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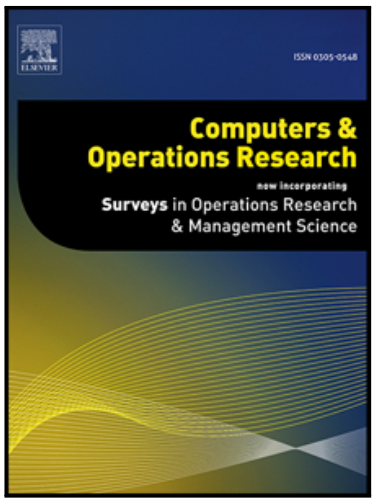

A multi-stage stochastic program for supply chain network redesign problem with price-dependent uncertain demands

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A multi-stage stochastic program for supply chain network redesign problem with price-dependent uncertain demands

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Abstract

In this paper, we address a multi-period supply chain network redesign problem in which customer zones have price-dependent stochastic demand for multiple products. A novel multi-stage stochastic program is proposed to simultaneously make tactical decisions including products' prices and strategic redesign decisions. Existing uncertainty in potential demands of customer zones is modeled through a finite set of scenarios, described in the form of a scenario tree. The scenarios are generated using a Latin Hypercube Sampling method and then a forward scenario construction technique is employed to create a suitable scenario tree. The multi-stage stochastic problem is formulated as a mixed-integer linear programming model and then Benders decomposition algorithm is applied for solving it. Numerical results demonstrate the significance of the stochastic model as well as the good performance of Benders algorithm. The scenario tree construction method is also evaluated in terms of out-of-sample and in-sample stability. Finally, several key managerial and practical insights in terms of pricing issues are highlighted.

Keywords: Supply chain network redesign, pricing and revenue management, Multi-stage stochastic programming, Non-anticipativity constraints, Scenario reduction, Benders decomposition

1. Introduction

In today's business environment, revenue management (RM) functions as a link between a supply chain (SC) and its customers and hence, it is important to study the RM issues in the context of supply chain planning [1]. In supply chain management (SCM), planning decisions are fixed for different time spans and upon this, the decisions are divided into operational (short-term), tactical (mid-term) and strategic (long-term) ones. In the SC planning, the RM decisions are made to maximize the profit or revenue of a SC by understanding, anticipating, and reacting to customers' behavior. As pointed out by Talluri and Van Ryzin [2], these decisions include quantity and price decisions at the tactical planning level and structural ones at the strategic level. Price decisions are how products' prices are determined dynamically for different customers over a planning horizon, and the quantity decisions consist of allocating available SC's capacities to different products, determining the amount of products held for the future sale and so on. Further, the structural decisions contain selling format, segmentation mechanisms, bundling products, etc.

Supply chain network design/redesign, as a strategic planning in SCM, determines physical configuration of a SC. In redesign process, an initial infrastructure of network is usually presumed. Embedding tactical price decisions from the RM perspective into profit-oriented SCN design/redesign problem often results in a complex optimization problem, which a few studies have addressed this issue. As pointed out by Fattahi et al. [3], price decisions play two principal roles in SCs: (1) they determine the revenue from selling one unit of each product to customers, and (2) demands of customer zones depend on price decisions and hence, they

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