



Decision Support

A scenario-based stochastic model for supplier selection in global context with multiple buyers, currency fluctuation uncertainties, and price discounts



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ABSTRACT

Suppliers network in the global context under price discounts and uncertain fluctuations of currency exchange rates have become critical in today's world economy. We study the problem of suppliers' selection in the presence of uncertain fluctuations of currency exchange rates and price discounts. We specifically consider a buyer with multiple sites sourcing a product from heterogeneous suppliers and address both the supplier selection and purchased quantity decision. Suppliers are located worldwide and pricing is offered in suppliers' local currencies. Exchange rates from the local currencies of suppliers to the standard currency of the buyer are subject to uncertain fluctuations overtime. In addition, suppliers offer discounts as a function of the total quantity bought by the different customer' sites over the time horizon irrespective of the quantity purchased by each site.

We first provide a literature review on the overlapping items of suppliers' selection and risk due to currency. Then, we model the problem using the mixed integer scenario-based stochastic programming method. The objective is to minimize the total system expected cost (purchased price + inventory cost + transportation cost + supplier management cost). Finally, we conduct numerical studies to show the value of the proposed model and we discuss some relevant managerial insights into the theory and practice of supply chain management research.

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1. Introduction

The selection of suppliers is a strategic process that determines the long viability of a company, especially when purchasing costs constitute a significant portion of the operating costs. The suppliers' selection plays a key role in achieving the objectives of an effective supply chain (Ng, 2008). The suppliers' selection is a complex decision making problem, which should include both quantitative, and qualitative criteria, as well as global factors to account effectively for suppliers' performance (Amid, Ghodsypour, & O'Brien, 2009; Aissaoui, Haouari, & Hassini, 2007; Sawik, 2010; Xu & Nozick, 2009). Some researchers agreed that a combination of factors should fit not only the technical requirements, but also the company's strategy. Some of these factors might include: financial metrics, consistency of the supplier, relationship, flexibility, technological capability, customer service, reliability and price

(Bode, Wagner, Petersen, & Ellram, 2011; Choi & Hartley, 1996; Qu, Huang, Chen, & Chen, 2009). The combination of factors to better select suppliers is not trivial, we refer the reader to Dickson (1966), Weber, Current, and Benton (1991), Bhutta and Huq (2002), Demirtas and Ustun (2008), Chen (2011) for more details about the suppliers' selection criteria. 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.

With the globalization of industrial activities and the expansion of offshoring there has been a steady increase in the global purchasing. Most companies have several sites located worldwide and are concerned with purchasing raw materials and components for these sites from a global network of suppliers. The sourcing economic development and the need for competitive advantage have increased the trend of sourcing products across the global marketplace. The global purchasing environment has unintended consequences; it exposes organizations to considerable sourcing risks and imposes new challenges that must be considered in the supplier selection process (Aloini, Dulmin, & Mininno, 2011; Hopkins, 2010). Some researchers (Aloini et al., 2011;

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Christopher, Mena, Khan, & Yurt, 2011; Sawik, 2010) outlined and classified the significant risks associated with global outsourcing.

One of these significant risks includes the currency exchange rates. Fluctuations in the exchange rates impact the sourcing from a global network of suppliers using different currencies. Different and fluctuating currencies expose the buyer to the currency risk. When different currencies are involved, the buyer should cope with the uncertain fluctuations of the exchange rates. Recently, the executive vice president procurement of Airbus argued that their procurement strategy is highly influenced by the €/€ fluctuation. Airbus decided to reduce \$ exposure by increasing \$ spend volume. It seems necessary that the suppliers' selection models evolve to take into account the currency fluctuation uncertainty in order to be in line with the new challenges faced by purchasing managers in global environments. The literature seems to be rather scanty on analytical approaches that integrate the currency fluctuation uncertainty in the suppliers' selection process; which is our underlying tenet in this research paper. We model the currency fluctuations through a scenario-based approach. The motivation behind this modeling approach will be presented in detail in Sections 3 and 4.

If one considers the exchange rate fluctuations between the supplier currency and the currency of reference then the purchasing price (expressed in the currency of reference) would depend on the order placement time. In this case, the buyer may have interest in ordering large quantities when the exchange rate is attractive. Therefore, the orders amounts and placement times decisions should be considered. The orders are likely to impact the total purchasing cost and, consequently, the suppliers to be selected. This also raises related inventory issues at the buyer's site. The inventory level incurred at the buyer's site and, consequently, the inventory cost are highly correlated to the amount and placement time of orders. In our model, we propose that the inventory costs with currency risk be taken into account in the assessment of suppliers' selection decisions in the global context.

Often complicating the supplier selection problem for the buyer is the presence of price discounts offered by suppliers (Xia & Wu, 2007). Crama, Pascual, and Torres (2004) indicated that traditional discount models involve one of two types of discounts: quantity discounts – based on the quantity of each item ordered – or business volume discounts – based on the total dollar value of all items ordered. In the suppliers' selection literature that incorporates discounts, the discounts are commonly calculated based on the nature of business done with each buyer. The discounts are not calculated based on multiple buyers' sites. It should be noted that in many global companies there is a central purchasing department that is concerned with the negotiations with suppliers and the provisions to the different subsidiaries. In our research, this is the commonly found situation in the automotive sector; companies have generally many offshore sites that consume the same type of input items. Hence, an increasing number of suppliers are finding more meaningful to offer discounts as a function of the total quantity of each item bought by the different customer' sites over a given time horizon, irrespective of the quantity purchased by each site. It seems to be a limited supplier selection models and methods addressing suppliers' discounts from this perspective. Our research work capitalizes on this void in the literature and proposes a model where suppliers are assumed to offer discounts based on the total quantity supplied to the different buyer's sites.

The global purchasing context, where buyer' sites and suppliers might be geographically dispersed, rises the impact of transportation costs on the suppliers' selection decision. Zelda and Zabinsky (2011) argue that the purchasing cost must include the costs associated with the whole purchasing process and over the purchased item's entire life in addition to the purchasing price. Among these costs, transportation costs constitute a significant

bulk. Nevertheless, Aissaoui et al. (2007) indicate that very little attention has been paid to transportation/logistics costs in the existing supplier selection research. Our proposed model explicitly considers the transportation costs in the global suppliers' selection process.

In this paper, we propose a mixed integer stochastic programming model for the supplier selection in the global context. The use of this mathematical programming/optimization approach is driven by two main conditions. First, the model allows the flexibility for selecting a variety of variables and facilitates the inclusion of uncertainty into these variables. Second, it allows allocating orders to each supplier with probabilistic conditions. Moreover, the selected technique takes into account the different constraints of the problem (Ding, Benyoucef, & Xie, 2003), which we have briefly outlined and will be discussed in detailed in Section 4. We consider the typical case where a global company is concerned with purchasing a given product for its different sites from different potential suppliers. We take into account the global supplier selection aspects discussed above.

The remainder of this paper is organized as follows: Section 2 presents a literature review on existing suppliers' selection models, and on a variety of risks associated with the selection of suppliers, additional emphasis is provided on currency fluctuation risk and discounts. Section 3 is dedicated to the problem statement. Section 4 addresses the mathematical formulation for the problem under study. In Section 5, the computational experiments and managerial insights are presented. Section 6 provides concluding remarks and future research directions.

2. Literature review

A key component in developing a reliable supply chain is the selection of suppliers. The sourcing of products from across the world has become an increasing trend by companies around the world looking for new sources of competitive advantage. These corporate initiatives to have prompted unexpected and unintended issues that have increased the complexity of supply chains. Some of these issues expose companies to different types of risks (Christopher & Lee, 2004) and traditional suppliers' selection models are evolving to incorporate such uncertainties. Our paper addresses some of these uncertainties. We review the analytical suppliers' selection literature from the perspective of assessing how well existing models fit in the context of global suppliers selection. In particular, we identify how sourcing risks, price discounts and logistics costs have been accounted for in the mathematical model-based suppliers selection approaches. Our main focus is on research published in the last decade.

2.1. Suppliers selection models

Many analytical techniques have been used to address the suppliers' selection problem. An innovative research presented by De Boer, Labro, and Morlacchi (2001) reviewed the literature on suppliers' selection and classified it according to the supplier's selection stage. De Boer et al.'s framework was revisited by Wu and Barnes (2011) in the context of agile supply chains. Their findings showed the need for the development of methods able to incorporate qualitative and quantitative goals. Wu's and Barnes' classification clustered the analytical models by linear weighting, by mathematical programming, by fuzzy set theory and by analytical hierarchical process. For more details on the different techniques and related references, please refer to Wu and Barnes (2011). Wadhwa and Ravindran (2007) classified the supplier selection to enhance outsourcing operations. These researchers broadly clustered the related literature by the method used in modeling the

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