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An integrated method for finding key suppliers in SCM

Rong-Ho Lin [a], Chun-Ling Chuang [b,*], James J.H. Liou [c], Guo-Dong Wu [a]

[a] National Taipei University of Technology, Department of Business Management, No. 1, Section 3, Chung-Hsiao East Road, Taipei 106, Taiwan, ROC
[b] Kainan University, Department of Information Management, No. 1, Kainan Road, Luzhu, Taoyuan 338, Taiwan, ROC
[c] Kainan University, Department of Air Transportation, No. 1, Kainan Road, Luzhu, Taoyuan 338, Taiwan, ROC

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ABSTRACT

Association rule is a widely used data mining technique that searches through an entire data set for rules revealing the nature and frequency of relationships or associations between data entities. Supplier selection is a significant work in supply chain management. Often, there will be thousands of potential suppliers and identifying a subset of these suppliers can be a complex process of determining a satisfactory subset based on a number of factors. In this paper, the supplier selection can be viewed as the problem of mining a large database of shipment. The proposed method incorporates the extended association rule algorithm of data mining with that of set theory to find key suppliers. This research has employed a numerical example for the integrated method to develop suitable supplier clusters. The results show that the method is effective and applicable.

1. Introduction

In today's ever-changing markets, many businesses move human resources, materials and information from some place to some other place throughout the world. Businesses around the world are attempting to position themselves to operate in a highly competitive marketplace. Gunasekaran (1999) indicates no single organization can respond quickly enough to the changing markets in a competitive environment of this type. Thus, competitive pressures over the past few years have promoted supply chain management (SCM) as one key strategy by which enterprises can make improvements to their business strategies (Fisher, Hammond, Obermeyer, & Raman, 1994). According to Simchi-Levi, Kaminski, and Simchi-Levi (2000), supply chain management is 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, at the right time, in order to minimize system-wide costs while satisfying service level requirements. The performance of the chain depends on every single organization involved. To attain a good performance for remaining competitive, the selection of an appropriate supplier can be important for a firm's competitive advantage. Selecting the right suppliers can significantly improve corporate competitiveness.

Developing a suitable approach for supplier selection is however a challenging research task. Often, there will be thousands of potential suppliers and identifying a subset of these suppliers can be a complex process of determining a satisfactory subset. AR can identify a subset of key suppliers. However, AR is a computationally and I/O intensive task. An exhaustive search over this exponential space is infeasible for anything except small values. Set theory can simplify complex processes of AR. In this research, the approach combining association rule (AR) with set theory is centered on developing suitable supplier clusters to find primary suppliers and secondary suppliers.

The remainder of this paper is organized as follows. The supplier selection model and association rule relating with brief literatures are reviewed and discussed in Sections 2 and 3. An integrated method is derived and proposed in Section 4. A numerical example is used to demonstrate the proposed method in Section 5. Discussions are presented in the Section 6 and conclusions are in the last section.

2. Supplier selection method

With the advent of supply chain management, much attention is now devoted to supplier selection. Supplier selection is a decision-making problem. In the supplier selection process, there are four phases: (1) problem definition (2) defining the criteria (3) pre-qualifying suitable suppliers (4) making a final choice. Most literature on supplier selection focuses on pre-qualifying suitable suppliers (Timmerman, 1986; Liu, Ding, & Lall, 2000) and making a final choice (Ghodsypour & O'Brien, 1998; Holt, 1998; Barbarosoglu & Yazgac, 1997). Usually, the existing literature on supplier selection method can be subdivided into two fields: Firstly, some publications have addressed this issue in recent years to discuss

* Corresponding author. Tel.: +886 33412500x6107; fax: +886 33412173.
E-mail addresses: rhlin@ntut.edu.tw (R.-H. Lin), clchuang@mail.knu.edu.tw (C.-L. Chuang).

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the complexity of the supplier selection from the points of view of Operations Research (OR). OR offers a range of methods and techniques, which may aid a decision-maker in finding optimal solutions of problems, such as linear programming (Pan, 1989), mixed integer programming (Jayaraman, Srivastava, & Benton, 1999; Rosenthal, Zydiak, & Chaudhry, 1995), goal programming (Sharma, Benton, & Srivastava, 1989; Hajidimitrious & Georgiou, 2002), and other quantitative approaches (Weber & Current, 1993; Degraeve, Labro, & Roodhooft, 2004).

Secondly, some other different methods for supplier selection have been proposed in the literature. Those methods include linear weighted point (Barbarosoglu & Yazgac, 1997; Li, Fun, & Hung, 1997), cost ratio (Timmerman, 1986), analytic hierarchy process (AHP) (Narasimhan, 1983; Ghodsypour & O'Brien, 1998), data envelopment analysis (DEA) (Weber, Current, & Desai, 1998), clustering analysis (Holt, 1998), and some others (Lau, Chin, Pun, & Ning, 2000; Samadhi & Hoang, 1998; Ghobadian, Stainer, & Kiss, 1993).

3. Association rule

AR, a quite widely used data mining technique, is used to search through an entire data set for rules of revealing the nature and frequency of relationships or associations between data entities. Moreover, the task of mining association rules is essentially to discover strong association rules in large databases. In the past, the association rule, based on the market basket analysis, is directed toward establishing "aggregate" customer behaviors to help managers to determine, which items are frequently purchased together by customers. Recently, there has been a marked tendency to extend the association rule in a wider variety of problems of academia and practitioners with applications, such as customer relation management (CRM), market baskets analysis (MBA), economic and financial time-series analysis, production process, are manufacturing diagnosis (Chen, Wei, Liu, & Wets, 2002). Many algorithms to find association rules have been proposed in the literature (Agrawal, Imielinski, & Swami, 1993; Houtsma & Swami, 1993; Agrawal & Srikant, 1994; Mannila, Toivonen, & Verkamo, 1994; Park, Chen, & Yu, 1995; Holsheimer, Kersten, Mannila, & Toivonen, 1995; Savasere, Omiecinski, & Navathe, 1995; Agrawal & Shafer, 1996; Zaki & Hsiao, 1999; Chen et al., 2002).

Part of the basic terminology of association rule is introduced in the original work described by Agrawal et al. (1993) as follows.

Let $I = \{i_1, i_2, \ldots, i_m\}$ be a set of m distinct attributes, also called items. A set of items is called an itemset, and an itemset with k items is called a k-itemset. Each transaction T in the database D of transactions, has a unique transaction identifier data (TID), and contains a set of items, such that $T \subseteq I$. An association rule is an expression $A \Rightarrow B$, where itemsets $A,B \subset I$, and $A \cap B = \emptyset$. Each association rule $A \Rightarrow B$ has two measurements relative to a given set of transactions: its support and its confidence. The support of the rule is the percentage of transactions that contains both A and B among all transactions in the input data set. Each itemset is said to have a supports if s of the transactions in D contain the itemset. It also has confidencec, if c of the transactions that contain A also contain B, i.e., c = support $(A \cup B)$/support (A), the conditional probability that transactions contain the itemset B, given that they contain itemset A. In other words, the confidence of a rule measures the degree of the correlation between itemsets, while the support of a rule measures the significance of the correlation between itemsets.

4. An integrated method

For organizations that experience uneven demands, bottlenecks may occur if the supplier's production capacity is insufficient to meet a peak demand. Having additional suppliers alleviates this problem (Jayaraman et al., 1999). To reduce the risk of the selected suppliers being unable to deliver as required, the proposed method establishes an available function for identifying clusters of potential suppliers capable of supplement to meet the required demands.

The method focuses on developing suitable supplier clusters and is classified into two stages. First, identifying critical parts, then using AR to classify the critical parts based on the shipment record in order to find suppliersets (supplier clusters). However, manufacturers tend to give their primary suppliers first priority when placing orders. If the needed parts are unavailable at the primary suppliers, then the order goes to the secondary (alternative) suppliers. Second, identifying primary suppliers and secondary suppliers by the set theory from the supplier clusters, the second stage proceeds to measure each cluster availability value, i.e. the ability to satisfy the required demands. The process in the proposed method is illustrated in Fig. 1.

4.1. Identify the critical parts

Usually an organization has complex product lines with deep bills of materials. A large number of parts will be offered by a lot of suppliers. Working with fewer suppliers makes long-term relationships with these suppliers easier. Parts should be classified according to the importance of products. The selecting methods are widely used as purchasing portfolio analysis for high-risk and high-volume, and Pareto analysis for high-value-added parts (Krause, Handfield, & Scannell, 1998).

4.2. Find the supplierset(s)

To reduce supplier bases, this research has to extend the traditional association rule from merchandise items to supplied parts. The algorithm for finding the maximum frequent partset(s) shown in Fig. 2 is to find key suppliers. First of all, set up minimum support (min_supp) for a frequent partset; then, find maximum frequent partset(s), when the support of k-partset is greater than min-supp and the k-partset is the maximum frequent of partset. Therefore, the maximum frequent partset can represent that those parts in partset are frequent purchased in the same time. A subset

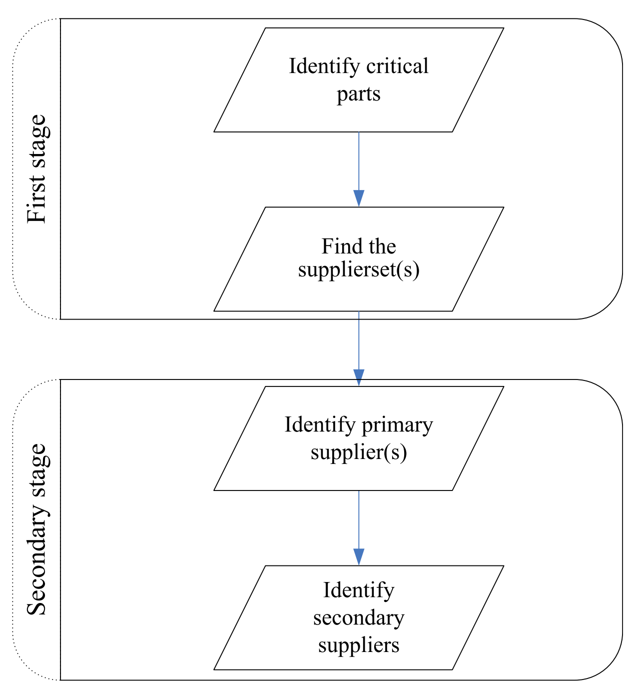

Fig. 1. Supply chain member selection method.