Mathematical Programming for Modelling Green Supply Chains Under Randomness and Fuzziness

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ABSTRACT

Nowadays by growing concerns about environmental problems, businesses and industries are under pressure to decrease their negative impact on environment, consequently firms and industries have to reconsider about their activities and make their business compatible with environment. So industries should green their supply chains to optimize economic and environmental concerns, but because of uncertainty in the real world like inconsistency of world economy, the process of greening supply chains can be more complex. To optimize total costs and the unfavourable sides of supply chains simultaneously in an uncertain situation, this paper presents a multi-objective mixed integer programming with fuzzy random variables (FRVs) and by using fuzzy theory and fuzzy random chance-constrained programming (FRCCP), the proposed model is converted to deterministic model. This paper can be also suitable for decision making with optimistic, pessimistic and realistic notion. Finally, a numerical example is presented to illustrate the model.

KEYWORDS

Environment, FRV, Green Supply Chain (GSC), Multi-Objective Model (MOM), Possibility and Necessity Measures

1. INTRODUCTION

In our modern world, if managers and decision makers want to have profitable companies and industries in the competitive markets, they should respond to their customers’ demands efficiently. Indeed customers’ satisfaction can be attained by servicing in better quality and shorter time. To reach this aim, managers should properly reform their activities from providing raw materials to distributing final goods or services to their customers, so the solution is supply chain which leads to more productivity and profitability. In last decade, destruction of environment by industries has become one of the important concerns of public opinion. Global concerns about environment has necessitated governments and unions to establish regulations like KYOTO PROTOCOL to pressure firms and industries to reduce negative effects of their activities on environment, therefore in the modern world, green practices should be applied in firms and organizations (Lin, 2013; Tseng, 2011; Yang et al., 2011).

In order to convert supply chain into green supply chain (GSC), managers should change their insight about their activities and consider green practices, consequently, they have to redesign their supply chain to make their activities compatible with the environment. In fact, GSC can be defined as a network in which suppliers, manufacturers, distributors, retailers and customers are the main players (Liang, 2013). So, in order to design the network, decision makers should select appropriate places for opening factories and distribution centers (DCs) and choose a proper vehicle for carrying
raw materials and final products to meet the customers’ demands. The selected vehicle should have less production of pollutants of the environment. Many factors like marketing and delivery policy can affect managers’ decisions for choosing vehicle type and places for building factories and DCs, for example, if managers of an organization want to deliver final goods or services in the shortest time, they have to select the most expensive vehicle type, so for having the best performance, companies should balance delivery and monetary policies with respect to the environmental concerns.

Global markets are directly affected by economic issues like exchange rate and economic crisis, therefore prices may not be consistent and managers should adapt themselves to this uncertain situation. The uncertainty also influences on GSCs, in fact exact values of some parameters like cost parameters cannot be estimated and due to the fuzziness and randomness, some approaches such as fuzzy theory can be employed for formulation and solving problems under uncertainty. (Colubi et al., 2001; Kwakernaak, 1978).

This paper proposes a new multi-objective model for GSCs with respect to inconsistency of economic conditions in which prices go up and down frequently. The model is able to satisfy the managerial aims simultaneously and can be extended for being compatible with companies and organizations with respect to their special traits and conditions. To consider the inconsistency and uncertainty, we have investigated the GSC with fuzzy random coefficients of the objective functions in the model and we employed a novel method for solving the fuzzy optimization problem. Therefore, this paper can provide a helpful insight for managers and decision makers to apply the proper strategy in economic crisis and other unpredictable situations.

The most important challenge in GSC is balancing between earnings and environmental concerns. This study tries to find a solution to optimize total costs and negative sides of supply chains on environment under uncertainty by introducing a multi-objective mixed integer programming in which some parameters like costs are fuzzy random variables (FRVs). As efficient solutions are needed to solve complex GSCs modelling (Grossmann & Guillen-Gosalbez, 2010), some methods are used to solve the complexities of the proposed model.

The remainder of the paper is organized as follows: section 2 reviews the literature about GSCs. Section 3 presents the definition of the problem. In section 4, the problem is formulated. In section 5, a numerical example is presented and section 6 contains conclusion and discussion of future research.

2. LITERATURE REVIEW

In last decade, due to the increasing importance of green concepts and global concerns about environment, researchers have tried to define GSCs and introduce new practical ways to apply green philosophy into supply chains. Furthermore, the fuzzy theory has been developed in recent decades. Li et al. (2006) found the fuzzy simulation-based genetic algorithm more efficient than the interactive fuzzy satisfying method for solving crisp models provided for multi-objective linear programming with fuzzy random coefficient. Testa & Iraldo (2010) concluded that GSC has a strong relation with other management concepts. Diabat & Govindan (2011) suggested a model for the main factors in GSCs by using an interpretive structural modelling framework. Liu (2001) provided a general framework fuzzy random chance-constraint programming; in order to solve fuzzy random programming models, the author proposed a powerful hybrid intelligent algorithm. Naini et al. (2011) employed game theory to invent a system of measuring which can assess the performance of business. Lin et al. (2011) used the fuzzy set theory, decision making trial, and evaluation laboratory to find important criteria that can affect the performance of automobile industry. Wang et al. (2012) combined fuzzy logic to analytical hierarchy process (AHP) for choosing the best strategy among
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