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Supplier selection and order allocation under disruption risk

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Abstract: The supplier's risk is nowadays one of the important topics in the supply chain management. This paper studies the problem of the supplier's selection and order allocation in a make-to-order environment in the presence of disruption risk supplier. Two mixed integer programs are developed. The first considers a risk neutral decision-maker who maximizes the expected profit, whereas the second regards a risk-averse decision-maker someone who minimizes the expected operational loss. The results demonstrate that the expected profit and the operational loss evolve in the same way. An increase of the expected profit will also increase the expected loss, which, in turn, reduces the profit. Our goal is to produce the evolution curve of these two indicators and provide the decision-maker with visual aid to choose solution corresponding to his sensitivity to risk

Keywords: Risk management supply chain, risk supplier, local disruption, expected net profit, expected operation loss

1. INTRODUCTION

Nowadays, global speedy transformations have strained on companies to investigate on risk supply chain management in order to overcome their insecure and instable conditions. In this context, to overcome these conditions, most companies apply different strategies such as diversifying supplier, diversified production to have cost production and market share globalization, outsourcing, supply-base rationalization, just-in time deliveries, and lean inventories. In fact, these actions are valid in some cases but they affect by themselves the supply chain of different kinds of risks such as the supplier risk, market risk, production risk, information sharing and so on. In this work, our objective is to deal with the supplier risk under the supply chain.

Real procurement problems are usually complicated by side constraints taking into account both qualitative and quantitative factors. The integration of risk criteria and uncertainty are among the most complicating features of the real procurement settings.

Actually, numerous chains of distribution (fashion, sports…) are organized in retail sales network with a central purchasing office. A retail sales network means a set of sales outlets (enterprises or establishments) and a network head company, which maintain lasting relationships and establish common interests. The "network head company" coordinates some activities, in particular procurement ones. The central purchasing office of the head company is a structure that manages the purchases of its affiliates by:

- Studying the products.
- Searching for suppliers.
- Negotiating the purchases.

Our work concerns the stage of supplier selection under risk management.

The remainder of this paper is organized as follows. Section 2 presents the relevant literature about the supplier selection under the supply chain of the risk management problem. The model description and the calculation method of the supplier's disruption scenario are introduced in Section 3. The formulation of the two mixed integer programs is presented in Section 4. Section 5 describes the illustrative examples and results. Finally, the concluding remarks are provided in section 6.

2. RELATED LITERATURE

A large body of literature has been devoted to the topic of the supplier selection under supply chain risk management. In addition, numerous techniques can be used to determine the optimal and the best suppliers. This section consists in presenting a previous literature review in which we divide the related literature into a qualitative and a quantitative approach:

In the former, we found many proposed approaches, which treat the present issue by using a qualitative approach and the frequent techniques such as an analytic hierarchy process, game theory, and decision tree. Among the references, we can mention Berger and Zeng (2006), Ruiz-Torres and Mahmoodi (2007), Berger et al. (2004), Sarkar and Mohapatra (2009) and Mirahmadi et al. (2012). Tapiero and Kogan (2007), Xiao and Yang (2008), Xiao et al. (2010), and Hsieh et al. (2014).

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Berger and Zeng (2006) supposed two states for suppliers: all the suppliers are down or all suppliers are not down. Ruiz Torres and Mahmoodi (2006) followed the same idea but they integrated in their work other sets of costs as well as the costs of maintaining suppliers, the quantity purchased... Ruiz-Torres and Mahmoodi (2007) criticised the hypothesis of all suppliers down or all not down and they proposed another realistic decision-making approach.

Hsieh et al. (2014) used a game theory by considering multiple manufacturers and a common retailer in a supply chain in the presence of uncertain and sensitive demand to selling prices. Yan and Nishi (2014) investigated a three echelon supply chain model with the supplier selection and asymmetric information under demand uncertainty. They assume that the quality of information between the manufacturer and the suppliers is asymmetric. In fact, they use game theory to model it.

With respect to the second group, many papers have been used in the topic of selection supplier under the supply chain management. In fact, in the proposed approach, there are many different techniques, like the linear program (LP), the mixed integer linear program (MILP), the multi-objective program… Among the papers which used the linear and the nonlinear program, we note the following references Burke et al.(2008),Ma et al.(2012), and Chen et al.(2012), Burke et al. (2008). Yang et al. (2007), Hou et al. (2010), Davarzani et al. (2011), Eng et al. (2013).

Other studies used the mixed integer linear program MILP, like: Hammami et al. (2014), who investigated the problem of the supplier selection in the presence of uncertain fluctuations of the currency exchange rates and price discounts.

Chiu and Okudan (2014), assumed two scenarios: the first scenario aims at minimizing the total supply chain cost under stable market demand, and the second seeks to minimize the total supply chain lead-time under the burden of volatile demand dynamics.

Ray and Jenamani (2014) developed two formulations. The first was risk-neutral the aim of which is to maximize the total expected profit under disruption risk. The second model involves a risk-averse decision-maker in which they integrated the service level as a constraint.

Sun et al. (2011), developed a two-stage fuzzy optimization method in which the material demand, the spot market material unit price, and the spot market material supply quantity are assumed to be uncertain. The aim is to minimize the expected material procurement costs. Sawik (2013) investigated the problem of the supplier selection, the order quantity allocation, and the customer order scheduling in the presence of supply chain disruption risks. Regarding the Multi-objective programming (MOP), Wu et al. (2013) developed a stochastic fuzzy multi-objective programming for the supply chain outsourcing risk management in the presence of both random and fuzzy uncertainty. They included both quantitative and qualitative supplier selection risk factors.

Azaron et al. (2008) developed multi-objective stochastic programming approaches for the supply chain design under uncertainty. They integrated unreliable suppliers, capacity expansion and other uncertain parameters, such as demand, processing costs… Ravindran et al.(2010) used Goal Programming. They incorporated value at risk (VaR) and missed the target (MtT) techniques to compute supplier risk. In fact, the VaR is used to model the less frequent events, whereas MtT techniques were used to model events that might happen more frequently. For more details, please refer to Hamdi et al. (2015) for a complete review on selection supplier under the supply chain risk management.

The decisions related to the suppliers' selection problem in the relevant literature are, mainly, which suppliers to select and how much to order from each supplier in each period and over the planning horizon. In this paper, we propose two mixed integer stochastic programming models for supplier selection under the supply chain risk management. The use of the stochastic mathematical programming is driven by two main reasons: first is the ability to integrate uncertainty criteria, then they allow integrating different constraints related to the proposed problem although it is possible to integrate different variables sets like qualitative, quantitative, fuzzy variables…

The stochastic program is a set of mathematical programming where the data which incorporate into objective or/and constraints is uncertain. In fact, uncertainty is based on probability on the parameters and a set of scenarios (possible future outcomes). In fact, the complexity of model grows exponentially with increase of the number of scenario. see Shapiro et al. (2009).

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In literature, we find two sets of stochastic programs: probabilistic constraints and recourse problems. In this paper, we focus on a recourse problem in which the decision maker takes some action in first stage, then they recourse to the decisions made in the second stage which compensates the