Article No. 43

Robust Optimization methodology for Designing of Closed-Loop Supply Chain with uncertain parameters

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Abstract

The concern about noticeable changes in the decision environment ,such as transportation costs, demands, sources and ect., has leaded to a motivation for designing of robust decision problems. An increasingly popular method to optimization problems with data uncertainty is robust optimization. This methodology tries to obtain an optimal solution which is robust with regard to changes in parameters. This paper applies the robust optimization approach to an uncertain supply chain problem and robust counterpart of this proposed problem is attained which is robust with regard to changes in uncertain parameters. The achieved robust counterpart is a mixed integer programming problem which can be easely solved by useing existing optimization algorithms. Ultimately the robustness of solutions achieved by solving robust counterpart problem is assessed by numerical performances using GAMS software and MIP solver.

Keywords:

Robust Optimization; Supply Chain; Uncertain Parameters; Uncertainty Set.

1 Introduction

A supply chain is a network which is composed of costumers, production and distribution centers, suppliers and some channels connecting them. In general, supply chain design considers determining the locations, numbers and capacities of different centers and also the quantity of flow in channels.

A designed supply chain will use for a long time and during this period some parameters such as demands or costs might be uncertain or change. And since it can be so expensive and time-consuming to change facilities locations with regard to parameters changes, a robust design of supply chain with regard to uncertain parameters is necessary and momentous. In fact uncertain supply chain management problems have been studied widely in literature using stochastic or dynamic programming. Unfortunately, these methods need extensive information of probability distributions and don't lead to a numerically tractable solution. Therefore the need for developing an optimization methodology which doesn't make an assumption on distributions of uncertain parameters and considers computational tractability of solution, seems essential.

An amazingly proper approach dealing with uncertain optimization problems is known as "robust optimization". Early work in robust optimization, which studied inexact linear programming, was done by Soyster [1]. Later many authors extended this methodology such as, Ben-Tal and Nemirovski [2-4], Ghaoui [5,6] and Goldfarb [7], and also robust optimization approach to linear programming and network flow is specially focused by Bertimas and Sim [8-12]. Robust optimization to general nonlinear programming is notices by Ben-Tal et al. [13], Zhang [14] and Soleimanian and Salmani [15].

To the best of our knowledge, a robust optimization methodology to the supply chain management problem was first introduced by Bertsimas and Thiele [12]. They applied robust optimization approach to an ordering problem which "the main storage hubs (the sources of the network) recive their supplies from outside manufacturing plants and send items throughout the network, each time bringing them closer to their final destination, until they reach the stores (the sinks of the network)" [12].

More recently, a robust approach also was proposed in a reverse supply chain by Pishvaee et al. [16]. They considered a simple uncertainty set which uncertain parameters belong to it. Actually, they assumed each of uncertain parameters varies in a specified closed bounded box. Hasani et al [17] proposed robust optimization approach to strategic closed-loop supply chain network design under interval data uncertainty. However the proposed uncertainty sets proposed in [16] and [17] were simple and useful in real world, the obtained robust counterpart problems were so conservative. It means that we give up lots of optimality to ensure robustness of solutions.

Ramezani et al [18] applied robust optimization approach to a closed-loop supply chain. They used a finite set of possible scenarios as the uncertainty set which is too simple to be usual in real application.

Considering these introduced related works and their discussed disadvantages, the goals of this article are to propose an uncertainty set which is usual and useful in real applications, and to achieve a robust counterpart problem