



Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

A strategic model using structural equation modeling and fuzzy logic in supplier selection

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ARTICLE INFO

Keywords:

Structural equation modeling (SEM)
Fuzzy analytic hierarchy process
Sensitivity analysis

ABSTRACT

Supplier selection attained the state of paramount importance for companies in the current scenario because of increasing global competition. Improper selection of suppliers will have an adverse impact on the overall performance of the company. The number of available alternatives in the current market is on a rise, and hence it becomes difficult to select a supplier from among a large lot. An attempt has been made to develop a new composite model using structural equation modeling and fuzzy analytic hierarchy process technique, based on the results of a survey of 151 respondents. Based on the criteria that influence the selection of suppliers, the model has been developed. The study also examines the supplier selection criteria and measures the supplier selection score using the developed model.

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1. Introduction

Supplier selection is one of the most important stages in the course of any supply chain. It has been prominently studied thoroughly in the past four decades. It determines the success of any supply chain or rather, of any organization. Satisfying the customer with high quality products in the shortest time possible at lowest cost is the key to success of any organization in the market. The cost of any product includes the raw material and component costs which constitute 70% of the total costs. This total cost can therefore be reduced by reducing the raw material and component costs, which mainly depend on the supplier. Hence, proper selection of suppliers is very important for the profitability of an organization. Selection of raw material suppliers initiates the supply chain. Supplier selection is the stage in the buying process when the intending buyer or the retailer chooses the preferred supplier or suppliers from those qualified as suitable. When the suppliers are able to provide the retailer with the right quantity of the right product/service at the right time in the right place, they are qualified as 'suitable' (Mandal & Deshmukh, 1994; Sarkis & Talluri, 2002). Supplier selection is a strategic decision in any organization. It is a multi-criteria decision making process involving various criteria which may be quantitative as well as qualitative. The criteria for the supplier

selection are determined by the buyer/retailer according to his requirement. The criteria may differ according to the situation.

There have been many analytical models proposed for the supplier selection problem in the extant literature. However, to the best of our knowledge, no author has developed an integrated model of structural equation modeling (SEM) and fuzzy analytic hierarchy process (AHP) for supplier selection to arrive at score value. This paper fills that gap. The reason for selecting the model is that structural equation modeling approach uses a combination of quantitative as well as qualitative data to test and estimate causal relationship. SEM does not have a limitation on the number of variables, and is hence considered as the best approach. Since SEM takes the confirmatory approach rather than exploratory approach, there is no difficulty in hypothesis testing. This model also takes measurement error into account when analyzing the data statistically. Moreover, fuzzy AHP considers the vagueness of the opinion into account. This brings out a more reliable and effective evaluation process. We, in this paper, describe a generic theoretical model taking into consideration the criteria that influence the supplier selection: management and organization, quality, technical capability, production facilities and capabilities, financial position, delivery, services, relationships, safety and environmental concerns and cost.

The model thus developed is demonstrated through a real life example. The example has been considered by a public sector company in India. The company uses steel alloys for manufacturing their main product – boilers. This paper attempts to use our generic model to select the right suppliers for structural steel sections by identifying the criteria which influence the supplier selection.

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2. Review of literature

Supplier/vendor selection is used to describe various phenomena in supply chain management. In the past few decades, there have been major changes in the supplier selection practices. The competition has risen and the market has become globally operating. In such a scenario, it has become highly difficult for industries to produce low cost and high quality products successfully without proper suppliers (Weber, Current, & Benton, 1991). This makes supplier selection a very important factor in production and logistics management of many industries. Determining suitable suppliers in the supply chain has become a key strategic decision. An efficient or a successful supply chain is said to be one which delivers the right quantity and desired quality of the final product at the right place in the right time (Mandal & Deshmukh, 1994; Sarkis & Talluri, 2002). Significant reduction in purchasing costs and improvement in the corporate competitiveness can happen by proper selection of suppliers (Ghodsypour & O'Brien, 2001). Supplier selection is an order quantity and order timing decision (Slack, Chambers, & Johnston, 2004).

Supplier selection process is divided into two stages – identification of the criteria influencing the selection process and using a specific decision making technique to arrive at the preference of the suppliers (Chan, Lau, Chan, & Choy, 2006). Another division of the process of supplier selection is given by Davidrajah (2003). He divided the vendor selection process into pre-selection, selection and the post-selection procedures. Strategic goal setting is necessary before the selection procedure and hence it comes under the pre-selection procedure. The selection procedure is further divided into the following stages: bidder selection, partner selection, and performance evaluation. Proper relationship must be maintained with the supplier after the selection process. Hence, relationship maintenance comes under the post-selection procedure. Chen and Li (2007) gave multiple phase suppliers sorting model based on the supplier development orientation using multiphase selection methods and unconventional criteria combination. The model classified selection into three phase: pre-selection, evaluation and development. Few other authors like Nydick and Hill (1992), Ghodsypour and O'Brien (1998) and Karpak et al. (2001) studied multiple objective sourcing selection.

Past literature and particularly Bei, Wang, and Hu (2006), classify the supplier selection process into three categories namely (i) Conceptual approach: emphasizing the strategic importance of the process of supplier selection (Benton & Krajewski, 1990; Burton, 1988; Ellram, 1990; Sheth, 1973; Treleven, 1987), (ii) Empirical study: (Chapman, 1989; Edwards, 1967; Payne, 1970) and (iii) Analytical models (Berens, 1972; Saaty, 1988; Timmerman, 1986; Weber, 1996; Weber, Current, & Desai, 2000; Zabkar, 2000).

The conceptual approach of supplier selection is outlined in this section. Outsourcing is a management approach by which a company assigns some noncore functions to service providers (Franceschini, Galetto, Pignatelli, & Varetto, 2003). In the era of “global market” and “e-economy”, outsourcing is one of the main supports to conceive the relationships among companies. Kakouris, Polychronopoulos, and Biniaris (2004) proposed a framework for purchasing and outsourcing decisions together with a process model for evaluating and assessing possible suppliers. They focused in particular on the “planning” and “qualifying” phases of the process.

Dickson (1966) proposed 23 criteria for selecting the suppliers, based on a survey in industries. Nydick and Hill (1992) considered four prominent criteria in the supplier selection: quality, price, delivery and service. Park and Krishnan (2001) examined the supplier selection practices among 78 small business executives and adopted 15 criteria from Ellram (1990). The relationship between supplier selection criteria was thoroughly studied by Chapman (1989), Tullous and Munson (1991), Tracey and Vonderembse (1998), Tracey

and Tan (2001) and Zhang et al. (2006). The supplier selection criteria are very crucial in the supply chain's success and thereby, in the success of the organization. Supplier selection is an order quantity and order timing decision making problem (Slack et al., 2004) involving multi-criteria decision making. In the past literature of supply chain, the supplier selection problem is considered as an optimization problem which needs the formulation of a single objective function (Nukala & Gupta, 2007). However, all the supplier selection criteria cannot be quantified, because of which, only a few quantitative criteria are included in the problem formulation.

Now, we present some of the empirical study of supplier selection models. Schurr (2007) studied the important interactions that fundamentally strengthen or fatally weaken relationship development. Humphreys, Mak, and McIvor (1998) explained how dimensional analysis approach can be used to measure not only suppliers' performance, but also the contribution to the purchasing relationship from the buyer organization and stated its benefits over traditional assessment. Purdy and Safayeni (2000) developed a framework for supplier evaluation based on whether the supplier evaluation focuses on information from product-based or process-based domains and whether the information acquisition mode used is direct or indirect. In doing so, various merits and demerits related to each approach were identified. The suppliers' perception of the buying firm's supplier evaluation communication process and its impact on suppliers' performance was studied by Prahinski and Benton (2004). An intelligent supplier relationship management system is developed by integrating a company's customer relationship management system, supplier rating system and product coding system by the case based reasoning technique to select preferred suppliers during the new product development process (Choy, Lee, & Lo, 2004). The opportunities and challenges faced in improving the supply chain performance by coordinated application of inventory management and capacity management was discussed by Jammerneegg and Reiner (2007). Cormican and Cunningham (2007) discovered that reducing the number and improving the quality of suppliers resulted in increased quality, reduced lead time and a reduction in the number of errors and defects, by evaluating supplier performance from a large multinational organization. Handfield and Nichols (1999) emphasized on the environmental issues in supplier evaluation.

We now review the analytical models given for supplier selection problems. Many analytical models for solving the multiple criteria decision making supplier selection problem have been proposed. These models consider different criteria and facilitate in selecting the best supplier for the manufacturer. These criteria are ranked and given weights according to their importance considered by the company or the organization, and scoring is done for each of the initial shortlisted suppliers. The supplier with the maximum score will be selected finally. A combination of the criteria from the literature with the rating scheme of industrial purchasing yields a sophisticated, systematic decision matrix approach (Berens, 1972) to supplier evaluation and selection which under certain conditions can eliminate much bias and incomplete evaluation of vendors. Saaty (1988) proposed the analytical hierarchy process (AHP) to assist in multi-criteria decision making problems to overcome the difficulties associated with the categorical and simple linear weighted average criteria ranking methods. Vendor selection is multi-objective in nature. Little has been done to develop techniques for measuring vendors' performance on multiple criteria. Weber (1996) used data envelopment analysis (DEA) as a tool for measuring the performance of vendors on multiple criteria. Weber et al. (2000) presented an approach for evaluating the number of vendors to employ in a procurement situation using multi objective programming (MOP) and data envelopment analysis (DEA). Ramanathan (2007) proposed a methodology to integrate DEA with the total cost of ownership

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