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A fuzzy logic based decision support system for evaluation of suppliers in supply chain management practices

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ABSTRACT

Supply chain management is an increasingly important organizational concern, and proper evaluation of suppliers constitutes one essential element of supply chain success. Continuous evaluation of a particular supplier becomes more important considering the fact that in most industries the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70%. However, there is little research that has helped organizations in continuous evaluation of their suppliers. We propose a new model based on fuzzy logic to handle the various attributes associated with supplier evaluation problems. Four multi-input single-output (MISO) Mamdani fuzzy inference systems have been proposed for supplier evaluation. The proposed model has also been illustrated through a case study.

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1. Introduction

Since the introduction of the term supply chain management (SCM) by consultants in the early 1980s, it has gained attention of researchers and academicians. Since the 1990s, academics have attempted to find more and more aspects of SCM [1,2]. With these attempts of academicians and researchers, the concept of SCM arose from a number of changes in the different stages of supply chain. These changes effected the rising costs of manufacturing, the shrinking resources of manufacturing bases as well as shortening product life cycles. As a result, the concept has undergone tremendous changes over a few years. It has entirely replaced the traditional terms used to describe the management of material and service flows [3].

The intensive global competition among manufacturers to co-ordinate with and respond quickly to the industrial value chain from suppliers to customers has made customer–supplier relationship in SCM important in the new business era. In such circumstances, decision making in each business plays a key role in the cost reduction, and supplier evaluation is one of the important functions in supplier relationship management, because doing business with appropriate suppliers is beneficial for the organization to provide a sufficient production volume with good quality [4]. This function becomes more important considering the fact that in most industries the cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for up to 70%. In such circumstances the purchasing department

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can play a key role in cost reduction, and supplier selection and continuous evaluation of supplier have become some of the important functions of purchasing management [5].

The increasing proportion of raw materials and work-in-process of manufactured products, where sourced globally by multinational manufacturers, is a trend in today's industries. The way to evaluate supplier capability is the main scope of supplier selection. A multi-national manufacturer cannot have direct control over the capability and performance of its hundreds or even thousands of suppliers. However, the evaluation of its suppliers' capabilities to provide raw materials/component parts is a crucial issue to a multi-national manufacturer. For example, it is common for suppliers, after receiving an order, to subcontract to satisfy the demand, due to the tightness of their own production schedule. Furthermore, internal rescheduling of production by suppliers may have an impact on their performance level. Their quality assurance and on-time delivery would be in doubt. Therefore, a manufacturer should analyse and evaluate the potential threats when continuing business with suitable supplier(s) resulting from a systematic evaluation process and its corresponding attributes [6]. After selection of an appropriate supplier, therefore, continuous evaluation of supplier(s) is very essential. In [7], Kumar et al. study the single decision supplier selection process in the Indian textile industry, whereas the current paper studies the continuous process of supplier evaluation.

2. Review of related work

The literature available on supplier selection and evaluation can broadly be considered to have two components: (1) supplier attributes and (2) the tool used in study.

Various attributes for supplier evaluation have been studied by various researchers. In general, supplier attributes from purchasing professionals, such as a purchasing manager or buyer, should be first identified for supplier evaluation. These attributes are fundamental when making purchasing decisions. While identifying these attributes, it should be clear that all criteria, rules, and priorities are identified and systematically classified. This helps in evaluating effectiveness of the purchasing performance. Chao et al. [8] concluded that quality and on-time delivery are the most important attributes of purchasing performance evaluation from survey results in a number of industries. Similar work of supplier evaluation was also considered by Talluri and Sarkis [9] taking price, quality, delivery, and flexibility as variables apart from just-in-time supply, and by Talluri and Baker [10], taking cost, product variety, quality, and lead time as main attributes. Wei et al. [11] suggested that the purchasing factors usually considered should include a supplier's history of supply, product price, technical ability, and transportation cost. Ghodsypour and O'Brien [5] agreed that cost, quality, and service are the three main categories when deciding supplier selection parameters. Yang et al. [12] took technological innovation as an attribute for supplier evaluation. Arntzen et al. [13] considered strategic decisions, such as location of customers and suppliers, location and availability of inexpensive skilled labour, cost of various transportation modes, export regulations, etc. for supplier selection. This revealed that the supplier evaluation process, usually made on the basis of cost and quality, has been recognized as a major decision-making process. However, Briggs [14] stated that joint development, culture, supply chain management, quality, and communication are the key attributes to be considered, apart from optimum cost. Braglia and Petroni [15] evaluated the relative performance of suppliers that have multiple outputs and inputs, based on capabilities relating to management, production facilities, technology, price, quality, and delivery compliance for a bottling industry. Ng et al. [16] considered supplier relationships, purchasing strategy, transportation cycle time, and packaging for supplier evaluation model development. The type of relationship between supplier and buyer has also been studied by Toni and Nassimbeni [17] by examining the role of supplier development in establishing and managing efficient buyer–supplier operational links from a study of 50 plants. Fynes et al. [18] also studied the different characteristics of relationships between suppliers and buyers and their effect on the supply chain.

The second part considered during the literature review for supplier evaluation is the tool used for evaluation. A combination of an analytic hierarchy process (AHP) and linear programming has been applied by Ghodsypour and O'Brien [5] to study the problems related to supplier evaluation, including both qualitative and quantitative factors. But, in this method, errors can creep in due to perception or biased behaviour of the decision-making managers and the independent nature of the attributes used. This problem can be solved by getting the rating done by a group of decision makers for continuous evaluation of vendors, following the principle of anonymity and integrating the method with a managerial tool: the Delphi method [19]. Handfield et al. [20] illustrated the use of an AHP as a decision support model that included relevant environmental criteria. Bhutta and Huq [21] applied an AHP in the supplier evaluation process and compared it with the total cost ownership method. Wang et al. [22] developed an integrated AHP and pre-emptive goal programming based multi-criteria decision-making methodology to take into account both qualitative and quantitative factors in supplier evaluation. Until the early years of the 2000s, no feedback from customers was incorporated in the process, and the attributes considered were largely independent. These problems can be overcome by using a more general form of the AHP, called the analytic network process (ANP). Agarwal and Shankar [23] used an ANP which incorporates feedback and interdependent relationships among decision attributes and alternatives. Lee et al. [24] also used an ANP for selecting the appropriate acquisition mode for a required technology during the supplier selection and evaluation process.

A new and general decision-making method for evaluating suppliers of weapons using a fuzzy AHP based on entropy weight has been used [25]. But the method used is very subjective, and the calculations are very complicated. A simpler way to solve the same problem of evaluating suppliers of weapons has also been used [26,27]. Ruoning and Zhai [28] used yet another method, a fuzzy logarithmic least square method, to solve a theoretical supplier evaluation problem. Ruoning and

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