Information Sciences xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Information Sciences

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

A two-stage fuzzy approach for supplier evaluation and order allocation problem with quantity discounts and lead time

Q1 Ferhan Çebi, İrem Otay*

Istanbul Technical University, Department of Management Engineering, Faculty of Management, Macka 34367, Istanbul, Turkey

ARTICLE INFO

Article history:
Received 13 October 2014
Revised 10 November 2015
Accepted 22 December 2015
Available online xxx

Keywords:
Supplier selection
Order allocation
Quantity discounts
Lead time
Fuzzy
MULTIMOORA

ABSTRACT

Supplier selection is one of the major determinants of organizational competitiveness. The decisions on supplier selection are inherently complicated because of the necessity to consider simultaneously a variety of conflicting issues in a broad set of criteria from strategic to operational, and from quantitative to qualitative. In this study we developed a two-stage fuzzy approach to supplier selection and order allocation problem. In the first stage, fuzzy MULTIMOORA was utilized to evaluate and select suppliers with regard to subjective measures. Then, in the second stage fuzzy goal programming was used to determine the amount of order allocated to selected suppliers. The problem is formulated as a multi-product, multi-supplier problem having multiple objectives by satisfying quantity discounts, lead time, capacity and demand constraints. We used augmented max-min model guaranteeing non-dominated solutions, to transform the fuzzy multiobjective model into a crisp single objective function model. The results of each stage were compared with those obtained from other alternative techniques. The study also covers a real life problem to test the applicability and feasibility of the approach.

1. Introduction

Supplier selection and evaluation issue has attracted considerable attention and importance from both practitioners and academicians since the mid of 1960s with the early studies (Dickson [12]; Wind and Robinson [40]) in the relevant literature. Previous studies highlight that supplier selection and evaluation process is inherently critical and complex.

It is critical because suppliers have a great impact on operational and strategic performance of organizations. The literature shows that working with the right suppliers contribute to organizations' competitiveness by incorporating several potential benefits, such as shortening product development cycle, improving product quality, reducing inventory levels, decreasing production costs, enhancing flexibility, and fulfilling customer expectations.

It is complex because it requires simultaneous consideration of both quantitative and qualitative criteria. The criteria depend on product type, services, companies' requirements and strategies, and sectors in which companies compete. In most cases, criteria are conflicting that require an analysis of the trade-offs among them. In real world applications where generally suppliers outperform others for different criteria, the problem becomes more difficult. In addition, the process becomes more complex if incomplete or uncertain data are used in the evaluation processes.

* Corresponding author. Tel.: +90 212 293 1300x2034; fax: +90 212 240 7260.
E-mail addresses: cebife@itu.edu.tr (F. Çebi), iremotay@gmail.com, iremotay@itu.edu.tr (İ. Otay).

http://dx.doi.org/10.1016/j.ins.2015.12.032
0020-0255/

To overcome the complexity of the process, we propose a two-stage methodology for supplier evaluation and order allocation problem by integrating Multi-Criteria Decision Making (MCDM) method with multiobjective mathematical model under fuzzy environment. The fuzzy approach covers multiple criteria and multiple products under quantity discounts offered by multiple suppliers and have the constraints satisfying demand and average lead-time of multiple items. To check the feasibility of the proposed model, a real life industrial problem is presented and solved.

The remaining paper is organized as follows: In Section 2 we provide a detailed literature review on the relevant subject. In Section 3 we describe the problem, explain fuzzy MULTIMOORA method, state the assumptions, and give the parameters, variables and the formulation of the model. In Section 4 we illustrate the findings of the implementation of proposed methodology to a real-life problem. In Section 5 we discuss the findings and compare our results with those of other approaches. In the last section we conclude and present future remarks.

2. Literature review

There exist several streams in addressing supplier evaluation and order allocation problem. One stream highlights that appropriate suppliers which have been selected depending on the strategies and policies of organizations, improve and sustain long-term success of organizations in today's highly competitive markets. In the literature, numerous studies exist to identify the criteria to be used for evaluating and selecting suppliers. Earlier studies (Dickson [12] and Wind and Robinson [40]) focused on identifying the factors that have played an active role on supplier performance. Weber et al. [38] analyzed the criteria and analytical methods used in the supplier selection process by reviewing most of the articles published during a specific period. The researchers addressed a variety of factors affecting supplier selection decision (Dickson [12]; Narasimhan [28]). Majority of the studies have suggested price, quality, lead time, on-time delivery, flexibility, and relationship building as the main criteria in supplier selection decision making process (Ghodsypour and O'Brien [15]; Goffin et al. [16]).

The other research stream uses mathematical models for supplier evaluation. Weber and Ellram [39] applied multiobjective programming model for supplier selection decision problem. Amin and Zhang [4] applied a multiobjective mixed integer linear programming model. Zhang and Chen [44] constructed a mixed integer programming (MIP) model and solved the problem by heuristics. Choudhary and Shankar [10] applied goal programming model for supplier selection, inventory lot-sizing and carrier selection decisions. For a detailed literature review of supplier selection problem, readers may refer to De Boer et al. [11] or Ho [18].

On the other hand, fuzzy methodology is also a common approach in supplier selection because of subjectivity in human judgments and vagueness in the decision making environment. Fuzzy analytic hierarchy process (FAHP) was employed in several studies for supplier selection problem (e.g. Narasimhan [28] and Yahya and Kingsman [42]). Roshandel et al. [32] conducted Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS). Kuo et al. [21] presented an integrated fuzzy AHP and Data Envelopment Analysis (DEA) for supplier evaluation decision. Ozgen et al. [31] applied two-phase possibility linear programming model under fuzzy environment for order allocation problem. Lin [26] implemented fuzzy analytic network programming (FANP) and integrated it with multi-objective linear programming. Lee et al. [24] constructed mixed integer programming model. Jadidi et al. [20] applied both crisp and fuzzy multi-objective optimization problem (MOOP) with a normalized goal programming.

Additionally, there is a number of studies which analyze supplier selection and order allocation decision under quantity discounts (Ghodsypour and O'Brien [14]; Xia and Wu [41]). Yet, there still exist some gaps in supplier selection and order allocation literature including quantity discounts (Amid et al. [3]; Xia and Wu [41]). In this specific area, supplier selection problems were mainly solved for a single product (Amid et al. [2]; Zhang and Chen [44]). In real life applications, most suppliers are capable of sourcing multiple products, so multi-product purchasing is one of the main concerns in the selection process. However, there exist only a few studies tackling the problem with multi-products. For example, Mak et al. [27] developed a new hybrid algorithm based on constraint programming and simulated annealing for multiple products. Lee et al. [24] proposed a MIP model and a heuristic method to solve a lot-sizing problem for multiple suppliers, multiple periods and quantity discounts.

Our study differs from above studies in its comprehensive approach. The literature review shows that little attention has been paid to complex systems including multiple items, multiple suppliers, multiple objectives and constraints (Tsai and Wang [36]). The study aims to fill this gap by proposing a model for multiple products having different lead times, under quantity discounts. We suggest a two-stage methodology under fuzzy environment to cope with vagueness of human judgments in supplier evaluation and order allocation problem. In the first stage, we evaluate alternative suppliers by fuzzy MULTIMOORA method. It is an MCDM technique which is used for assessing both qualitative and quantitative criteria by offering more robust solutions (Baležentis et al. [6]; Brauers and Zavadskas [8]). In the second stage, we formulate a supplier order allocation model under quantity discounts. To the authors' knowledge, it is the first study which employs fuzzy MULTIMOORA for the supplier evaluation and uses the results obtained from fuzzy MULTIMOORA in a fuzzy multiobjective linear programming model (MOLP). We use an augmented max-min model because it guarantees non-dominated solutions (Lee and Li [25]), provides balanced solutions, and allows decision makers to set preferred achievement levels for the fuzzy objectives and constraints (Arikan [5]).

Please cite this article as: F. Çebi, İ. Otay, A two-stage fuzzy approach for supplier evaluation and order allocation problem with quantity discounts and lead time, Information Sciences (2016), http://dx.doi.org/10.1016/j.ins.2015.12.032