Applied Soft Computing 40 (2016) 674–682

Contents lists available at ScienceDirect

Applied Soft Computing

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

A novel multi attribute decision making approach for location decision under high uncertainty

Gül Tekin Temur *

Beykent University, Department of Industrial Engineering Ayazağa Yerleşkesi, Ayazağa Mah., Hadım Koruyolu Cad., 34396 İstanbul, Turkey

ARTICLE INFO

Article history:
Received 12 August 2015
Received in revised form 24 October 2015
Accepted 16 December 2015
Available online 29 December 2015

Keywords:
Cloud based design optimization
Location selection
Multi attribute decision making
Multi criteria decision making

ABSTRACT

Location selection is a multi dimensional issue which requires consideration of quantitative and qualitative evaluation criteria. Some of these criteria may have imprecise and uncertain data which make the location selection decision hard to progress. Although many multi attribute decision making (MADM) techniques are utilized in location decision study field, there is a lack of studies which provide solutions by considering high number of supply chain uncertainties. In this study, against the drawbacks of traditional MADM techniques, a novel MADM approach is applied for location decision under high uncertainty as a first time. In the proposed model, a new notion named as cloud based design optimization (CBDO) is utilized because CBDO can take into consideration certain and uncertain factors simultaneously. Furthermore, it provides robust solution within worst case scenario to existing approaches by mediating between aspects of fuzzy set theory and probability distributions. Robustness enables decision makers have managerial and operational foresights about possible unexpected situations, and take necessary actions against risk. An illustrative example is conducted in warehouse location selection problem area to indicate the performance of the proposed approach. It is revealed out that location decision is very sensitive to the consideration of uncertainty and CBDO can be a helpful supportive tool for decision makers in providing solution under high uncertainty.

1. Introduction

Supply chain is an integrated network which is coordinated to transform the raw materials to the finished goods by adding value to the products, transfer the finished goods to the demand points and simplify the information flows between actors of the network. A supply chain network process includes three decision levels: (1) number, location and capacity of facilities; (2) selection of suppliers, channels and transportation modes and assignment of products; and (3) material flow [1,27]. As one of strategic supply chain decisions, location selection has drawn much attention from both the academic and business environment [2] because it directly affects long-term profits of companies [3]. This critical decision is hard to redeemable compared to short term decisions, difficult to reverse and implies a high degree of uncertainty [4]. It is prone to have high degree of uncertainty because of the complex nature of supply chain network. In a typical supply chain, the uncertainties can be mainly originated from following issues [5]:

- suppliers (such as average on time deliveries by suppliers, average supplier quality in filling orders, etc.);
- manufacturing process (such as duration of planned shutdown, duration of unplanned stoppages, etc.); and
- customers (such as average accuracy of monthly demand forecasts, size of customer base, etc.).

Under these circumstances, it becomes hard to develop an effective and feasible process for evaluation of the alternative locations.

Location selection is one of geographical multi criteria decision making (MCDM) problem. MCDM problems mainly include three steps: (1) data processing; (2) planning; and (3) evaluation. In the planning stage, two approaches are utilized: multi objective decision making (MODM) and multi attribute decision making (MADM) [6,7]. MODM techniques goal to design best option that meets the objective function under some constraints. On the other hand, MADM techniques are utilized to make decision makers be able to select the best alternative in related to priorities and interaction between criteria. Most popular MADM techniques are maximin, maximax, conjunctive method, disjunctive method,

* Tel.: +90 444 1 997.
E-mail address: gultemur@beykent.edu.tr

http://dx.doi.org/10.1016/j.asoc.2015.12.027
1568-4946/

elimination by aspects, linear assignment method, simple additive weighting (SAW), elimination and choice expressing reality (ELECTRE), technique for order preference by similarity to ideal solution (TOPSIS), linear programming techniques for multidimensional analysis of preference (LINMAP), analytic network process (ANP), analytical hierarchical process (AHP), and multi attribute utility theory (MAUT) [6]. Besides them, there are group decision making (GDM) approaches which include multiple individuals coordinate for selection of best alternative. GDM has five main steps: problem definition, problem analysis, determination of options, determination of criteria and expert panel, and implementation of the process [8]. In Appendix 1, there are some important papers, which examine location selection by utilizing decision making approaches.

Although multi criteria decision making is known as the most popular area of decision making [9], its traditional methods have some main drawbacks [10]. One of the important drawbacks is that they mostly take into account personal ideas [11,12]. That makes the process result in subjective decisions which have high potential to change across time. The decision making process is sensitively affected by uncertainties and traditional methods are not good enough at dealing with uncertainties and inaccuracies [7,13]. Furthermore, for example, in GDM techniques, the most important disadvantage is that several experts are required to predict the lost values of a specific one, which connected to remarkable difference between the preferences of experts could lead to the prediction of information not inherently compatible with the rest of the information of the expert [14]. In the past, it was popular to tackle uncertainties by interval assignment or safety margins to the uncertain variables. The intervals are refined by experts who focus on worst case scenario and the values can be more pessimistic or optimistic. This process is not computed and evaluated by experts. Besides interval assignment, there are also some popular methods that deal with uncertainties, such as fuzzy programming and simulation (like Monte Carlo). Simulation techniques need high amount of reliable information. The lack of information results in underestimation of the impacts of the uncertain tails of the probability distribution [15]. Therefore, it inevitably becomes necessary to improve more robust techniques that tackle imprecise and unknown factors independently of the amount of data. Rather than utilization of only subjective decisions, it is also required to evaluate and filter out the probability distributions of some uncertain parameters. Because, handling high number of certain and uncertain parameters strengthens the system against possible variances and risks.

The trends in utilization of decision making techniques address the importance of handling uncertainties which are originated from various resources [16]. In the literature, interest in combination of handling uncertainty and MADM is increased recently. Hanandeh and Zein [17] proposed modified decision-making tool named ELECTRE-SS which was built for uncertainties in criteria weightings and threshold values. The proposed methodology is utilized for cases where incomplete or uncertain preference data are available. Vahdani et al. [13] proposed a new interval-fuzzy modified TOPSIS method in order to handle subjective and objective data simultaneously. By the help of new methodology version, the flexibility of decision-making process has been increased and uncertainties are better represented. Huang and Li [7] proposed a multiple inputs and outputs information (MIO) classification technique represented as the FVM-index method integrates fuzziness, variable precision rough set theory, and a modified cluster validity index function. Its robustness is validated by comparing the obtained for the three different FVM-index filtered datasets. Ureña et al. [8] stated that reciprocal intuitionistic fuzzy preference relations have important impact on uncertainty dealing because they have ability to address uncertainty and hesitation. Therefore they improved a new notion as confidence-consistency driven group decision making approach to decrease the computational complexity of intuitionistic fuzzy preference relations. Considering these studies, the overview given in Appendix 1, and comprehensive reviews of Farahani et al. [6] and Chen et al. [18], it is noticeable to state that there is an important necessity for utilization of methods with an explicit focus on high number of various uncertainties.

Under the circumstances stated above, the motivation of this study is mainly depending on two following main issues:

1. Location decision is a complex and risky MCDM problem due to uncertainty and volatility of business environment. But unfortunately, it is important to point out that many MADM techniques are not strong to deal with high uncertainties in quantitative and qualitative data. Although some fuzzy integrated techniques can handle the human subjective linguistic data and some techniques consider the judgments of decision makers on supply chain uncertainty, there is a lack of techniques which can handle the imprecision of the high number of quantitative data. Decision makers who utilize MADM techniques should no longer continue to ignore the influence of uncertainties.
2. Moreover across the time, any of parameters of location decision process can become highly unsteady and fluctuate widely. The process should be safeguarded against the worst situations. Recognizing this, development of robust solution techniques under uncertainty is a high priority for decision makers and researchers to provide solutions by considering the worst case performance of the system. Otherwise, the decisions cannot effectively have foresight for most unexpected situations to take necessary actions, cannot reduce supply chain risk, and thereby cannot increase competitiveness and profitability of companies.

Recognizing motivating factors, this study goals to utilize a novel approach named cloud based design optimization (CBDO) that is efficiently utilized for problems including high amount of uncertainties. In CBDO, high amount of uncertainties are transformed to a basic form by the help of potential cloud formalism that allows a worst case analysis development on generated scenarios' confidence regions. The reasons of CBDO utilization can be summarized as following: (1) CBDO can take into consideration high number of certain and uncertain factors simultaneously; (2) provides alternative solution to existing approaches by mediating between aspects of fuzzy set theory and probability distributions; and (3) gives robust solution within worst case scenario. By the help of robust programming approach, decision makers and experts become able to have foresights about unexpected situations, and take necessary actions against risk. The proposed model has been applied only in two case studies from spacecraft industry [19]. Although it is addressed that the performance of the proposed model is satisfactory, in the literature there is a lack of cases generated from various problems. The originality of this study comes from providing solutions for these lack points by following ways:

1. This paper is the first study which aims to implement CBDO to verify its feasibility in industrial problems, and increase its popularity to motivate researchers benefit from this technique in different kinds of decision-making problems from various sectors.
2. Comparison of an alternative model with traditional ones increases the originality. The trends in utilization of decision making techniques indicate that utilization of a robust approach which handle uncertainties which are originated from various resources is a significant necessity. Recognizing these, after implementation, the results of CBDO are compared with traditional MADM techniques in order to highlight the sensitiveness of models against high uncertainties.