Multi-Objective Programming for Supplier Selection and Order Allocation Under Disruption Risk and Demand, Quality, and Delay Time Uncertainties

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ABSTRACT

The purpose of this article is to develop a new stochastic multi objective optimization model to mitigate disruption risks while simultaneously addressing operational risks as well. Indeed, this model considers five objective functions for selecting a set of suppliers considering disruption risk and stochastic demand, quality, and delay time. The authors use two types of risk evaluation models: value-at-risk (VaR) and conditional value-at-risk (CVaR). Two examples are given to illustrate our model and two solution methods are compared and tested.

KEYWORDS

CVaR, Disruption Risk, Multi-Objective Programming, Supplier Selection, VaR

1. INTRODUCTION

Nowadays, companies have realized that improvements in competitiveness must be achieved by extending their focus to the purchasing function, which is increasingly considered by managers as a key strategic tool to achieve competitive advantage and to ensure the viability of the company. The success of manufacturing lies hugely on selecting best suppliers. An effective supplier selection model is a critical success factor for supply chains in a complex environment.

Uncertainty and imprecision are inherited in real life. Management of supply chain is a complicated process of stochastic and complicated events among different parts of a supply chain. Therefore, managing uncertainty is a main challenge within supply chain management. Vagueness or ambiguity are the main source of uncertainty (Tavana, 2014).

The supplier selection problem is obviously affected by the complexity and uncertainty due to the lack of information associated with related business environment in a global market. In recent years, it has seen a growing attention given in the field of uncertainty on the selection of suppliers with different criteria such as quality level, delivery, capacity, price and service.

Different supplier selection models have been developed by different scholars to deal with uncertainty in the field of supplier selection. These models are often developed using mathematical
theories such as linear programming, nonlinear programming, multiple objectives linear and nonlinear mathematical models, decision theory and game theory.

Due to the nature of supplier selection problem as a multi-objective decision problem, the multiple objectives programming (MOP) model was first introduced by Weber and Ellram (1993) as a technique for selecting vendors in procurement environment characterized by multiple conflicting criteria. MOP models involve more than one objective regardless of whether there are goal target levels involved. The main aim of multi-objective programming is to assist a decision maker to choose a preferred solution among all the trade-offs. Its main advantages are that it is easy to implement, efficient and a very intuitive way to knowledge representation due to the ability of the human mind to comprehend it. MOP take the form of linear, integer, and mixed integer which have continuous, discrete, and both continuous and discrete solutions respectively.

In the literature, there are many researches that treat the mitigation of operational risks by developing various mathematical models but there is a shortage of models for addressing disruption risks. Disruptive events such as earthquakes, hurricanes and labor strikes have caused major damage to various companies.

The use of the Var and the CVaR techniques as optimization criteria in a multi-objective paradigm was first studied by Roman et al., (2007). These two risk measure have been widely used in financial engineering in the field of portfolio management. CVaR is used in conjunction with VaR. Uryasev (2000) and Rockafellar and Uryasev (2000, 2002) introduced a new approach to select a portfolio with the reduced risk of high losses. The portfolio is optimized by minimizing CVaR. This approach has been applied to solve supplier selection problem under disruption risk (Sawik (2011a, 2011b), Sawik (2013a, 2013b)).

This paper aims at developing a multi objective optimization model to mitigate disruption risks while simultaneously addressing operational risks as well. Selecting the supply portfolio under variety of risks is a hard discrete stochastic optimization problem. Risk measurement is a key concept in risk management that why the use of CVAR and VAR seems to be required. The model proposed in this paper is a contribution to the literature by developing a new stochastic multi-objective model based on chance constraint. Apart from the two risks described above, this model also takes into account the minimization of the percentage of poor quality parts, the quantity of parts delivered late and the maximization of the total level of service.

The remainder of this paper is structured as follows. Section 2 presents a literature review that presents studies about supplier selection under uncertain decisions. Section 3 presents the CVar and Var definitions; section 4 presents the mathematical formulation while Section 5 presents the solution methodology. To demonstrate the proposed model section 6 and 7 gives two illustrative examples. Conclusions and directions for future research are given in section 8.

2. LITERATURE REVIEW

The supplier selection problem has attracted the attention of a number of researchers who have proposed various models and solutions. In real cases, majority of the input information is not known precisely and the criteria are not equally important, so that the values of many criteria are expressed in uncertain terms. Deterministic models cannot easily consider this vagueness. Numerous studies about supplier selection under uncertainty have centered on the type of supplier selection methods applicable under uncertain conditions. Gloch and Ries (2013) presented mathematical models for a multiple supplier single buyer integrated inventory problem with stochastic demand and variable lead time. A mixed integer programming method has been used by Zhang and Zhang (2011) to determine suppliers and the corresponding order quantities among the selected suppliers under stochastic demand. Burke et al., (2009) investigated the implications of uncertain supplier reliability on a firm’s sourcing decisions. Kara (2011) proposed an integrated methodology and its solution for supplier selection problem. In the two-stage stochastic programming model demand is assumed as uncertain. Markabi
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