This paper introduces a multi-criteria approach to select suppliers for collaborative relationships based on two types of performance information: supplier performance information and overall performance of the collaborating enterprises. Performance data of the suppliers is the common performance information considered in the literature for supplier selection problems. In addition, we have introduced the BSC of the whole collaborative enterprises as it is important that the supplier selected should contribute the most to the overall efficiency improvement. Therefore, in our approach, supplier performance information is linked to the common performance indicators defined by all the enterprises that are collaborating. With this approach, enterprises will have a tool to select suppliers aligned with their own strategy increasing the quality of the supplier selection process, its long-term partnership and improving the competitiveness of the whole enterprise association.

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References

1. Petersen, K.J., Handfield, R.B., Ragatz, G.L. Supplier integration into new product development: coordinating product, process and supply chain design. Journal of Operations Management, 23, 371–388 (2005)
2. Mentzer, J. Managing Supply Chain Collaboration. Supply Chain Management. Sage Publications, Inc., Thousand Oaks, California (2001)
3. Pun, KF., White, AS. A performance measurement paradigm for integrating strategy formulation: a review of systems and framewors. International Journal of Management Reviews. 7, 1, 49-71 (2005)
4. Kaplan, R.S., Norton, D.P. The balanced scorecard – measures that drive performance. Harvard Business Review, 70, 1, 71-79 (1992)

5. Brewer, P.C., Speh, T.W. Using the Balanced ScoreCard to measure supply chain performance. Journal of Business Logistics, 21, 1, 75-93 (2000)
6. Bititci, U.S., Mendibil, K., Martinez, V., Albores, P. Measuring and managing performance in extended enterprises. International Journal of Operations & Production Management. 25, 4, 333-353 (2005)
7. Folan, P.; Browne, J. Development of an Extended Enterprise Performance Measurement System. Production Planning and Control, 16, 6, 531-544 (2005)
8. Alfaro, JJ., Ortiz, A., Rodríguez, R. Performance measurement system for Enterprise Networks. International Journal of Productivity and Performance Management, 56, 4, 305-334 (2007)
9. Masella, C, & Rangone, A. A contigent approach to the design of vendor selection systems for different types of co-operative customer/ supplier relationships. International Journal of Operations & Production Management, 20, 1, pp.70-84 (2000).
10. Chan FTS, Kumar N. Global supplier development considering risk factors using fuzzy extended AHP-based approach. Omega, 35; 417–431 (2007).
11. Mohr, J. Spekman, R. Characteristics of partnership success: Partnership attributes, communication. Strategic Management Journal, 15, 2: 135-152 (1994).
12. Saaty, T.L. The Analytic Hierarchy Process. McGraw-Hill, New York (1980)
13. Rangone, A. An analytical hierarchy process framework for comparing the overall performance of manufacturing departments. International Journal of Operations & Production Management, 16, 8; 104-119 (1996).
14. Perçin S. An application of the integrated AHP-PGP model in supplier selection. Measuring Business Excellence, 10, 4; 34-49 (2006).
15. Ghodsypour SH, O'Brien, C. A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. International Journal of Production Economics, 56-57; 199-212 (1998).
16. Akarte MM, Surendra NV, Ravi B, Rangaraj N. Web based casting supplier evaluation using analytical hierarchy process. Journal of the Operational Research Society, 52; 511-522 (2001).
17. Al-Harbi KM. Application of AHP in project management. International Journal of Project Management, 19, 4; 19–27 (2001).
18. Muralidharan C, Anantharaman, S,. Deshmukh SG. A Multi-Criteria Group Decision making Model for Supplier Rating. The Journal of Supply Chain Management: A Global Review of Purchasing and Supply, November; 22-33 (2002).
19. Huan SH, Sheoran SK, Wang G. A review and analysis of supply chain operations reference (SCOR) model. Supply Chain Management: An International Journal, 9, 9; 23-29 (2004).
20. Chan, FTS. Interactive selection model for supplier selection process: an analytical hierarchy process approach. International Journal of Production Research, 41, 15: 3549–3579 (2003).
21. Kahraman C, Cebeci U, Ulukan Z.. Multi-criteria supplier selection using fuzzy AHP. Logistics Information Management, 16, 6; 382-394 (2003).
22. Bittencourt F, Rabelo RJ. A systematic approach for VE partners selection using the SCOR model and the AHP method. In Collaborative Networks and their Breeding Environments, Luis Camarihna-Matos, Hamideh Afsarmanesh, Angel Ortiz, eds. Boston: Springer (2005).
23. Clinton BD, Webber SA, Hassell JM. Implementing the balanced scorecard using the analytical hierarchy process. Management Accounting Quarterly, 3, 3; 1-11 (2002).
24. Searcy DL. Aligning the balanced scorecard and a firm's strategy using the analytic hierarchy process. Management Accounting Quarterly, 5; 1-10 (2004).
25. Chiang Z. Decision Approach for Long-Term Vendor Selection Based on AHP and BSC. In Advances in Intelligent Computing, De-Shuang Huang, Xiao-Ping Zhang, Guang-Bin Huang eds. Berlin/Heidelberg: Springer (2005).
26. Bhagwat R, Sharma, MK.Performance measurement of supply chain management using the analytical hierarchy process. Production Planning & Control, 18, 8; 666–680 (2007).
27. Lee AHI, Chen WC, Chang CJ. A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan. Expert Systems with Applications, 34, 1: 96-107 (2008).
28. Cebeci U. Fuzzy AHP-based decision support system for selecting ERP systems in textile industry by using balanced scorecard, Expert Systems with Applications, 36; 8900–8909 (2009).
29. Croom, S.R. The dyadic capabilities concept: examining the processes of key supplier involvement in collaborative product development. European Journal of Purchasing & Supply Management, 7; 29-37 (2001).
30. Interop. Interoperability ontology. Interop-vlab platform. http://interop-vlab.eu/