Expert Systems with Applications 42 (2015) 6224–6236

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

The application of ISM model in evaluating agile suppliers selection criteria and ranking suppliers using fuzzy TOPSIS-AHP methods

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ARTICLE INFO

Article history:
Available online 4 April 2015

Keywords:
TOPSIS
Agile suppliers
Interpretive structural model
Hierarchical analysis
Fuzzy environment

ABSTRACT

In the present competitive world, the organizations need to endeavor constantly so as to make progress as well as maintaining their current position through employing the appropriate strategies. Organizations surroundings have been undergoing rapid changes among which the different demands and the variety of customers are to be mentioned. The scarce and limited number of sources and facilities are also worth being cited as another example of an important restrictions placed on companies. One way to bring down these problems is employing agile suppliers and outsourcing appropriately. The current study results from two theses completed in the fields of agility and ISM. It begins with identifying the criteria to evaluate agile suppliers. Then these factors are ranked and categorized using the interpretive structural model. The results of this study depict that the delivery speed variable lays on the bottom level of the model outlet with quite high driving power. The delay reduction variable has the same characteristics. Next, using fuzzy hierarchical analysis method, the weight of the agility evaluation criteria of suppliers are measured and put as TOPSIS model input. Finally, six suppliers are rated using fuzzy TOPSIS method. The results of this study shows that the criteria with higher driving power and lower dependence have higher weight in AHP model. It is, therefore, necessary to focus on variables of the first and second level of model in order to increase suppliers' agility. In this study, the weight of data has been determined using hierarchical analysis so as to increase the efficiency of the results of fuzzy TOPSIS technique. At the same time, interpretive structural model has been also employed to interpret the effects of the criteria on suppliers.

1. Introduction

In the past, an organization's products including services or goods used to be bought by customers, and organizations did not have to show any concerns about making any changes or improving their system. As a matter of fact, customers had no choice except to purchase the goods available in the market. However, with the number of manufactures and, as a result, competitors being increased gradually, customers had more freedom to choose and buy whatever suited their preferences among a wide variety of products and organizations offering them. Rapid technological revolution, risk increase, globalization, and privatization expectations are of environmental features with which the current trading organizations are dealing. To succeed in this environment, agility creates a competitive advantage which can be preserved by being famous for innovation and quality. An agile organization makes processes and people compatible with new state-of-the-art technology and accommodates customer's needs based on its quality products and services in a rather short period of time. This certainly would occur when agility was considered a disciplined organizational value and a competitive strategy for managers. In this regard, organizations have to offer the products which can gain customer's satisfaction. Supply chain management and supplier selection process has been given a particular consideration recently. In 1990s a lot of factories were searching for a way to share with suppliers so that they can improve their management efficiency and competitiveness. The supplier and consumer relationship has been seriously considered. Supply chain of a company would be a strong and serious barrier against competitors if there were a long lasting relationship between these two items (Shahaei, 2007). With purchase and supply growth, purchase decisions have become of more importance and since current organizations are more dependent on suppliers, the direct and indirect consequence of feeble decision making appears more serious (De Boer, Labro, & Morlacchi, 2001). In most industries, the cost of raw materials and the constituents of the product accounts for

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http://dx.doi.org/10.1016/j.eswa.2015.02.035
0957-4174/

the main proportion of price of the finished product (Ghodsypour & O'brien, 1998). In this regard, supply section can play a key role in the performance and efficiency of an organization and has a direct effect on cost minimization, profit making, and flexibility of a company (Ghodsypour & O'brien, 2001). Supply chain is a network which includes all tasks pertinent to goods stream and conversion from raw material to final product stage as well as the corresponding information system. The materials and information are both flowing at the top and bottom of the network and for the supply chain to have a good performance and to gain customer satisfaction, a proper management is needed (Farahani & Asgari, 2007). As a matter of fact, selecting an appropriate collection of suppliers serves a vital function for a company to succeed, on which there has been great emphasis since a long time ago (Zhang, Lei, Cao, To, & Ng, 2003). With the concept of supply chain management having been introduced recently, a majority of researchers, scientists, and managers have found selecting the appropriate supplier and managing it a useful way which can be used to improve supply chain competitiveness (Lee, Ha, & Kim, 2001). Considering a supplier as a supply chain network with the ultimate goal of offering customer's expected product has been introduced and discussed since 2000 (Ali Ahmadi, Tajeddin, & Fatola, 2003). Foreign suppliers contribute to cost minimization, better delivery, and customer satisfaction; in other words, if a company can get in contact with foreign suppliers, it would be one of the most significant duties of the manager to select the supplier. In 1974, Warfield introduced the ISM approach to identify interrelationships between factors from a recommended list (Jindal and Sangwan, 2013; Kannan & Haq, 2007; Kannan, Pokharel, & Sasi Kumar, 2009) This approach was also used to identify the influential role of factors from a recommended list, and it suggested the use of expert opinions based on various management techniques such as brainstorming, nominal technique, etc. to develop a contextual relationship among variables. Attri, Dev, and Sharma (2013) summarized that the ISM technique was an interactive learning process where a set of different and directly related elements are structured into a comprehensive system model. In addition, ISM is a better approach to solve the complexity of relationships with many elements (Mathiyazhagan & Haq, 2013). Similarly, Ansari, Kharb, Luthra, Shimmi, and Chatterji (2013) pointed out that ISM enables individuals or groups to develop a map of the multiple relationships between many elements involved in a complex situation. Generally, ISM is a combination of three modeling languages – words, digraphs, and discrete mathematics – to ensure a solution to a structure of complex issues. This approach is used for an effective decision making process. It is also used traditionally in management studies. The researchers selected this approach because of its benefits; direct and indirect relationships between variables based on situations are revealed far more accurately than individual factors taken in isolation (Cagno, Micheli, Jacinto, & Masi, 2014). In fact, ISM method states that how the factors being studied such as cost, supply chain, innovation, and etc are involved in a company to meet its targets and how they are dependent. That is to say, these features are agility drivers which have been introduced by several different researchers for years. According to the studies done, achieving agility can guarantee the persistence and progress of an organization. These features are explained in details in the agility section. One important aspect of agility is the supply chain section of an organization. If the management section can select the agile and prominent supplier using the appropriate factors and methods, it will be of great help for the organization to achieve its goals. Interpretive structural model is capable of identifying the relationship between criteria which have individual or group dependence on each other. Multi-criterion decision making is one of the research areas in operational and management science which considering various functional needs has been developed rapidly during the current decade. Computers have helped decision making techniques be quite acceptable in all steps of decision making process. Applying computers has had a considerable increase particularly in recent years; therefore, considering mathematical complexities it has become very easy to use multi-criterion decision making methods. Decision making is a way to find the best choice from a set of existing choices. When several criteria are considered in decision making problems, they are called multi-criterion decision making (MCDM) problems (Wang, Lee, & Lin, 2003). Since making decision and selecting agile supplier by an organization is a decision making problem on which several criteria have effect, one of the multi-criterion decision making methods called analytical hierarchical process, AHP, is used in this study. Choy and Lee (2002) introduced a decision making model for suppliers in which the most important suppliers' task are defined in five sections (Choy, Lee, & Lo, 2002). Sarkis and Talluri (2002) have offered a model to evaluate suppliers which has ranked factors based on analytic network process, ANP. Ravi, Shankar, and Tiwari (2005) evaluated and selected the suppliers of a computer network using balance score card and decision making model based on ANP. Ravi et al. (2005) determined eleven barriers to select suppliers in car industry and used ISM methodology to analyze the interaction of these barriers. The details of supplier's selection are introduced by the scientists like Kannan, Haq, Sasikumar, and Arunachalam (2008) and Pokharel and Mutha (2009). Kannan and Haq (2008) used ISM and AHP in a certain environment to determine the ranking and the interaction of different criteria to select a supplier based on his performance.

ISM analyzes the relationship between criteria by decomposing them into different levels (Kannan et al., 2009). ISM can be used to analyze the relationship between the features of several variables which are defined for a problem (Jw, 1974). The study carried out by Saxena and Vrat (1992) centers on the ISM function to analyze the relationship between defined variables for cement factory in India. Mandal and Deshmukh (1994) used ISM method to analyze the most important criteria to select the best vendor and the relationship between criteria. Also Sharma (1995) has hierarchically analyzed necessary tasks for a sound production management. Kannan and Haq (2007) have analyzed the criteria and sub criteria needed to select supplier. ISM methodology has few limitations and identifying the relationship between the variables usually depends on the information and the decision maker's acquaintance with the company being studied. Consequently, the individuals' judgment, on the variables can influence the final result (Kumar, Kee, & Manshor, 2009). Despite the wide and successful applications of AHP in a lot of decision making problems, it has always been criticized for its inability in managing uncertainty resulting from relating whole numbers to decision makers' understanding (Deng, 1999). The natural approach to confront the judgments or uncertain decisions is to use fuzzy sets or fuzzy numbers in comparison ratios. In this study, the given framework to analyze and evaluate the agile suppliers includes a number of stages in part of which the fuzzy AHP method has been used to weigh criteria. TOPSIS is a well-known technique for classic MCDM, firstly proposed by Hwang and Yoon. The underlying logic of TOPSIS is ideal and negative ideal solution. The ideal solution is the solution that maximizes benefit criteria and minimizes cost criteria. To sum up, the ideal solution includes all the best values of available criteria while the negative ideal solution is mixture of the worst values of available criteria. The best alternative is the one which has the shortest distance from the ideal solution and the farthest distance from the negative ideal solution. Considering the fact that TOPSIS is a well-known method for classic MCDM, a lot of researchers use it to solve the FMCDM problems. Some researchers have done dis-Fuzzy rates and weights (Yu, 2002). While dis-Fuzzy lead to a loss of some data, some others