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Supplier selection with an integrated methodology in unknown environment

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ABSTRACT

This paper proposes an integrated methodology and its solution for supplier selection problem. A two-stage stochastic programming model and fuzzy TOPSIS methods are consolidated in this methodology. After pre-research phase, in the second part of the methodology, fuzzy TOPSIS is used for ranking potential suppliers considering qualitative data under fuzzy environment. In the third part of the methodology a group of ranked potential suppliers are included in a two-stage stochastic programming model for evaluation. In the two-stage stochastic programming model demand is assumed as uncertain and different scenarios are generated for this parameter. With this methodology, supplier evaluation procedure can be done in unknown environment. Our methodology is interested with a problem in multi-product, multi-period and multi-sourcing environment.

1. Introduction

A supply chain is a network of suppliers, manufacturing plants, warehouses, and distribution channels organized to acquire raw materials, convert these raw materials to finished products, and distribute these products to customers (Bidhandi, Yusuff, Ahmad, & Abu Bakar, 2009). Companies' primary goal is to satisfy customer demands. For this reason they need to plan each chain in their networks. The first chain of the network is the supplier chain. This supplier planning process has an extremely important role in operating whole network accurately. If companies want to get raw material in required specifications with a low cost and high speed, a detailed survey has to be done in supplier selection process. Selecting an appropriate supplier can significantly reduce purchasing costs, decrease production lead time, increase customer satisfaction, and strengthen corporate competitiveness. Firms should select the most appropriate suppliers according to the production capacity of all potential suppliers and build long-term and profitable relationships with them (Wang & Yang, 2009).

The selection of techniques is based on these reasons: selection process involves conflicting criteria. Therefore, techniques that propose solutions considering different criteria help decision-makers in getting accurate results. Multi-criteria approaches are convenient for this kind of problems. Also necessity of using crisp evaluations is removed in fuzzy multi-criteria approaches. In this manner, uncertainty can be represented in a more consistent way. The technique for order performance by similarity to ideal solution (TOPSIS) (Hwang & Yoon, 1981) is a widely accepted multi-attribute decision-making technique due to its sound logic, simultaneous consideration of the ideal and the anti-ideal solutions, and easily programmable computation procedure (Karsak, 2002). This technique is based on the concept that the ideal alternative has the best level for all attributes, whereas the negative ideal is the one with all the worst attribute values. In fuzzy TOPSIS, attribute values are represented by fuzzy numbers. Using this method, the decision-maker's fuzzy assignments with different rating viewpoints and the trade-offs among different criteria are considered in the aggregation procedure to ensure more accurate decision making.

Another efficient way of representing uncertainty is two-stage stochastic programming represented by Birge and Louveaux (1997). In this modeling uncertain parameters can be easily included in the model. They can be represented by random events. Also decisions can be taken before or after random events are realized.

The proposed methodology integrated two techniques. In the second phase, all potential suppliers are ranked and grouped in a fuzzy environment with different qualitative opinions. The best group that has the highest ranking in fuzzy environment is included in the third phase. This phase can be called as "pre-evaluation" phase. By this way, the suppliers that have low attributes are eliminated and not included in the third phase. In the third phase, two-stage stochastic programming method is performed under demand uncertainty. The outputs of our methodology are the selected suppliers and flow amounts. By this way, potential suppliers are evaluated under qualitative data and uncertain demand. The special feature of our methodology is to be not confusing. Owing to the pre-evaluation procedure in the second phase, a clear evaluation process can be carried out.

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The most applied techniques for supplier selection problem are multi-criteria decision-making approaches and mathematical programming models. Some examples of recent studies in fuzzy multi-attribute decision making are as follows: Wu (2009), used grey related analysis and Dempster–Shafer theory to deal with this fuzzy group decision-making problem. Boran, Kurt, and Akay (2009), combined the technique for order preference by similarity to ideal solution (TOPSIS) method with intuitionistic fuzzy set is proposed to select appropriate supplier in a group decision making. Tseng, Chiang, and Lan (2009) proposed a novel hierarchical evaluation framework, based on "ANP" and "Choquet integral" to assist the expert group to select the optimal supplier. Chen and Wang (2009), provided a more efficient delivery approach for evaluating and assessing possible suppliers/vendors using the fuzzy VIKOR method. Önüt, Soner Kara, and Işik (2009), developed a supplier evaluation approach based on the analytic network process (ANP) and the technique for order performance by similarity to ideal solution (TOPSIS) methods to help a telecommunication company in the GSM sector in Turkey under the fuzzy environment where the vagueness and subjectivity are handled with linguistic terms parameterized by triangular fuzzy numbers.

Also some researchers integrated multi-attribute decision making and mathematical programming applications. Lin (2009) suggested a comprehensive decision method for identifying top supplier by considering the effects of interdependence among the selection criteria by using analytic network process (ANP) and Fuzzy preference programming. Kokangul and Susuz (2009) integrated analytical hierarchy process and non-linear integer and multi-objective programming which is applied to determine the best suppliers and to place the optimal order quantities among them. Aktar Demirtas and Ustun (2009) suggested an integrated approach of Archimedean goal programming (AGP) and analytic network process (ANP) to evaluate the suppliers and to determine their periodic shipment allocations given a number of tangible and intangible criteria. Ustun and Aktar Demirtas (2008) proposed integrated approach of analytic network process (ANP) and multi-objective mixed-integer linear programming (MOMILP) for choosing the best suppliers and defines the optimum quantities among selected suppliers. Lee, Kang, and Chang (2009) developed a fuzzy multiple goal programming (FMGP) model to help downstream companies to select thin film transistor liquid crystal display (TFT-LCD) suppliers for cooperation. Fuzzy analytic hierarchy process (FAHP) is applied first to analyze the importance of multiple factors. Besides, Ma and Zhang (2008) considered a configuration problem for a manufacturer's supply network in the presence of volume discounts.

As can be seen from the literature review, several multi-criteria decision-making techniques and mathematical programming solutions were proposed for supplier selection problems. But two-stage stochastic programming models did not applied to these problems. Also integration of a multi-criteria decision-making technique and two-stage stochastic programming models could not be found in the literature. Our study tries to fill these gaps in supplier selection problem. Our study proposes a combined fuzzy TOPSIS and two-stage stochastic programming methodology for evaluating and selecting the most convenient suppliers and flow amounts from them.

The rest of the paper is organized as follows. Section 2 describes the contents of the fuzzy TOPSIS and two-stage stochastic programming methodology. Section 3 presents application of the integrated model to the supplier selection problem as a real world case study. The results of the application and sensitivity analysis are also discussed in Section 3. In Section 4, conclusions, main findings and contributions are drawn and future developments are suggested.

2. Proposed methodology

Our methodology is based on fuzzy TOPSIS and two-stage stochastic programming. The proposed methodology integrated two techniques. In the second phase, all potential suppliers are evaluated by using fuzzy TOPSIS. In the third phase, two-stage stochastic programming method is performed under demand uncertainty. By this way, potential suppliers are evaluated under qualitative data and uncertain demand. The framework of our methodology and short descriptions of applied methods are given in this section.

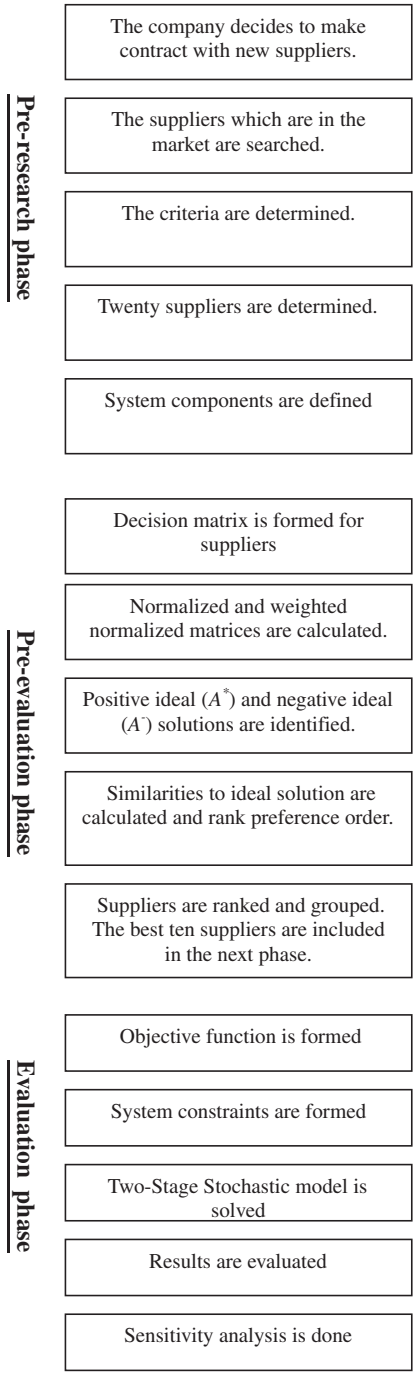

Fig. 1. The framework of the proposed methodology.