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The Fuzzy ART algorithm: A categorization method for supplier evaluation and selection

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ABSTRACT

For most of managers purchasing is a strategic issue. Thus, to select the suitable suppliers has strategic importance for every company. The objective of supplier selection is to reduce purchasing risk, maximize overall value to the purchaser and build a long term, reliable relationship between buyers and suppliers. Many methods have been proposed and used for supplier evaluation and selection; most of them try to rank the suppliers from the best to the worst and to choose the appropriate supplier(s). Supplier evaluation and selection is a complex and typical multi criteria decision-making problem. Because of human judgment needs in many area of supplier selection such as preferences on alternatives or on the attributes of suppliers or the class number and borders supplier selection becomes more difficult and risky.

In this study, a new tool for supplier selection is proposed. In this paper, we applied Fuzzy Adaptive Resonance Theory (ART)'s classification ability to the supplier evaluation and selection area. The proposed selection method, using Fuzzy ART not only selects the most appropriate supplier(s) and also clusters all of the vendors according to chosen criteria. To explain the Fuzzy ART method a real-life supplier selection problem is solved and suppliers are categorized according to their similarities. The obtained results show that the proposed method is well suited as a decision-making tool for supplier evaluation and selection problem.

1. Introduction

Generally in the process of supplier evaluation and selection, firms are ranked by grading with respect to various criteria, classified and best suited one/s is chosen. As a result of this classification, for example with a high classified firm a long term, less controlled, trust based commercial relationship can be established or vice versa. Consequently, managing supplier categorization has become momentous in terms of profitability, productivity and success in achieving time targets.

Although many methods have been proposed and used for supplier evaluation and selection, most of them try to rank the suppliers from the best to the worst or to choose the best supplier among others. This study focuses on supplier evaluation and selection from the point of a new perspective based on Fuzzy ART neural networks. In following sections, we introduce the supplier evaluation and selection problem, and formulate the problem as a decision-making model and solve with Fuzzy ART algorithm to categorize the suppliers using many criteria.

The rest of the paper is organized as follows: Section 2 mentions supplier selection and its shortcomings. Section 3 describes Adaptive Resonance Theory (ART) neural networks. Section 4 explains Fuzzy Adaptive Resonance Theory which is one of the ART networks. The proposed Fuzzy ART method for supplier selection problem is presented in Section 5. A real case sample problem – solved by this method – and its results take part in Section 6. The final section is for discussion and conclusions.

2. Supplier evaluation and selection

Supplier selection is a fundamental issue in the supply chain which heavily contributes to the overall supply chain performance. Significant supplier selection reduces the purchasing cost and improves corporate competitiveness.

It is one of the most critical activities of purchasing management in supply chain and in this process suppliers are reviewed, evaluated and chosen to become a part of the company's supply chain (Guo, 2009; Sanayei, Mousavi, Abdi, & Mohaghar, 2008). Supplier selection decision is the most important decision-making process in production and logistics management (Che & Wang, 2008).

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Supplier evaluation and selection problems are complex and multi criteria decision-making problems. The research on this subject is abundant. First publications can be traced back to the 1960s. Chen, Lin, and Huang (2006), Lee (2009), Li, Yamaguchi, and Nagai (2007), Özgen, Onut, Gülsün, Tuzkaya, and Tuzkaya (2008), Saen (2007) realized a comprehensive literature review for supplier evaluation and selection till 2006.

The researches and applications in recent years are: applied analytical hierarchy process (Kokangul & Susuz, 2009; Xia & Wu, 2007), used analytic network process (Hsu & Hu, 2008; Üstün & Demirtaş, 2008; Wu, Sukoco, Li, & Chen, 2009), proposed neural network (Guosheng & Guohong, 2008; Lee & Ou-Yang, 2009), proposed a fuzzy model (Amid et al., in press; Lee, 2009; Lee, Kang, & Chang, 2009), proposed a hybrid method (Ha & Krishnan, 2008; Moghadam, Afsar, & Sohrabi, 2008) and proposed fuzzy hierarchical TOPSIS for the supplier selection problem (Wang, Cheng, & Kun-Cheng, 2009).

While the traditional vendor evaluation methods primarily considered financial measures in the decision-making process, more recent emphasis on the incorporation of multiple vendor criteria into evaluation process. It is never expected from a supplier being perfect, according to all supplier selection criteria. As it seen, for making good decisions, supplier selection process must be handled systematically (Gencer & Gürpınar, 2007).

It is difficult to find the best way to evaluate and select supplier, and companies use a variety of different methods to deal with it. Therefore, the most important issue in the process of supplier selection is to develop a suitable method to select the right supplier (Chen et al., 2006). Many methods have been proposed and used for supplier evaluation and selection. These are; linear weighted models, total cost models, mathematical programming models, statistical models and artificial intelligent (AI) based techniques.

In linear weighted models, every criterion is being weighted and supplier's performance is multiplied by this weight for every criteria. The sum of these multiplications represents the total performance of supplier. Although it is a very simple method, it depends heavily on human judgment and also weights the attributes equally, which rarely happens in practice. It is divided as categorical method, weighted point model (linear weighted model) and analytical hierarchy process (AHP) model. In categorical method, the criteria are weighted equally and the decisions by made with this method are subjective. In weighted point model, because of the total criteria performance, the criterion with low performance is not taken into consideration. In AHP model, human judgment forms the main structure of comparison matrices.

Total cost models are complex methods which depend to cost. They consider not only the product's rate but also, indirect item cost. It is divided as cost ratio method and ownership total cost model. The cost ratio method is not widely used in companies because it requires a comprehensive cost accounting system which is only to be found in large scaled companies and has a complex structure. In ownership total cost model, the potential risk is available during the supplier selection process, the subjectivity cannot be removed.

Mathematical models are used to represent the complex structure of supplier selection and have been widely used for modeling selection and allocation problems. On the other hand, mathematical programming (MP) models cause a significant problem in considering qualitative factors. The drawback of MP is that it requires arbitrary aspiration levels and cannot accommodate subjective attributes. Supplier selection is a multiple-attribute decision-making (MADM) problem. The decision-makers (DMs) always express their preferences on alternatives or on the attributes of suppliers, which can be used to help rank the suppliers or select the most desirable one. The preference information on alternatives of supplier and on attributes belongs to the DMs' subjective judgments. In conventional MADM methods, the ratings and weights of the attributes are known precisely. Generally, DMs' judgments are often uncertain and cannot be estimated by an exact numerical value. Thus, the problem of selecting suppliers has many uncertainties and becomes more difficult. In conventional MADM methods, the ratings and the weights of attributes must be known precisely. However, in many situations DMs' judgments are often uncertain and cannot be estimated by an exact numerical value (Li et al., 2007). The most used are: linear programming, integer programming, mixed integer programming, multi criteria programming and goal programming.

For using the statistical approaches, it is essential to reach implicit and accurate knowledge about suppliers. Obtained knowledge about previous performances of suppliers are significant for the usage of these models. The common models are classification analysis and fundamental components analysis.

Also, the methods such as data envelopment analysis, neural networks, fuzzy set theory, and analytic network process and quality function deployment are used for supplier selection.

Furthermore, in the case of fuzzy data classical set theory is deficient, fuzzy set theory can be used together with mathematical models. Linear programming models are figured out by including fuzziness. Chen et al. (2006) used fuzzy TOPSIS method to select the suitable suppliers and for classifying the suppliers, they divide the closeness coefficient interval [0,1] to five equal parts, and place each supplier according its closeness coefficient in one of these five "assessment status" classes.

Except these models, integrated models are existed. A favorable example is using linear programming and analytic hierarchy process together.

Artificial intelligence (AI) technologies are designed to be more like human judgment functioning, so they can cope better with complexity and uncertainty than 'traditional methods'. The user of AI systems only has to provide the information on characteristics of current situation, e.g. performance of a supplier on the criteria. The AI technologies subsequently make the actual trade off of the users, based on what they have 'learned' from the experts or cases in the past (Guo, 2009).

Supplier Selection is a multiple criteria decision-making (MCDM) problem which is affected by several conflicting factors. Consequently, a purchasing manager must analyze the trade off among the criteria. And MCDM techniques support the decision-makers in evaluating a set of alternatives. Among the methods supporting supplier selection, artificial intelligence (AI) based models play important role in the domains. Examples of methods based on AI technologies that have been applied to supplier choice include neural networks and other new techniques (Guo, 2009).

One of the neural networks called Adaptive Resonance Theory (ART) is a new and promising classification technique. It is mostly used in various classification problems.

3. Adaptive Resonance Theory (ART) neural network

The Adaptive Resonance Theory was introduced by Grossberg in 1976. ART nets are designed to control the degree of similarity of patterns place on the same cluster unit. This algorithm can automatically find the adaptive clusters based on training patterns (Liu & Li, 2005).

An ART network composes of two layers: an input layer and an output layer. There are no hidden layers. The networks dynamics are managed by two sub-systems: an attention subsystem and an orienting subsystem. The attention subsystem proposes a winning neuron (or category) and the orienting subsystem decides whether to accept it or not (Kondadadi & Kozma, 2002).