Applied Mathematical Modelling 38 (2014) 5705–5725

Contents lists available at ScienceDirect

Applied Mathematical Modelling

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

A fuzzy optimization approach for procurement transport operational planning in an automobile supply chain

Manuel Díaz-Madroñero, David Peidro, Josefa Mula *

Research Centre on Production Management and Engineering (CIGIP), Universitat Politècnica de València, Spain

ARTICLE INFO

Article history:
Received 12 February 2012
Received in revised form 24 May 2013
Accepted 29 April 2014
Available online 10 May 2014

Keywords:
Fuzzy multi-objective integer linear programming
Uncertainty modeling
Supply chain planning
Transport planning
Procurement
Automobile

ABSTRACT

We consider a real-world automobile supply chain in which a first-tier supplier serves an assembler and determines its procurement transport planning for a second-tier supplier by using the automobile assembler's demand information, the available capacity of trucks and inventory levels. The proposed fuzzy multi-objective integer linear programming model (FMOILP) improves the transport planning process for material procurement at the first-tier supplier level, which is subject to product groups composed of items that must be ordered together, order lot sizes, fuzzy aspiration levels for inventory and used trucks and uncertain truck maximum available capacities and minimum percentages of demand in stock. Regarding the defuzzification process, we apply two existing methods based on the weighted average method to convert the FMOILP into a crisp MOILP to then apply two different aggregation functions, which we compare, to transform this crisp MOILP into a single objective MILP model. A sensitivity analysis is included to show the impact of the objectives weight vector on the final solutions. The model, based on the full truck load material pick method, provides the quantity of products and number of containers to be loaded per truck and period. An industrial automobile supply chain case study demonstrates the feasibility of applying the proposed model and the solution methodology to a realistic procurement transport planning problem. The results provide lower stock levels and higher occupation of the trucks used to fulfill both demand and minimum inventory requirements than those obtained by the manual spreadsheet-based method.

© 2014 Elsevier Inc. All rights reserved.

1. Introduction

The supply chain (SC) encompasses all the activities associated with moving goods from the raw materials stage to the end user, including sourcing and procurement, production scheduling, order processing, inventory management, transportation, warehousing and customer service [1]. Transport processes are essential parts of the SC as they perform the flow of materials by connecting an enterprise with its suppliers and customers [2]. Hence, transport planning contributes to: the overall successful SC management goal, the planning and control of material flows [3], and the delivery of superior value to end consumers [4].

Frequently, real-world transport planning problems have two main properties; first, there are conflicting objectives in the problem structure; second, fuzziness at the aspiration levels of planners, and/or the epistemic uncertainty or lack of

* Corresponding author. Escuela Politécnica Superior de Alcoy, Plaza Ferrándiz y Carbonell 2, 03801 Alcoy, Alicante, Spain. Tel.: +34 96 652 84 23; fax: +34 96 652 85 85.

E-mail addresses: fcodiama@cigip.upv.es (M. Díaz-Madroñero), dapeipa@cigip.upv.es (D. Peidro), fmula@cigip.upv.es (J. Mula).

http://dx.doi.org/10.1016/j.apm.2014.04.053
0307-904X/© 2014 Elsevier Inc. All rights reserved.

knowledge of some data. Fuzziness is modeled by fuzzy sets and may reflect the fact that goals or constraints are linguistically formulated, and that their satisfaction is a matter of tolerance and degrees or fuzziness [5]. Epistemic uncertainty is concerned with ill-known parameters modeled by fuzzy numbers in the possibility theory setting [6,7]. Fuzziness and vagueness related to uncertain epistemic parameters can be found in Bhattacharya and Vasant [8], Elamvazuthi et al. [9], Vasant [10], Vasant et al. [11], Vasant et al. [12], Vasant et al. [13], Vasant et al. [14], among others. The multi-objective nature and the existence of fuzzy goals, constraints or parameters make the mathematical expression of problems harder to solve with traditional approaches. In order to overcome this difficulty, the fuzzy set theory [15,5] and the possibility theory have been applied to fuzzy multi-objective linear programming (FMOLP), and many approaches have been developed [16–21].

The SC procurement transport operational planning (SCPTOP) problem is used as a manual process based on planners' personal judgment and experience. Furthermore, manual processes consider a short or myopic time perspective when planning instead of an entire view of the whole horizon planning at any time, which could generate suboptimal plans. Given the motivation of providing optimal solutions to the SCPTOP problem, we propose a novel fuzzy multi-objective integer linear programming (FMOILP) model for the SCPTOP problem in a three-level, multi-product and multi-period SC network. The model's fuzzy goals are to minimize the number of used trucks and total inventory levels by determining the amount of each product to procure, which also contemplates the fuzzy data related to the transport maximum capacity levels and the minimum percentages of demand in stock. The fuzzy parameter of the FMOILP model is, firstly, defuzzified based on the possibility approach proposed by Lai and Hwang [22], which is used in Liang [23] and Wang and Liang [24]. Then, the FMOILP model, with fuzzy objective functions, is adapted to a mixed-integer linear programming (MILP) model by using the two fuzzy solution approaches provided by Selim and Ozkarahan [25], based on Werners [26], and Torabi and Hassini [27], which we compare.

Moreover, an interactive solution methodology by Liang [28] based on the previous works of Bellman and Zadeh [5] and Zimmermann [29], Zimmermann [30] is adopted as the basis to solve the fuzzy multi-objective SCPTOP problem for the purpose of finding a preferred compromise solution. To illustrate the validity of the proposed solution method, we applied the FMOILP model to a real-world automobile SC and compared the results obtained with the manual procedure currently applied.

The rest of the paper is arranged as follows. Section 2 presents a literature review about supply chain transport planning at the operational level under uncertain conditions. Section 3 proposes the FMOILP model for the SCPTOP problem. Sections 4 and 5 describe the solution methodology. Next, Section 6 evaluates the behavior of the proposed model in a real-world automobile SC. Finally, Section 7 provides conclusions and directions for further research.

2. Literature review

The scope of this work is the procurement transport operational planning problem based on mathematical programming approaches. Along these lines, several authors have analyzed supply chain operational transport planning from a deterministic point of view. Cisheng et al. [31] analyze the model of load matching. An effectual truck stowage planning model is proposed by equilibrating truck cargo weight and volume. Moreover, Sarkar and Mohapatra [32] describe a case of an integrated steel plant where the plant engages a third-party transporter to bring a large number of items from its suppliers by maximizing the utilization of the vehicles capacity.

In our previous works [33–36], we review and provide several approaches for SC planning under uncertainty conditions. Among them, the fuzzy mathematical programming for transport planning is being increasingly applied. Chanas et al. [37] consider several assumptions on the supply and demand levels for a given transportation problem in accordance with the type of information the decision maker has. On the other hand, Shih [38] addresses the cement transportation planning problem in Taiwan by using fuzzy linear programming with three different approaches [29,39,40]. Bilgen et al. [41] present a distribution planning problem in an uncertain environment with a fuzzy linear programming approach. Bilgen et al. [42] proposes a possibilistic linear programming model for solving the blending and multi-mode, multi-period distribution planning problem with uncertain transportation, blending and storage costs. Moreover, Aliev et al. [43] present an integrated multi-period multi-product production–distribution aggregate planning model in the SC in which customer demand and capacities in production environment are uncertain. More recently, Bilgen [44] proposes a model which addresses the production and distribution planning problem in a SC system that involves allocation of production volumes among the different production lines in manufacturing plants, and the delivery of products to distribution centers under uncertain conditions. Kumar et al. [45] and Kumar and Kaur [46] present new methods to find the fuzzy optimal solution of fuzzy transportation with transshipment and unbalanced problems occurring in real life situations. On the hand, Vinotha et al. [47] propose an algorithm for solving total time minimization in fuzzy transportation problem where the transportation time, source and destination parameters have been expressed as exponential fuzzy numbers by the decision maker.

With regard to multi-objective linear programming (MOLP) models, some works (for instance, Bit et al. [48], Bit et al. [49], Bit [50], Jiménez and Verdegay [51], Li and Lai [52], and Lee and Li [53]) provide fuzzy programming approaches to solve multi-objective transportation problems in a fuzzy environment. Besides, Liang [23] and Liang [28] develop an interactive multi-objective method for solving transportation planning problems by using fuzzy linear programming and a piece-wise linear membership function. Moreover, Peidro and Vasant [54] consider the transportation planning decision problem with fuzzy goals, available supply and forecast demand represented by modified s-curve membership functions which is solved

Download English Version:

https://daneshyari.com/en/article/1703236

Download Persian Version:

https://daneshyari.com/article/1703236

Daneshyari.com