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A fuzzy logic approach to supplier evaluation for development

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ABSTRACT

Decision making techniques used to help evaluate current suppliers should aim at classifying performance of individual suppliers against desired levels of performance so as to devise suitable action plans to increase suppliers' performance and capabilities. Moreover, decision making related to what course of action to take for a particular supplier depends on the evaluation of short and long term factors of performance, as well as on the type of item to be supplied. However, most of the propositions found in the literature do not consider the type of supplied item and are more suitable for ordering suppliers rather than categorizing them. To deal with this limitation, this paper presents a new approach based on fuzzy inference combined with the simple fuzzy grid method to help decision making in the supplier evaluation for development. This approach follows a procedure for pattern classification based on decision rules to categorize supplier performance according to the item category so as to indicate strengths and weaknesses of current suppliers, helping decision makers review supplier development action plans. Applying the method to a company in the automotive sector shows that it brings objectivity and consistency to supplier evaluation, supporting consensus building through the decision making process. Critical items can be identified which aim at proposing directives for managing and developing suppliers for leverage, bottleneck and strategic items. It also helps to identify suppliers in need of attention or suppliers that should be replaced.

1. Introduction

Nowadays, manufacturing companies rely heavily on suppliers for providing materials and components used in finished products. Some authors say that approximately 50–70% of production costs are spent on purchased materials and components (Prajogo et al., 2012). Purchasing decisions affect important activities such as inventory management and production planning and control (Katsikeas et al., 2004; Govindan et al., 2010) and have a significant influence on the cost, quality and delivery of products of the buying company (Talluri and Sarkis, 2002). Thus, managing the performance of suppliers and supporting their continuous improvement has become very critical for managing organizations and supply chains (Schoenherr et al., 2012).

Managing buyer–supplier relationships includes activities such as supplier selection and development (Park et al., 2010; Chen, 2011; Inemek and Matthyssens, 2011). Supplier evaluation helps to make decisions about supplier selection and development (Schmitz and Platts, 2004). Supplier development is commonly defined as any effort or set of practices of a buying company with its supplier aiming at increasing the performance and capabilities of the supplier so as to better meet the buying firm's supply needs (Govindan et al., 2010; Bai and Sarkis, 2011). There are many supplier development practices that may be used (Krause, 1997; Govindan et al., 2010; Bai and Sarkis, 2011; Blome et al., 2013; Dekkers et al., 2013; He et al., 2014). Choosing what type of supplier development practice or what course of action to deploy to a particular supplier first of all depends on the supplier's evaluation.

There are variety of models proposed in the literature aimed at evaluating and segmenting the base of suppliers based on the evaluation of the suppliers related to several factors such as quality, delivery, financial health and technical capabilities, among others (Olsen and Ellram, 1997; Araz and Ozkarahan, 2007; Sarkar and Mohapatra, 2006; Omurca, 2013; Rezaei and Ortt, 2013a, 2013b). Most of them are two dimensional models and the supplier base segmentation process is based on dimensions related to supplier performance, such as attractiveness of the supplier and intensity of the relationship (Olsen and Ellram, 1997), short-term performance and long-term capability (Sarkar and Mohapatra, 2006) and willingness and capabilities (Rezaei and Ortt, 2013a, 2013b). However, decision making related to what type of supplier development practice or what course of action to take regarding a particular supplier depends not only on the categorization of the supply based on its evaluation of performance. The type of item to be supplied and what implications it may have on supply management should also be considered. A much cited item classification model was proposed by Kraljic (1983), which classifies items into four categories: strategic; bottleneck; leverage and noncritical. Kraljic

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(1983) proposes that each of these categories demands a distinctive purchasing strategy. According to a study carried out by Nellore and Söderquist (2000) in the automotive industry, leverage, bottleneck and strategic items all require increasing degrees of collaboration in the specification process. Consequently, the higher the evaluation of the potential for partnership of a particular supplier, the higher the chance of developing a strategic partner will be.

Another important issue to be considered refers to the techniques used in the decision making process. Different decision making techniques are proposed in the literature to deal with the process of supplier evaluation, especially in supplier selection (De Boer et al., 2001; Wu and Barnes, 2011; Ho et al., 2010; Chai et al., 2013). Evaluation for the purpose of supplier development differs from the case of supplier selection, in the sense that the latter seeks to define an order of preference among potential suppliers while the former aims to categorize suppliers (De Boer et al., 2001; Keskin et al., 2010; Omurca, 2013). However, the techniques proposed by most of the studies on supplier evaluation found in the literature are more adequate for ordering suppliers (Chen et al., 2006; Sarkar and Mohapatra, 2006; Araz and Ozkarahan, 2007; Çelebi and Bayraktar, 2008; Wang, 2008; Lee et al., 2009; Lin, 2009; Park et al., 2010; Chen, 2011; Zeydan et al., 2011; Baskarahan et al., 2012; Pitchipoo et al., 2013; Rezaei and Ortt, 2013a). Another limitation regards the use of techniques based on comparison between suppliers (Olsen and Ellram, 1997; Sarkar and Mohapatra, 2006; Araz and Ozkarahan, 2007; Tuzkaya et al., 2009; Lee et al., 2009; Park et al., 2010; Shirinfar and Haleh, 2011; Zeydan et al., 2011; Rezaei and Ortt, 2013a). Since the main aim of evaluation for supplier development is to classify individual suppliers based on gaps between real and desired performance, techniques that yield relative performance evaluations are not the most adequate ones. On the other hand, fuzzy rule-based classification methods (Ishibuchi et al., 1992; Nozaki et al., 1996; Castellano and Fanelli, 1999; Nguyen et al., 2012; Lima et al., 2013) are especially useful for categorizing alternatives, as is the case of segmenting products or suppliers in purchasing models. However, none of the proposals found in the literature dealing with supplier evaluation and segmentation adopts a procedure for fuzzy pattern classification based on decision rules.

Therefore, this paper proposes a new approach for evaluation of suppliers for development purposes. Categorization of suppliers for development is dependent on the evaluation of the suppliers, as well as on the categorization of the supplied items. Items are categorized according to the dimension complexity of item and complexity of supply market. Evaluation of suppliers is made on the basis of short-term delivery performance and long-term potential for partnership. Fuzzy inference system combined with the simple fuzzy grid method (Ishibuchi et al., 1992) is also proposed in a procedure for pattern classification so as to categorize items and suppliers. In doing so, it is possible to categorize supplier performance according to the item category so as to indicate strengths and weaknesses of current suppliers and to aid decision making concerning action planning for supplier development. Representation of classes of supplier performance and items by fuzzy numbers allows for subjectivity of the decision makers. Also, the base of decision rules of a fuzzy inference system is designed grounded on *if–then* scenarios devised by specialists, therefore modeling human reasoning.

A descriptive quantitative approach was adopted as a research method (Bertrand and Fransoo, 2002). The fuzzy inference systems were implemented in FuzzyTech® and MATLAB® and applied to a case in the automobile industry. A 3^k factorial design was used to test the consistency and sensitivity of the inference systems. This paper is organized as follows: Section 2 briefly revises the subject of supplier management, presenting the contributions from the literature on supplier evaluation. Section 3 presents some fundamental concepts regarding the fuzzy set theory used in the proposition. The proposed fuzzy inference systems combined with the fuzzy grid method are described in detail in Section 4. Section 5 presents the application case and the sensitivity analysis. Final remarks and conclusion about this research are made in Section 6.

2. Supplier evaluation and development

Supplier evaluation is a fundamental activity to manage buyer–supplier relationship. There are at least two distinct phases in the supply management process in which supplier evaluation happens. First, evaluation is made during the selection process. In this case, the final goal of the evaluation process is to define an order of preference among the potential suppliers so as to select those preferred ones. After selecting, in the supplier development phase, supplier evaluation is made on a regular basis with the aim of managing and improving the buyer–supplier relationship. In the development phase, the main aim is to assess individual suppliers in order to plan and implement initiatives aiming at improving the performance and capabilities of the supplier so as to better fulfill the supply needs. Unlike the selection phase, the main point of evaluation in the development phase is to assess the performance of individual suppliers compared to desired levels of performance.

Supplier development initiatives may include continuous improvement programs for certification of management systems, knowledge and resource transfer for improving co-design and production capabilities (Krause, 1997; Blome et al., 2014; Dekkers et al., 2013; He et al., 2014). Supplier development is especially important for critical items such as leverage, bottleneck and strategic items (Kraljic, 1983; Nellore and Söderquist, 2000; De Boer et al., 2001). Leverage items, despite the possibility of several suppliers, have a high impact on the quality and cost of final products. On the contrary, bottleneck items, despite their relatively low profit impact, present supply risks because of scarcity or a monopolistic market. Strategic items are critical as they have a high impact on quality and cost and at the same time there are few suppliers which can attend the specification requirements (Nellore and Söderquist, 2000; De Boer et al., 2001). Thus, supplier development is important to establish long-term collaborative relationship so as to minimize supply risks and enable supply chain management strategies to be used such as early supplier involvement (He et al., 2014), vendor management inventory and collaborative planning, forecasting and replenishment (Yao et al., 2013).

There are variety of quantitative and qualitative criteria used to evaluate supplier performance. Table 1 presents a review of the criteria for supplier evaluation found in the literature. Criteria such as price, quality, delivery, financial and technological capabilities are the most commonly used.

Several studies presented in the literature group these criteria into one or two dimensions of supplier evaluation and classification. Olsen and Ellram (1997) propose a segmentation model to evaluate suppliers regarding two dimensions: supplier attractiveness and strength of the relationship. They suggest that supplier attractiveness is dependent on technological, organizational, financial and economic factors, production performance, culture and strategy. As for the strength of the relationship, they suggest economic factors, characteristics of the exchange relationship, cooperation and proximity. Based on these dimensions, the supplier is then categorized into one out of nine categories depending on the level (low, moderate or high) that a particular supplier is evaluated concerning these two dimensions. Araz and Ozkarahan (2007) propose a uni-dimensional model to evaluate and classify suppliers according to their co-design ability and overall performance. Based on 10 criteria, including design-related criteria, suppliers are categorized as pruning, competitive, promising or strategic. Omurca (2013) also propose a uni-dimensional model to group suppliers in clusters based on a set of 11 criteria. Sarkar and