

Supply Chain Network Design Optimization with Risk-Averse Retailer

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ABSTRACT

This paper proposes a model to formulate a supply chain network design (SCND) problem against uncertainty. The objective of the model is to minimize total cost of the network. The model employs risk averseness of retailers to obtain more realistic model regarding uncertain demand. Using Conditional Value at Risk (CVaR) to deal with this uncertainty makes the model to be robust. In this way, data-driven approach is used to avoid any distributional assumptions because realizations of uncertain parameters are the only information obtainable. This approach reformulates the initial uncertain model as a mixed integer linear programming problem. Numerical results show that the proposed model is efficient for robust SCND with respect to retailers risk averseness.

KEYWORDS

Conditional Value at Risk, Risk Averseness, Robust Optimization, Supply Chain Network Design, Uncertainty

INTRODUCTION

A Supply Chain (SC) is a system containing either supply and demand. Nowadays, according to quick technology and market changes, the basic SC is swiftly developing into what is known as a Supply Chain Network (SCN). The network is a system of companies, information, and materials to obtain a channel to handle a product from supplier to final consumer (Wang, 2012). According to Watson (2013), the bulk of product cost is due to flow process, determined between companies, in designed SCN. Therefore, Supply Chain Network Design (SCND) is arisen as an important issue of SCN and its management (Manzouri, Ab Rahman, & Arshad, 2015). Supply Chain Network Design Problem (SCNDP) is a challenging problem to define optimal location of companies and the flow through them. The problem is to seek for significant reduction in end-to-end SCN costs and farther to enhance its service level. This paper formulates the same problem throughout a Mixed Integer Linear Programming (MILP) problem (presented in Appendix 1).

On the other hand, the SCND has drawn more attention with respect to environmental elements as the sources of uncertainties (Laequddin, Sahay, Sahay, & Waheed, 2011). Although the uncertainties enhance the complexity of the SCNDP (Klibi, Martel, & Guitouni, 2010), it has to be considered in order to define effective connections in a SCN (Bagchi & Bhattacharya, 2014). But there are some ambiguities about the definition of uncertainty in comparison to certainty and risk.

Since, certainty, uncertainty, and risk are not the same terms, there are some differences between decision-making under certain, risky or uncertain environment (Rosenhead, Elton, & Gupta, 1972). According to Klibi et al. (2010) and Kouvelis and Yu (2013), certainty means there is no element of chance involved between decisions and outcomes. In risky situations some probability distributions are involved to construct links between outcomes and decisions. There are some uncertainties obtained, if it is impossible to assign probabilities to the possible outcomes of decisions. In other words, by the perfect information availability, the situation is certain and by the partial information availability, the uncertainty is accrued. By these means, the proposed model is formulated under uncertainty,

because there is no perfect information about the demand from the market place. Therefore, the term uncertainty should be rather defined.

Different qualities of information are available under uncertain environment. Randomness, hazard, and deep uncertainty are the three types of uncertainties as Klibi et al. (2010) explained. Randomness is to describe situations with random variables. Hazard explains conditions with low-probability high-impact unusual events. Deep uncertainty introduces some situations with lack of information to measure the likelihood of plausible future extreme events. This paper is based on the 3rd type of uncertainty in order to obtain optimality for the SCNDP. This is because of the same probability of the random scenarios according to no preferences involved between them. The scenarios are necessary to be considered, in response to uncertain amount of demand. Naturally, demand uncertainty is involved with the problem due to the unknown future business environment of the SCN. Under stochastic assumptions, random variables are assigned to each environmental factor such as demand. In this approach some new catastrophic events, as the sources of SCN deficiencies, are missed. Therefore, considering uncertain parameters, such as demand, in the SCND and obtaining the SCN robustness is essential to ensure sustainable value creation.

Beside these definitions, Klibi et al. (2010) and Hêriş Golpîra and Saghaei (2014) introduced that the uncertainty leads to the risk. Therefore, in this paper, Conditional Value at Risk (CVaR) is successfully adapted to deal with demand uncertainty. CVaR is a quantile-based measure of the risk with some desirable computational properties. This approach not only may deal with the uncertainty of demand, but also makes the model formulation to be robust. The CVaR approach, on the other hand, makes decision makers (DMs) to be more effective in the final decision due to leveraging their risk averseness. Risk averseness is the propensity to avoid taking the risk and is generally conceived of as a personality variable (Hêriş Golpîra, Zandieh, Najafi, & Sadi-Nezhad, In press).

This research formulates the SCNDP regarding the uncertainty of demand and the risk averseness of retailers. The objective function of the model covers the fixed alliance cost, production cost and transportation cost. The uncertainty of demand makes the model to be directly not solvable. Therefore, scenario-based CVaR approach is employed to transform the model to its robust linear counterpart. Using this approach makes the model to be able to consider not only the demand uncertainty, but also the risk averseness of retailers. The rest of the paper is as follows: the literature review will be done in section 2. The problem description and mathematical formulation will be described in section 3. Computational results will be presented in section 4 and finally conclusions will be presented in section 5.

Literature Review

According to the multi-dimensionality of the idea, the literature review is divided into the three basic streams of research: 1) robust optimization, 2) SCND under uncertainty, and 3) SCND using CVaR. The SCNDP has been successfully studied in the literature for some time. Dynamic programming is one of the first standard approaches to deal with this problem and has led to significant discoveries as early as 1960. Dynamic programming is a good approach in order to characterize the optimal policy in some simple systems. Nonetheless, the complexity of the real-life SCNDP makes the approach not acceptable for this application. The other barrier for applying the approach is its need for full information on the underlying distributions. The first attempt to address the issue of imperfect information was done by Karlin, Scarf, and Arrow (1958) in the field of inventory control. They studied the optimal policy in a one-period one-stage inventory model according to known mean and variance of demand. Gallego and Moon (1993) extended this approach to single-period newsboy problem in a one-stage inventory model. Similar idea was studied by Gallego, Ryan, and Simchi-Levi

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