Introduce an Integrated Approach to Vendor Evaluation

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Abstract: Vendor selection is a strategic issue in supply-chain management for any organization to identify the right supplier. Such selection in most cases is based on the analysis of some specific criteria. Most of the researches so far concentrate on multi-criteria decision making (MCDM) analysis. However, it incurs a huge computational complexity when a large number of suppliers are considered. So, data mining approaches would be required to convert raw data into useful information and knowledge. Hence, a new hybrid model of MCDM and data mining approaches was proposed in this paper to address the supplier selection problem. In this paper, Fuzzy Adaptive Resonance Theory (FART) method as a data mining model has been used to classification suppliers into groups. Then, Analytic Network Process (ANP) method has been employed to rank the suppliers.

Keywords- Selection, Multiple Criteria Decision Making, Fuzzy Analytic Network Process, Fuzzy Adaptive Resonance Theory.

I. Introduction

An important concern in supply-chain management is supplier selection. Normally, above 60% of a manufacturer’s total sales are spent on purchased items, such as components, parts and raw materials [1]. Moreover, purchases of goods and services by the manufacturer constitute up to 70% of product price [2]. So, selection of suppliers has gained an enormous extent of importance as a tactical issue in the area of supply-chain management. Che and Wang [3] declared that enterprises must make an important decision regarding the selection and evaluation of suppliers in order to collaborate with qualified suppliers and eliminate those unqualified ones. Establishing a long-term cooperation with qualified suppliers can lead to rapid exchange of information which can provide beneficial support for supply-chain management. Lin et al. [4] mentioned that performance of outsourcing operations is greatly affected by vendor selection activities. Mafakheri et al. [5] pointed out that costs reduction and quality improvement of end products is highly dependent on choosing the appropriate supplier.

Consequently, considerable amount of interests exist in development of suitable frameworks to evaluate and select suppliers. He et al. [6] suggested that selecting the suitable suppliers based on the characteristics of market and product features is a key factor in achieving good supply-chain management. In order select a supplier, some different alternative suppliers should be evaluated according to different criteria. According to Degraeve and Roodhoft [7], price considerations in supplier evaluation were the main focus in supplier selection. Later, companies realized that being dependent on this single criterion in supplier selection could be harmful to their performance. A list of 23 criteria was indentified for supplier evaluation and selection process by a study done by Dickson [8]. In another study, Weber et al. [9] identified that the decisions to select the suppliers are influenced by some key factors. These key factors were derived from reviewing 74 related papers that appeared after Dickson’s [8] distinguished research work. According to this well established review in the area of supplier selection, it was disclosed that price, quality and delivery performance are the most important factors to be considered in solving the problem of supplier selection. Multi criteria decision-making (MCDM) is involved with the process of supplier selection. This process is mainly influenced by different intangible and tangible criteria such as price, quality, technical capability, delivery performance, etc. [10,11].

Many researchers solved the problem of supplier selection by different approaches which include linear programming (LP), integer non-linear programming, mixed integer linear programming (MILP), analytic network process (ANP), multiple objective programming, neural networks (NN), goal programming, data envelopment analysis (DEA), simple multi-attribute rating technique (SMART), analytic hierarchy process (AHP), cost-based methods (CBM), genetic algorithm, techniques for order preference by similarity to ideal solution (TOPSIS) and Elimination and Choice Expressing Reality (ELECTRE) methods [12-26].In this research, Fuzzy Adaptive Resonance Theory algorithm has been utilized which allows objects to belong to more than one cluster. This feature makes FART more flexible than clustering methods [38]. Also, in this research activity, ANP is used to weight the criteria. Then, FART is utilized in order to classify suppliers into clusters.

II. BASIC DEFINITIONS AND NOTATIONS

A. *Fuzzy Adaptive Resonance Theory*

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 [20,31]. 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 [10, 11].
ART adapts to new inputs indefinitely. New categories can be existed when the input does not match any of the stored patterns, but the input cannot change stored patterns unless they are adequately similar. ART networks are widely used in the clustering and classification problems. A clustering algorithm takes as input a set of input vectors and gives as output a set of clusters. Input vectors which are close to each other according to a specific similarity measure should be mapped to the same cluster. Clusters can be labeled to indicate a particular semantic meaning pertaining to all input vectors mapped to that cluster.

B. Analytic Network Process (ANP)

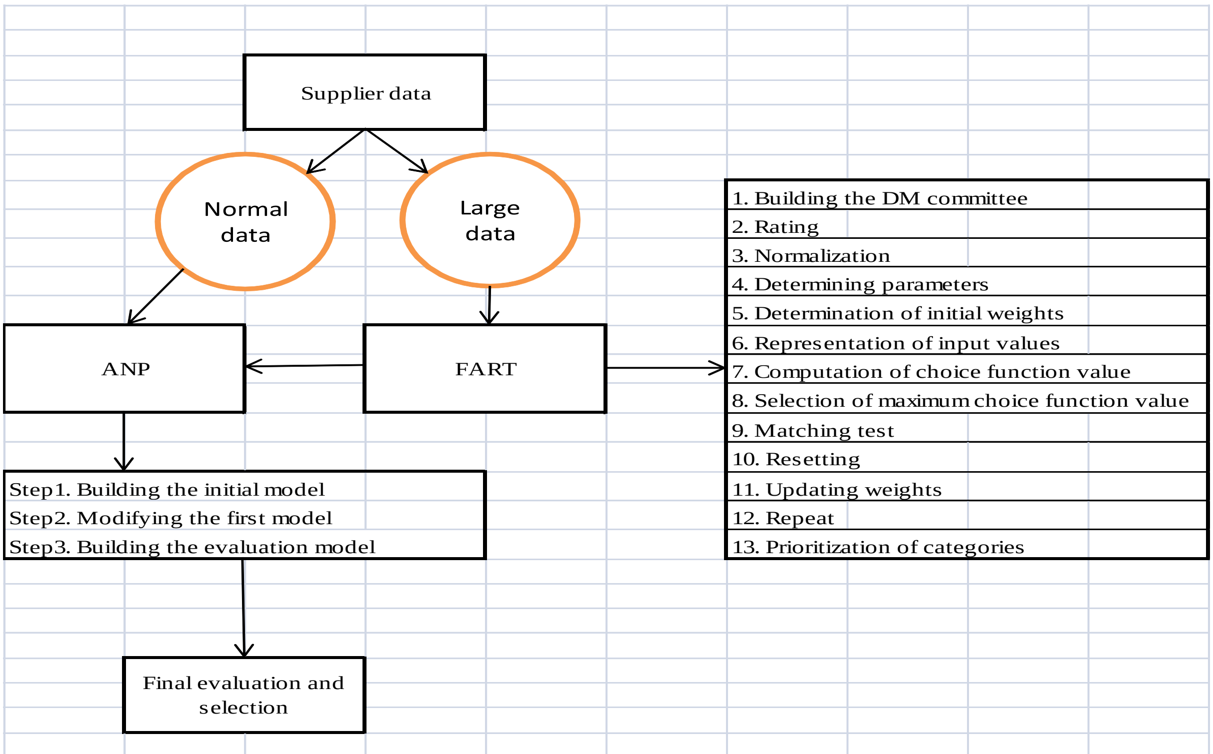
The analytic hierarchy process (AHP) was proposed by Saaty (1980). It has been widely used in multiple criteria decision making (MCDM) to evaluate/select alternatives for many years. However, using the AHP must assume that the information sources involved are non-interactive/independent. This assumption is not realistic in many real-world applications. In order to solve this problem, Saaty (1996) proposed a new MCDM method, the ANP, to overcome the problems of interdependence and of feedback between criteria and alternatives in the real world. The ANP is an extension of the AHP; indeed, it is the general form of the AHP. The ANP handles dependence within a cluster (inner dependence) and among different clusters (outer dependence).

The ANP is a nonlinear structure, while the AHP is hierarchical and linear with the goal at the top and the alternatives at lower levels [10,11].The ANP has been applied successfully in many practical decision-making problems, such as project selection, product planning, green supply chain management, and optimal scheduling problems [26, 35].

In ANP procedures, the initial step is to compare the criteria in the whole system to form an unweighted supermatrix by pairwise comparisons. Then the weighted supermatrix is derived by transforming each column to sum exactly to unity (1.00). Each element in a column is divided by the number of clusters so each column will sum to unity exactly. Using this normalization method implies each cluster has the same weight. However, using the assumption of equal weight for each cluster to obtain the weighted supermatrix seems to be irrational because there are different degrees of influence among the criteria. Thus, the purpose of this paper is to establish a model to overcome the problems of interdependence and feedback between criteria and alternatives in the real world.

III. METHODOLOGY

A. Research framework chart:



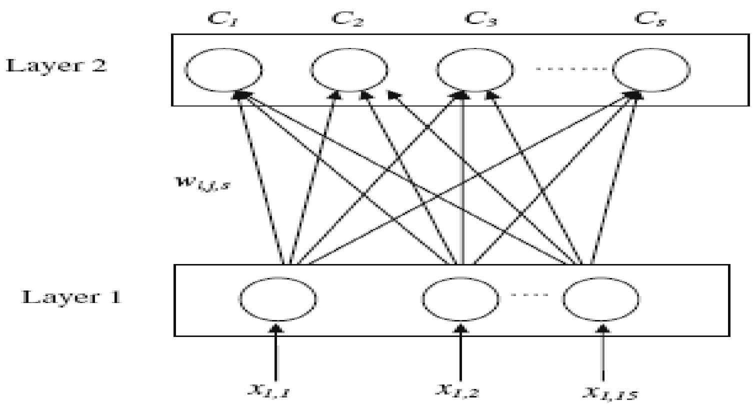
As shown in figure , the framework can be divided into four levels. The first level is indentifying that product and supplier. Second level is specifying that product which has many suppliers. Criteria for evaluating supplier performance are listed in the third level; these criteria are interrelated. Each criteria has several sub criteria that are listed in the third level. In the fourth level data will divide into two parts: large data and normal data. The large data classify by FART then go to ANP to weighting and normal data go into ANP directly and final selection and evaluation will be done. More description and details about methodology is available on next parts.

The proposed algorithm for classification of supplier using Fuzzy ART

Fuzzy ART neural network involves several differences according to ART 1: (1) non-binary input vectors can be processed; (2) there is a single weight vector connection; and (3) in addition to vigilance threshold (ρ), two other parameters have to be specified: a choice parameter (α) and a learning rate (β)[24].

The main characteristic of Fuzzy ART methodology is adaptation; algorithm controls the similarity between input values. By considering the vigilance parameter, it defines the membership of each input to the appropriate category. This method aims to support the DMs for determining the suitable suppliers. For this purpose Fuzzy ART algorithm categorize the candidate suppliers, according to their similarities with the aid of the vigilance parameter.

The number and boundaries of resulting supplier categories and category memberships of the suppliers are determined by the algorithm on its own. The used Fuzzy ART model for supplier selection is shown in follow figure:



As shown in figure, fuzzy ART model for supplier selection. xij is the input of the model: rating of the j evaluation criterion for the i candidate supplier. Cs represents the supplier category. w_{ijs} represents the weights between Layer 1 and Layer 2. Also it determines the membership of each input at Layer 1 to the categories at Layer 2 [24].

The stepwise explanation of the Fuzzy ART Supplier Selection and Evaluation methodology that modeled above is as follows:

Step 1 – Building the DM committee: This committee is formed to identify the evaluation criteria, and makes a preliminary if necessary.

Step 2 – Rating: DM committee determines the grading scale and rates each candidate supplier according to evaluation criteria.

Step 3 – Normalization.

Step 4 – Determining parameters for supplier selection.

Step 5 – Determination of initial weights.

Step 6 – Representation of input values.

Step 7 – Computation of choice function value.

Step 8 – Selection of maximum choice function value.

Step 9 – Matching test.

Step 10 – Resetting.

Step 11 – Updating weights.

Step 12 – Repeat: The algorithm continues with the next input at step 6. Stop if all data is allocated to s different categories.

Step 13 – Prioritization of categories: Obtained supplier categories should be prioritized. Arithmetic mean of the input values in each class is used as prioritization measure. Categories are ranked by their priority and then labeled.

Proposed algorithm for weighting of criteria and selection of supplier using ANP

Generally AHP and ANP involve four basic steps: (1) deconstructing a problem into a complete set of hierarchical or network models; (2) generating pairwise comparisons to estimate the relative importance of various elements at each level; (3) building a supermatrix to represent the influence priority of elements; and, (4) making decisions based on the supermatrix. The final procedure is suitable when using the ANP approach.

The following sections designs a supplier performance evaluation model based on these steps:

Step1. Criteria's determination

Step2. Modifying the first model

External experts in supply chain management and chiefs of operation and management departments will invite to identify appropriate criteria to evaluating supplier performance. After identifying the dimensions for evaluating supplier performance and the associated criteria, reviewers identify the interrelationships among the criteria. The interrelationships provide the foundation for prioritizing improvement efforts when attempting to maximize the return from performance improvement activities.

Step3. Building the evaluation model

After building the AHP/ANP-based framework, pairwise comparisons are performed. In Step 2, the relationships between factors in the first and second levels (part A) are shown in the network structure, and the relationships between factors in the second and third levels (part B) follow a strict hierarchical structure. Therefore, the ANP approach is applied to part A, and the AHP approach is applied to part B. To perform pairwise comparisons, separate questionnaires will prepar for the goal and each dimension. The heads of outsourcing departments, heads of purchasing departments, heads of manufacturing departments, and heads of management departments and they will utilize to answer the designed question.

A Saaty's scale ranging from 1–9 scale will use to gauge answers, where, 1 denoted "equal importance", 3 represented "moderate importance", 5 was "strong importance", 7 denoted "very strong importance", and 9 was "extreme importance" [10].
The pairwise matrix can be defined by

$$\boldsymbol{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix},$$

Where n is the order of matrix.

Then the consistency property in the pairwise comparison will examin by the procedure as following[47]:

(1) Build the normalized pariwise comparison matrix A1

$$\boldsymbol{A_1} = \begin{bmatrix} a_{11}' & a_{12}' & \cdots & a_{1n}' \\ a_{21}' & a_{22}' & \cdots & a_{2n}' \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1}' & a_{n2}' & \cdots & a_{nn}' \end{bmatrix},$$

And $a_{ij}' = \dfrac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$ for i , j = 1, 2,…, n,

(2) Calculate the eigenvalue and the eigenvector.

$$\boldsymbol{W} = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}, \text{ and } w_i = \frac{\sum_{i=1}^{n} a_{ij}'}{n} \text{ for } i = 1, 2, \ldots, n,$$

$$\boldsymbol{W'} = \boldsymbol{AW} = \begin{bmatrix} w_1' \\ w_2' \\ \vdots \\ w_n' \end{bmatrix}, \qquad \text{and} \qquad \lambda_{max} = \frac{1}{n}\left(\frac{w_1'}{w_1} + \frac{w_2'}{w_2} + \cdots + \frac{w_n'}{w_n}\right),$$

Where W is the eigenvector, wi is the eigenvalue of criterion I, and λmax is the largest eigenvalue of the pairwise comparison matrix.

CONCLUSION

In this paper, a new hybrid method based on classification method and MCDM methods was proposed. It is shown that the new method can deal with supplier selection problem when the amount of suppliers' data increased. ANP is employed to weight the criteria. After that, FART was used to group suppliers into four predefined clusters. The main contributions of this study are described as follows:

1. A new method of decision support system for supplier selection will be developed.
2. The pre-processing of suppliers' data will be facilitated.
3. FART integrated with ANP will be used to cluster the suppliers.

In spite of the fact that a large numbers of suppliers generate difficulties in the process of decision making; the proposed approach has overcome this problem by employing data mining methods to transfer the data into useful information. As a result, managers can benefit from the major advantage of the proposed method.

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