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A rough set based approach to distributor selection in supply chain management

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ABSTRACT

Distributor's selection is an important issue in Supply chain management, particularly in the current competitive environment. The current research works provide only conceptual, descriptive, and simulation results, focusing mainly on firm resources and general marketing factors. The selection and evaluation of distributors generally incorporate qualitative information; however, analyzing qualitative information is difficult by standard statistical techniques. Consequently, a more suitable approach is desired. In this paper, a method based on Rough set theory, which has been recognized as a powerful tool in dealing with qualitative data in the literature, is introduced and modified for preferred distributor selection. We derived certain decision rules which are able to facilitate distributor selection and identified several significant features based on an empirical study conducted in China.

1. Introduction

Industry is now strongly recognizing that total management of the supply chain enhances the competitive edge of all "players" therein. As a result, Supply chain management (SCM) has received more attentions from both academicians and practitioners in the past decade. Many articles and books have been published for the methods and opinions about the application of supply chain management. Although there is no generally accepted notion of supply chain, at least it should contain the suppliers' suppliers and the customers' customers. Supply chain in this paper refers to a network of integrated and dependent process through which specifications are transformed to finished deliverables. Fig. 1 depicts a conceptual framework for supply chain.

Supplier selection and evaluation play an important role in the supply chain process and are crucial to the success of manufacturing firms (Sevkli, Lenny Koh, Zaim, Demirbag, & Tatoglu, 2008). There are many researchers in supplier selection, and many methodologies are applied in practice, such as the cost-ratio method, linear or mixed integer programming to goal and multi-objective linear programming models (Ghodsypour & O'Brien, 1998; Oliveria & Lourenco, 2002; Yan, Yu, & Cheng, 2003). Although these methods have been widely used in the area of supplier selection, there are certain drawbacks associated with the implementation of these methods. Apart from these traditional methods for supplier selection, recently fuzzy systems theory has been successfully applied to supplier selection problems (Chan & Kumar, 2007; Kahraman, Cebeci, & Ruan, 2004; Kahraman, Cebeci, & Ulukan, 2003), and Rough set theory (RST) has also been applied for preferred suppliers prediction (Tseng, Huang, Jiang, & Ho, 2006).

To date, numerous literatures have explored the issues of supplier selection. In contrast, little work has been done in selection of distributor, particularly in empirical studies. Only conceptual, descriptive and simulation results focused primarily on firm resources and general marketing/selling factors were discussed (Abratt & Pitt, 1989; Cavusgil, Yeoh, & Mitri, 1995; Shipley, Cook, & Barnett, 1989; Yeoh & Calantone, 1995). It should be noted that distributor selection has not been studied deeply and the theoretical methods developed by academics have not been fully applied in industry. In this paper, we propose a rough set based methodology which is able to perform rule induction effectively. Moreover, the weight of each input feature is incorporated in the proposed approach so as to enhance quality of the derived rules.

The remainder of this paper is organized as follows: The next section introduces the background of distributor rough set theory and the standard rough set-based rule induction problem. Section 3 presents the basic rule identification algorithm to determine the reducts with both equal and unequal weight features. A case study is presented to show how the rule identification approach can be applied to distributor selection in Section 4. Section 5 concludes the paper with discussion of empirical findings and future research directions.

2. Literature review and rough set-based rule induction problem

2.1. Literature review on distributor research

As mentioned above, there are few empirical studies for manufacturers' distributor selection. Ross (1973) studied the selection of

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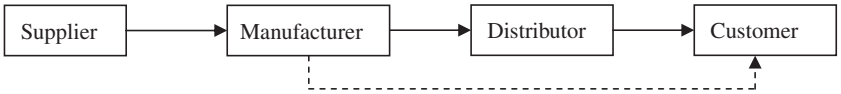

Note: The dash-line indicates a few factories sell their products directly to the customers.

Fig. 1. The conceptual framework for supply chain.

the overseas distributor. The author concluded that whether or not the exporter will be able to achieve his goals depends to a great extent on how well he has carried out his analysis of which firm will do the best possible job for him in a particular market. Lindqvist (1983) reviewed the research trends in distribution in Finland and found that the factors affecting the length of the distribution channel, the variables accounting for dimensions of retail trade in commune level centers, and the influence of the location and size of the automobile dealership on its profitability are at the heart of distribution research. Fram (1992) highlighted the importance of selecting the correct international distributors if a firm wishes to trade effectively in the worldwide market. The author described a study commissioned exploring the steps required to minimize the risk when selecting a distributor, e.g., use of end-user reference and suggestions.

Fonsson and Zineldin (2003) proposed a conceptual model including behavioral dimensions of supplier–dealer relationships and presented hypotheses about how to achieve satisfactory inter-organizational relationships. Their results showed that good reputation and close relationship are key variables for the achievement of high satisfaction in a "high-trust and commitment relationship". Sharma, Sahay, and Sachan (2004) proposed a composite Distributor Performance Index (DPI) to evaluate distributors' performance. Based on a case study, Wang and Kess (2006) found that task-related and partner-related dimensions in partner selection of international joint ventures were useful in distributor relationship. A distributor relationship is a product-tied relationship, and product innovation can be used as an approach for performance improvement in distributor relationship. Lin and Chen (2008) derived four key constructs from marketing, supply chain, and logistics literature to investigate their influences on the distributor selection.

2.2. Rough set-based rule induction

Rough set theory (RST) was originated by Pawlak (1982) and was developed to classify imprecise, uncertain, and incomplete information or knowledge expressed in terms of data acquired from experience; therefore, RST complements fuzzy set theory (Dubois & Prade, 1990). RST is suitable for processing qualitative information that is difficult to analyze by standard statistical techniques (Heckerman, Mannila, Pregibon, & Uthurusamy, 1997). It integrates learning-from-example techniques, extracts rules from a data set of interest, and discovers data regularities (Komorowski & Zytkow, 1997).

RST is a new mathematical approach to vagueness and uncertainty. The theory has found many real life applications and is considered as a very well suited new mathematical tool to deal with various decision problems. Many papers on rough set theory and decision support have been published recently. RST gives new insight into the decision process and offers new efficient algorithms. The original version of RST has proved to be particularly useful in the analysis of multi-attribute classification problems under inconsistency following from information granulation, i.e., objects having the same description but belonging to different classes.

Greco, Matarazzo, and Slowinski (2000) extended the original version of RST in a number of directions in order to deal with problems of multi-criteria decision analysis (MCDA). Daubie, Levecq, and Meskens (2002) compared the rough set and decision tree approaches as techniques for classifying credit applicants. Mickee (2003) applied RST to deal with the problem of apparent indiscernibility between objects in a set. Wei and Zhang (2004) combined the fuzzy set and rough set. Kumar, Agrawal, and Joshi (2005) explored the use of rough-set methods for marketing decision support systems in the retail business. Some other applications are summarized in Table 1.

The main theme of RST is concerned with measuring what may be described as the "ambiguity" inherent in the data. In RST, the essential distinction is made between objects that may definitely be classified into a certain category and those that may possibly be classified. Considering all decision classes yields what is referred to as the "quality of approximation" that measures the proportion of all objects for which definite classification may be achieved.

2.2.1. Information system

According to RST, information can be associated with every object in the universe and thus it can be expressed in a decision table (e.g., see Table 2), in which each row represents an object and each column represents an attribute. The attributes are generally classified into *conditions* and *decisions* (e.g., in Table 2, the four features – $F1$, $F2$, $F3$, and $F4$ – define the conditions and O describes the decision).

Table 1
Rough set application.

Applications	Researchers	Description
Human resource management	Chien and Chen (2007)	Exploring and analyzing human resource data for personal selection and human capital enhancement
Supplier prediction	Tseng et al. (2006)	Presenting a data mining-based hybrid approach that consists of a novel rough-set algorithm for feature selection and enhanced multi-class support vector machines (SVMs) method for accurate prediction
Marketing application	Beynon, Curry, and Morgan (2001)	Identification of most important attributes and induction of decision rules from market data set
Medical decision making	Kusiak, Kern, Kernstine, and Tseng (2000)	Analysis of large data sets to identify key factors in a medical data set
Fault diagnosis on diesel engine	Shen, Tay, Qu, and Shen (2000)	A new discretization method is developed for discretizing attributes without a priori knowledge
Risk management	Dimitras, Slowinski, Susmaga, and Zopounidis (1999)	Rough set based approach to rule extraction to discriminate between healthy and failing firms for risk management