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Integration of particle swarm optimization-based fuzzy neural network and artificial neural network for supplier selection

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ABSTRACT

This study is intended to develop an intelligent supplier decision support system which is able to consider both the quantitative and qualitative factors. It is composed of (1) the collection of quantitative data such as profit and productivity, (2) a particle swarm optimization (PSO)-based fuzzy neural network (FNN) to derive the rules for qualitative data, and (3) a decision integration model for integrating both the quantitative data and fuzzy knowledge decision to achieve the optimal decision. The results show that the decision support system developed in this study make more precise and favorable judgments in selecting suppliers after taking into account both qualitative and quantitative factors.

1. Introduction

An ever-increasing trend in today's industrial firms is to exploit outsourcing for those products and activities deemed to be outside the company's core business. This is because that under the changing environment, industrial firms have to focus more on their core components and employ suppliers to outsource. Thus, selecting suitable suppliers becomes a very important issue in supply chain. However, managers always give too much self-concern making an accurate decision. Recently, Artificial Intelligent (AI)-based models have very promising results in a number of areas, like forecasting. Therefore, this study intends to present an AI-based decision support system so that managers can choose the suitable suppliers to get more business benefit. In addition, the other objective is to consider the qualitative as well as the quantitative factors, since both of them are critical for decision making.

The proposed system is composed of (1) collection for quantitative factors, (2) a fuzzy neural network (FNN) model for handling qualitative data, and (3) decision integration model. The quantitative factors include quality, finance, location, price, delivery deadline and productivity. The fuzzy IF-THEN rules are summarized from the questionnaire filled by the experts and generated by a proposed fuzzy neural network (FNN) with initial weights generated by particle swam optimization (PSO) algorithm. Finally, the results from the above two parts are integrated through a feed-forward artificial neural network (ANN) with error back-propagation (EBP) learning algorithm. The simulation results show that PSO-based FNN is able to learn the fuzzy relationship between fuzzy inputs and outputs. In addition, a real world problem from a well-known Laptop computer company indicates that the proposed decision support system can provide better result compared with regression model.

The rest of this paper is organized as follows. Section 2 presents brief review of the backgrounds, while the proposed method is illustrated in Section 3. The real world problem results are shown in Section 4. Finally, the concluding remarks are made in Section 5.

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2. Literature review

This section will briefly give some descriptions to supplier evaluation criteria and supplier selection methods, respectively.

2.1. Suppliers evaluation criteria

Supply chain management can be defined as "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements [1]. Therefore, it is really an important issue to choose the appropriate supplier in today's supply chain. The cost-oriented industry may consider capital cost as the most important factor, while the quality-oriented industry may rely on the supplier's product quality as the most critical reason. Therefore, it depends on every industry's business culture, competitive strategy and product types.

The early works on supplier selection identified over twenty supplier attributes which manager tradeoff when choosing a supplier [2]. Since then, a number of ideal articles mentioned about supplier selection have appeared [3]. The conceptual articles like [4,5], and (Kraljic, 1983) are examples of papers emphasizing on the strategic importance of the supplier selection process. The above articles underscore the tradeoff among quality, cost and delivery performance measures in the supplier selection process.

Choi and Hartley [6] generalized 26 attributes for the supplier evaluation criteria according to the research done by Dickson [2], and Weber et al. [3] make factor analysis and then they are cataloged into eight factors including finance, consistency, relationship, flexibility, relationship, technological capability, customer service and reliability.

Several other authors have evaluated the relative importance of quality, cost, delivery performance, and other supplier attributes. According to a review of 74 articles discussing about supplier selection criteria, quality was perceived to be the most important one and following with delivery performance and cost [7].

Through Table 1, it is easy to realize the evolution of the decision criteria from past to present. Three decades before customers require a product for their basic demand but not take the service as desirable factors. This may be the reason why the first four priorities in 1970's are. In the 1990's, with the shift of society organization and the rapidly growth of technology, what customers want is not only just something for use but also goods with much more additional functions and superior quality.

2.2. Supplier selection methods

In the following some techniques used to select supplier will be presented.

2.2.1. Data envelopment analysis (DEA)

For each supplier, the DEA method not only finds the most favorable set of weights but also helps the buyer classify the suppliers into two categories: the efficient suppliers and the inefficient suppliers. DEA was proposed for evaluation of vendors that were already selected. Besides, the application of DEA in supplier selection is also applied in several publications [11]. A combination of multi-objective programming and the DEA method provides buyers a tool for negotiating with vendors that were not selected right away as well as to evaluate different numbers of suppliers to use [12,13]. Recently, a combination of AHP and DEA is applied in the field of supplier evaluation [14].

2.2.2. Clustering analysis (CA)

CA is a basic statistical method that uses a classification algorithm to group numbers of items which are described by a set of numerical attribute scores into a number of clusters. Apparently, CA can also be applied to group suppliers that are described by scores on some criteria in use. The result is a classification of suppliers in clusters of comparable suppliers.

2.2.3. Linear weighting models

In linear weighting models, weights are given for every criteria and the largest weight indicates the highest importance. Analytic hierarchy process (AHP) is utilized to deal with the imprecision in supplier selection [15]. In short, AHP avoids the difficulty of providing point estimates for criteria weights as well as performance scores in the basic linear weighting model.

Table 1
Summary decision criteria [8].

	Rank order of decision criteria			
	1	2	3	4
Lehmann and O'Shaughnessy [9]	Delivery	Price	Quality	Service
Lehmann and O'Shaughnessy [10]	Quality	Price	Service	Delivery
Wilson [8]	Quality	Service	Price	Delivery

*Rank 1 implies the highest importance, while rank 4 represents the least important.