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Minimizing downside risks for global sourcing under price-sensitive stochastic demand, exchange rate uncertainties, and supplier capacity constraints

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ABSTRACT

In this paper, a methodology for minimizing downside risks in relationship to the supplier base, supplier capacities, purchase-order-quantity, purchase-order-time, and selling-price is presented. Specific purchasing and selling strategies to minimize downside risks when suppliers have limited capacities is offered. Numerical analyses are used to demonstrate the profound impact on risks due to the increases in the potential supplier base, together with the effects of purchasing price trends and the impact factor of selling price to the demand.

We assume that the retailer stocks a certain quantity of a single product globally during a certain time period and then sells it to the domestic customers during the selling season. As exchange rate fluctuations are involved in the overseas purchasing and because the demand in the domestic selling is random and negatively impacted by the selling price, the retailer needs to combine uncertainties in both purchasing and selling to determine when an order should be placed, what quantity must be ordered, and what the selling price should be in order to minimize its downside risk, i.e., the possibility of missing target expected profits. We then consider multiple supplier candidates from different countries with limited capacity and determine the corresponding purchasing and selling decisions to minimize downside risks. The study is further extended to allow multiple purchasing at any time during the purchasing period from any supplier candidates.

1. Introduction

Typically, the exchange rate for a free-floating currency varies constantly against that of other currencies and is determined by the market forces of supply and demand, thus making it more difficult for buyers to know when to order. A poor prediction about the exchange rate movement could result in a substantial financial loss (Suranovic, 2005). Recently a Mexican Brewing Company reported that in the second quarter its net profit fell by 1.5% from a year ago on account of higher taxes and exchange rate losses. The management stated that the fluctuations in the exchange rate would remain the top priority of the company as they moved forward (Guthrie and Harrup, 2011). Huchzermeier and Cohen (1996) also mentioned that "in real applications, unpredictable currency changes were often the most important determinants of short-run changes in profitability and material flows". According to these authors, "an exchange-rate-based model functioned as a tractable, first-order approximation to a much more complicated underlying reality" (Huchzermeier and Cohen, 1996).

Generally, many newsvendor retailers, such as fashion retailers, enjoy a long lead time (normally 4–6 months) to place a single order while the sales season to sell the products are short. So during these 4–6 months lead time, the retailer chooses to purchase right away or wait for some time to possibly get a more favorable exchange rate.

Furthermore, as a result of exchange rate fluctuations in international sourcing, a company typically increases or decreases its order quantity based on how favorable the exchange rates are thus impacting the seller's demand and profits accordingly. In 2011, Johnson & Johnson's favorable currency-exchange rates created an 8% increase in its return to sales growth for its consumer-products in the second-quarter (Loftus, 2011). Also, Medtronic Inc.'s sales in the first quarter rose 2.4% to $4.3 billion, on account of a favorable foreign currency exchange rate (Kamp, 2011).

Apart from the order quantity adjustment, the buyer would also need to adjust its domestic selling price accordingly.

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The buyer would increase or decrease the selling price of the product to attract more sales. For example, a Swedish home appliance maker, Electrolux AB, reported a worse-than-expected second quarter net profit due to a decrease in demand in some of its most valued markets. This was attributed to the selling price increase on account of competitive pricing and increase in raw material costs (Hansegard, 2011). Lastly, Dana and Jeanblanc (2007) concluded that most agents are risk-averse. As demand and costs, driven by exchange rate movements, impacted companies' profits, it was reasonable for a risk-averse agent to combine demand and global purchase uncertainties. Procurement and selling decisions were then considered together as an entire entity to lower risks.

In this paper, we simulate the above decision environment and procedure by assuming that the retailer stocks a certain amount of a single product from a supplier overseas during a certain time period, and then sells it to the customer during the selling season. As there are exchange rate fluctuations and capacity limits for the suppliers, the retailer needs to decide how many supplier candidates should be considered, when to place an order and from whom, how much to order, and what should be the selling price to minimize its downside risk.

2. Literature review

Though risk control is predominantly addressed in the economics and finance literature, there are several studies that deal with risk control and risk aversion in the operations area as well. Bouakiz and Sobel (1992) and Eeckhoudt et al. (1995) studied the inventory problem of a risk-averse firm. In 2011, Buzacott, Yan, and Zhang examined the price and inventory decisions jointly for a risk-averse company. Two common methods for dealing with risk aversion, identified in the above studies, were mean-variance analysis and downside risk analysis. The mean-variance approach worked best when the retailer's profit follows a normal distribution. However, this assumption did not work in the newsvendor setting where the downside risk was more important than the profit variance for the newsvendor (Gan et al., 2005). Gan et al. (2005) define downside risk as a critical value for profit, a measure we borrowed in this paper.

Other measurements of downside risk includes semi-variance computed from mean return (SVM), semi-variance computed from a target return (SVT), and value at risk computed from a specific fractal of the return distribution (VaR). Literature studies that addressed downside risks in the newsvendor included Gan et al. (2005), Fotopoulos et al. (2008), and Buzacott et al. (2011), among others.

Several papers on downside risks analysis illustrate how value-at-risk (VaR) or downside risk is used to develop risk control strategies under exchange rate uncertainties. Kazaz et al. (2005) examined the influence of exchange rate uncertainty when choosing optimal production policies and concluded that the distribution decision can be postponed until exchange rates were understood. They also showed that the level of association between exchange rates moderated the occurrence of production hedging. This paper studied production and allocation hedging, instead of the purchasing time and quantity decisions in profit hedging, like our paper. Hallerbach and Menkveld (2004) created the “component value-at-risk (VaR)” framework so that companies could recognize the multi-dimensional downside risk profile, as identified by stakeholders facing increasing risks from external factors such as exchange rate fluctuations. Jorion (1991) utilized two factor and multi-factor arbitrage pricing models to investigate the pricing of exchange rate risk in the U.S. stock market. Other papers that further analyzed risk control strategies to reduce exchange rate threats included Reuer and Leiblein (2000), Lowe et al. (2002), and Bond and Satchell (2006). These papers analyzed downside risks and hedging strategies facing exchange rate varieties in buying or selling only. In our paper, however, we illustrate that when exchange rate fluctuations arise in the purchasing actions, the retailer must adjust both its purchasing decisions and its selling strategies to minimize downside risks for the whole buying and selling cycle.

In the existing literature on the multi-supplier newsvendor problem with capacity constraints and demand uncertainties, Serel (2008) analyzed how to maximize the retailer's expected profit by optimally allocating the order between two competitive suppliers. In this situation, there existed a possibility that one of the suppliers would not be able to deliver the product. Giri (2011) proposed a newsvendor sourcing model for a risk-averse retailer from a primary supplier with cheaper but unreliable yield and a secondary supplier with more expensive but reliable and fixed capacity. Burke et al. (2007) analyzed joint supplier selection and quantity allocation decisions when the supplier faces both unreliable supplies combined with demand uncertainty. Dada et al. (2007) investigated a supplier selection problem for a newsvendor where the cost levels and the reliability to supply enough order quantities are different. Feng (2010) integrated the pricing decisions for uncertain demand and sourcing decisions and for uncertain supply capacities. The author then deployed an optimal policy characterized by a reorder point and a target safety stock. Feng and Shi (2012) studied how to replenish a certain product from a set of capacitated suppliers to satisfy a price-dependent demand. They concluded that a cost-based supplier-selection criterion was optimal for deterministic capacity suppliers while a reorder-point policy was recommended for random capacities suppliers. Mieghem and Rudi (2002) designed stochastic newsvendor networks to study stochastic capacity investment and inventory management problems under dynamic settings. Zhang and Zhang (2011) analyzed how a buyer procured a product from a group of potential suppliers with restricted order sizes to satisfy the uncertain demand. They used a mixed integer programming method to determine the suppliers and the corresponding order quantities among the selected suppliers to minimize the total selection, purchasing, holding, and shortage costs.

Similarly, some papers also studied the multi-product or multi-customer newsvendor problem with capacity constraints and demand uncertainties. Examples of multi-product studies included Erlebacher (2000), Niederho (2007), and Reimann (2011) and multi-customer researches included Pinto (2012), Bassamboo (2010), and so on. The above capacity related papers focused on how to assign quantity among multiple products, multiple suppliers, or multiple customers when the capacity was limited or uncertain. Unlike our paper, the purchasing costs were assumed to be constant in these models.

There are only a few papers that include spot market purchasing price uncertainties in their limited-capacity newsvendor studies. For example, Inderfurth and Kelle (2011) assumed that spot market prices and market demand were uncertain. They then studied how to combine capacity reservation contract and a spot market purchasing. Their technique showed how to pool the advantages of risks hedging from capacity reservation and lower spot market prices or insufficient reserved capacity from spot market purchasing. Serel (2007) studied similar purchasing strategies problems under spot market capacity uncertainty and demand uncertainties. The above papers focused on how to allocate quantity between capacity reservations from contract suppliers and spot market purchasing at a certain time point, instead of multiple spot market prices during a time period with limited capacities. Also the selling strategies are not integrated into procurement decisions in these papers.