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Supplier selection and performance evaluation in just-in-time production environments

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ABSTRACT

The purpose of this paper is to aid just-in-time (JIT) manufacturers in selecting the most appropriate suppliers and in evaluating supplier performance. Many manufacturers employ the JIT philosophy in order to be more competitive in today's global market. The success of JIT on the production floor has led many firms to expand the JIT philosophy to the entire supply chain. The procurement of parts and materials is a very important issue in the successful and effective implementation of JIT; thus, supplier selection and performance evaluation in long-term relationships have became more critical in JIT production environments. The proposed systems can assist manufacturers in handling these issues. In this research, neural network based supplier selection and supplier performance evaluation systems are presented. The proposed approach is not limited to JIT supply. It can assist manufacturers in selecting the most appropriate suppliers and in evaluating supplier performance. The proposed neural network based systems are tested with data taken from an automotive factory, and the results show that the proposed systems can be used effectively.

1. Introduction

Today's companies are faced with fierce competition, which is forcing them to increasingly consider new applications to improve quality and to reduce cost and lead time. For this reason, manufacturers must keep pace with the dynamic requirements of the market and be receptive to change. The aim of many new manufacturing systems, like the just-in-time (JIT) philosophy, is to eliminate waste in the production environment and to continue this process as a continuous cycle, always striving for the best (Lubben, 1988).

The JIT philosophy is an important action in the supply chain management (SCM) system. The JIT purchasing system requires smaller order quantities and tighter delivery times. Hence, manufacturers dealing with the JIT philosophy must collaborate with their suppliers. In order to achieve a successful JIT system, a relationship between the supplier and buyer must be established for close business collaboration as strategic partners.

Matson and Matson (2007) suggested that, for global competitiveness, further support is required for efficient JIT supply chains and that it is critical that JIT suppliers identify and address performance issues as effectively as possible.

Manufacturers practicing JIT require suppliers that punctually supply materials and outsourced parts – in the appropriate quantity and with consistent quality. Because reliable suppliers enable manufacturers to reduce inventory costs and improve product quality, it is understandable that manufacturers are increasingly concerned about supplier selection (Braglia & Petroni, 2000). It is apparent that the selection of appropriate suppliers and effective supplier relationship management are key factors in increasing the competitiveness of firms (Choy, Lee, & Lo, 2003a; Ghodsypour & O'Brien, 2001). In a long-term relationship, after selecting the suppliers, purchasing departments need to periodically evaluate the performance of their suppliers in terms of critical criteria.

Supplier selection and evaluation play an important role in reducing the cost and time to market whilst improving the quality characteristics of the products. They can significantly affect manufacturing costs and production lead time. Although several techniques and models have been employed for selecting and evaluating suppliers, each technique has its own strengths and limitations under different situations. Therefore, there is a strong need to further improve the performance and effectiveness of supplier selection and evaluation approaches in manufacturing environments in order to act effectively in different situations. A detailed literature review with respect to supplier selection and evaluation methods is given in the following section.

In this research, a neural network (NN) technique is used to select suppliers and to evaluate the selected suppliers' performance in order to cope with the limitations of traditional

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techniques. A neural network represents an information-processing technique that is developed to simulate the functions of a human brain.

The remainder of this paper is organized as follows. Section 2 presents a literature review. Section 3 explains the proposed approach and presents a neural network based supplier selection system and supplier performance evaluation system for JIT manufacturers. Application examples and results are provided in Section 4. Finally, conclusions are presented in Section 5.

2. Literature review

There are several papers regarding the implementation of JIT systems and buyer–supplier relationships under JIT systems in the literature. It can be seen that there is not yet enough research regarding the benefits of neural network approaches in supplier selection and supplier performance evaluation in JIT manufacturing.

Dong, Carter, and Dresner (2001) reported that the implementation of JIT purchasing systems can result, on average, in reduced inventory costs, shorter lead times and improved productivity for buying organizations. Dong et al. (2001) also stated that JIT purchasing strategies are aimed at a synchronized and timely product flow from the supplier to the buyer.

Boer, Labro, and Morlacchi (2001) suggested that with increasing significance of the purchasing function, purchasing decisions become more important. As organizations become more dependent on suppliers, the direct and indirect consequences of poor decision-making become more severe. In addition, several developments further complicate purchasing decision-making. The globalization of trade and the Internet enlarge a purchaser's choice set. Changing customer preferences require a broader and faster supplier selection.

In the supplier selection process, it is not always easy to recognize precise rules, but there is, in general, a coherent way to solve the problem. The choice of supplier is then a problem usually solved by subjective criteria, based on personal experiences and beliefs, on the available information and, sometimes, on techniques and algorithms supporting the decision process (Albino & Garavelli, 1998). The key to enhancing the quality of decision-making in the supplier selection function is to take advantage of the powerful computer-related concepts, tools and techniques that have become available in the last years (Wei, Zhang, & Li, 1997).

Chao, Scheuing, and Ruch (1993) concluded that quality and on-time delivery are the most important attributes of purchasing performance. Ghodsypour and O'Brien (1998) agreed that cost, quality and service are the three main categories to consider when determining supplier selection parameters. Briggs (1994) stated that joint development, culture, forward engineering, trust, supply chain management, quality and communication are the key requirements of a supplier partnership, apart from optimum cost. Petroni and Braglia (2000) 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. Wei et al. (1997) determined that factors such as a supplier's supply history, product price, technology ability and transport cost have effects on the selection of suppliers.

2.1. Supplier selection methods in the literature

The literature presents several methods for selecting a supplier. Categorical methods are qualitative models. Based on the buyer's experience and historical data, suppliers are evaluated by a set of criteria. The evaluations actually consist of categorizing the supplier's performance based on a set of criteria as either 'positive', 'neutral' or 'negative' (Boer et al., 2001). After a supplier has been rated on all criteria, the buyer gives an overall rating, such that the suppliers are sorted into three categories.

Data envelopment analysis (DEA) is concerned with the efficiency of a decision alternative. The DEA method aids the buyer in classifying the suppliers into two categories: efficient suppliers and inefficient suppliers. Liu, Ding, and Lall (2000) used DEA in the supplier selection process. They evaluated the overall performances of suppliers by using DEA. Saen (2007) used IDEA (Imprecise Data Envelopment Analysis) to select the best suppliers in the presence of both cardinal and ordinal data.

Cluster analysis (CA) represents a class of statistical techniques that can be applied to data that exhibit "natural" groupings (Boer et al., 2001).

Case-based reasoning systems (CBR) combine a cognitive model describing how people use and reason from past experience with a technology for finding and presenting experience (Choy et al., 2003a). Choy, Lee, and Lo (2002b) enhanced a CBR-based supplier selection tool by combining the supplier management network (SMN) and supplier selection workflow (SSW). Choy, Lee, Lau, and Choy (2005) used CBR to select suppliers in the new product development process.

In linear weighting methods, criteria are weighted and the criterion that has the largest weight is given the highest importance. Ghodsypour and O'Brien (1998) integrated AHP and linear programming to consider both tangible and intangible factors in choosing the best suppliers and placing the optimum order quantities. Lee, Sungdo, and Kim (2001) used only AHP for supplier selection. They determined the supplier selection criteria based on the purchasing strategy and criteria weights by using AHP. Liu and Hai (2005) used DEA for determining the supplier selection criteria. Then, they interviewed 60 administrators to determine the criterion priorities and they used AHP for selecting suppliers.

Ting and Cho (2008) presented a two-step decision-making procedure – AHP for selecting a set of a firm's candidate suppliers, followed a multi-objective linear programming (MOLP) model for optimal allocations of order quantities to the candidate suppliers.

Boer, Wegen, and Telgen (1998) used the ELECTRE 1 technique to evaluate five supplier candidates. Xia and Wu (2007) used an integrated approach of AHP improved by rough sets theory and multi-objective mixed integer programming, which was proposed to simultaneously determine the number of suppliers to employ and the order quantity allocated to these suppliers in the case of multiple sourcing and multiple products, with multiple criteria and with the supplier's capacity constraints. Wang, Huang, and Dismukes (2004) used an integrated AHP and preemptive goal programming (PGP)-based multi-criteria decision-making methodology to take into account both qualitative and quantitative factors in supplier selection. Liu and Hai (2005) compared the voting analytic hierarchy process (VAHP) and AHP for supplier selection process. Chan and Kumar (2007) identified some of the important and critical decision criteria including risk factors for the development of an efficient system for global supplier selection. They used fuzzy extended analytic hierarchy process (FEAHP)-based methodology to select suppliers.

Total cost of ownership (TCO) based models include all costs related to the supplier selection process that are incurred during a purchased item's life-cycle. Degraeve and Roodhooft (1999) evaluated the suppliers based on quality, price and delivery performance by using TCO. They emphasized that the uncertainty of demand, delivery, quality and price must be reflected in the decision problem. Ramanathan (2007) proposed an integrated DEA-TCO-AHP model for the supplier selection problem.

According to Boer et al. (2001), mathematical programming models (MP) allow the decision-maker to formulate the decision