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Original article

Two-Stage Supply Chain Network Design Problem with Interval Data*

Masoud SANEI [1], Ali MAHMOODIRAD [2†], Sadegh NIROOMAND [3]

[1†] Department of Mathematics, Central Tehran Branch, Islamic Azad University, Tehran, Iran, masoudsanei49@yahoo.com

[2†] Department of Mathematics, Masjed-Soleiman Branch, Islamic Azad University, Masjed-Soleiman Iran, alimahmoodirad@yahoo.com, Corresponding Author

[3] Departments of Industrial Engineering, Firouzabad Institute of Higher Education, Fars, Iran, sadegh.niroomand@yahoo.com

Abstract

Supply chain is usually represented by a network (which is called supply chain network) that contains some nodes. In a supply chain network these nodes are suppliers, plants, distribution centers and customers which are some facilities connected by some arcs to each other. The arcs connect the nodes in the direction of their production flow, meaning that each arc shows a route between the facilities for transporting the products. A multi-stage supply chain network (MSCN) is defined as a sequence of multiple supply chain network stages. This paper addresses a typical supply chain network problem which is based on a two-stage single-product system under uncertain conditions such that both cost and constraint parameters are interval numbers. The combination of these uncertain parameters are considered in this typical problem for the first time. In this case, two different order relations (the order relations $\leq_{UC}$ and $\leq_{HW}$) for interval numbers are considered. Then, two solution procedures are developed in order relations for the interval two-stage supply chain network design problem. The efficiency of the proposed method is illustrated by a numerical example where it is proved that the relation $\leq_{HW}$ shows better performance than the relation $\leq_{UC}$.

Keywords: Supply chain, Interval numbers, Multi-objective.

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I. Introduction

Supply chain is often represented as a network (called a supply chain network) that comprise of some nodes (e.g. suppliers, plants, distribution centers (DC) and customers) representing some facilities plus some arcs. The arcs connect the nodes in the direction of their production flow. A multi-stage supply chain network (MSCN) is defined as a sequence of multiple supply chain network stages. In this case the flow can only be moved between two consecutive stages. Usually, for a connecting arc, the outgoing node and the incoming node are defined as depot and source respectively (Costa et al. 2010; Guo et al. 2015; Sabzehparvar et al. 2015). The MSCN problem involves the choice of some facilities (e.g. plants and DCs) to be established and moreover a distribution network design satisfying the demand of customers with minimum cost.

In recent years, many studies have been done to design different MSCNs. Syarif et al. (2002) considered a multi-source, single-product MSCN design problem which was formulated as a mixed integer linear programming problem. They proposed a spanning-tree based genetic algorithm that applies prufer number representation to solve the problem. Yeh (2006) used a modification of the mathematical model of Syarif et al. (2002) to formulate the same problem. He suggested an efficient hybrid heuristic algorithm that is a combination of a greedy method, linear programming technique and three local search algorithms. Altiparmak et al. (2009) considering a single-source, multi-product MSCN design problem proposed a solution method based on steady-state genetic algorithms with a new encoding structure.

Olivares-Benitez et al. (2013) introduced a supply chain design problem based on two-echelon single-product network. The problem was formulated by a bi-objective mixed integer linear model. A meta-heuristic algorithm that uses concepts of greedy functions, scatter search, path relinking and mathematical programming together, was proposed as the solution method.

In real-world MSCN problems, it is usually difficult to estimate the actual value of parameters (e.g. transportation cost, delivery time, amount of goods delivered, under-used capacity, demands, etc.) as they may be tolerated because of many reasons. Depending on different aspects, those, fluctuate due to uncertainty in judgment, lack of evidence, insufficient information and the like and so on. For example, in MSCN, transportation costs of each stage are affected by the amount of transported goods. However, in the real word applications, we may face some difficulties arising from considering fixed charges which are independent of the amount transported. This reality was a motivation for some recent studies on different MSCN problems in both crisp and uncertain environments.

Petrovic et al. (2001) proposed a heuristic method to calculate the order quantities in a supply chain problem. They applied fuzzy sets to satisfy the assumption of uncertain demands and delivery due-dates. A special purpose simulating tool was suggested by Petrovic (2010) to study performance of supply chains with uncertain parameters. Chen and Lee (2004) formulated a supply chain scheduling problem with multi-product, multi-stage and multi-period properties by a mixed integer non-linear model. Aliev et al. (2007) integrated a multi-period, multi-product fuzzy production and distribution aggregate planning model for supply chains. The integration was done considering a sound trade-off between the filtrated fuzzy customer demand and the profit. The model was