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Sourcing decisions under risks of catastrophic event disruptions

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ABSTRACT

In this paper, a supplier selection problem is studied under risks of supplier failure due to the catastrophic events disruption. An analytical model is developed to determine the optimal number of suppliers considering different failure probability, capacity, and compensation. An algorithm is designed to find the optimal solution and numerical study is carried out to illustrate the model. Results of numerical study and sensitivity analysis provide useful guidelines for managers to select the optimal number of suppliers under the risks of supply disruption.

1. Introduction

Supplier selection is one of the most important activities of purchasing department of any organization. Selection of right suppliers significantly reduces the purchasing cost and improves the corporate competitiveness. Earlier literature and business practices revealed that the business performance of organizations largely depends upon the suppliers. Therefore, supplier selection is becoming one of the most critical issues for purchasing managers. In the present competitive business environment companies are focusing on integrating their supply chains in order to reduce costs, shorten production lead time, increase quality and improve the relationship with suppliers (Moritz and Pibernik, 2008). Recently, due to the pressure of cost reduction and development of various logistics theories and practices like just-in-time philosophy, lean production, etc., the trend of supply base reduction has increased. The major reason behind this supply base reduction is diminution of administrative and transaction costs and cost savings from concentrating greater purchase volumes with fewer suppliers (Trent and Monczka, 1998). Choi and Krause (2006) have defined supply base as a group of suppliers from whom buyer purchases the parts, materials, and services. Reduction of supply base can have many advantages in costs and management such as cost-effectiveness, higher quality of coordination, improved delivery performance, continuous improvement and innovation (Carbone, 1999; Burt et al., 2004; Nam et al., 2009). On the other hand, reduced supply base might not always be beneficial for a buying firm as it has some negative consequences also. A reduced supply base increases the risks of supply disruption and suppliers opportunism for the buying organization (Trevelen and Schweikhart, 1988; Norrman and Jansson, 2004; Manuj and Mentzer, 2008). Failure of a single supplier to supply the negotiated order quantity (e.g. raw materials) can badly affect the performance of the entire supply chain.

A well known example that highlights the shortcomings of the single sourcing option is the case of Ericsson. A fire at the manufacturing plant of Ericsson supplier (Philips microchip) located at Albuquerque, New Mexico in 2000 caused Ericsson to incur a loss of about 400 million Euros. Similarly, there are many other examples such as, the insolvency of one of the Land

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Rover suppliers in 2001 causing the company to lay off 14,000 workers; reduction of $900 million in the quarterly earnings of General Motors (GM) is observed in 1996 due to the labor strike at one of the brake supplier factory that idled workers for 18 days at 26 assembly plants of GM and in 1997 Boeing incurred a loss of $2.6 billion due to the failure of its two key suppliers to deliver critical parts, etc. The above examples highlight the importance of determining the right number of suppliers that optimally trades off between potential risks of having fewer suppliers and benefits.

Recent high-profile catastrophic events like 9/11, the hurricane Katrina and Rita in 2005, and the tsunami in 2004, etc. have motivated researchers to include risks of catastrophic events disruption into procurement and supply chain problems (Oke and Gopalakrishnan, 2009; Knemeyer et al., 2009; Yu etl al., 2009; Chopra and Sodhi, 2004; Tang, 2006; Kleindorfer and Saad, 2005). Numerous other types of catastrophic events like, snowstorms, heavy rain, excessive wind, fire, industrial and road accidents, strikes, and changes in government regulations (Ellis et al., 2010; Stecke and Kumar, 2009) regularly interrupt business operations suggesting that the possibility of supply disruption should not be overlooked by purchasing managers while taking sourcing decisions. Hou et al. (2010) have defined supply disruption as the sudden non-availability of supplies due occurrence of an unexpected event making one or more supply sources totally unavailable. More than half of the respondents of an Indian Business Continuity Survey of 95 organizations have reported that they have faced at least one significant business disruption in the year 2008. The survey stated that the average number of significant disruptions per organization is increased to 1.8 in 2008 compared to the 1.6 in year 2007. The survey also mentioned that the average loss per disruption in 2008 has increased significantly to Rs. 205 million compared to Rs. 77 million in 2007, which is an increase of more than 200%. Hence, today's business environment, one cannot ignore the risks of disruption. In the real world, disruptions do and will occur and the best business plans are those that anticipate and prepare for this inevitability (Handfield and McCormack, 2008).

Tomlin (2006) and Linthorst and Telgen (2007) have suggested multiple sourcing as one of the efficient strategies to cope with risks of supply disruption. Though multiple sourcing option is more reliable, but it increases the management cost which includes cost of negotiation, managing a supplier contract, and monitoring the quality, etc. (Moritz and Pibernik, 2008). Therefore, in today's competitive and uncertain business environment, the task before a buying firm is to find the optimal number of suppliers that tradeoff between supplier management cost and the costs due to supply disruption. Nevertheless, research pertaining to sourcing decisions or supplier selection under risks of supply disruption is limited. The motivation of the current study emanates from this limitation.

In this study, we have made an attempt to develop an analytical model for determining the optimal number of suppliers to minimize the total cost considering the risks of catastrophic events. Furthermore, the concept of service level (SL) is also incorporated into the model to measure the performance of supply network. Service level is defined here as the probability that a buyer/manufacturer will not face loss due to complete disruption of all supply sources during the cycle and receive the negotiated ordered quantity. Intuitively, the service level will be more when the buyer/manufacturer engages more number of suppliers. However, this will increase the management or operating cost. Therefore, the challenge is to balance between the total cost and service level. Two constraint based optimization models are developed considering service level for determining the optimal number of suppliers. The first model deals with maximizing the service level within total budget constraint and in the second model, minimum cost required to achieve a target service level is determined.

The paper is organized as follows. A brief review of literature is included in Section 2. In Section 3, an analytical model is developed for minimizing the total expected cost of manufacturer. Solution for determining the optimal number of suppliers is provided in Section 4. In Section 5, a numerical study is carried out to illustrate the model and sensitivity analysis is performed to determine the optimal number of suppliers. The optimization models of service level and their sensitivity analysis is carried out in Section 6. Finally, conclusions and future scope of the work are presented in Section 7.

2. Literature review

The research carried out related to this study can be classified into three categories. The first category, deals with different sourcing strategies. Enormous studies have been made towards single or multiple sourcing, and most of the studies have focused on the advantages and disadvantages of various sourcing strategies. Under high costs of exchange, negotiation administration and monitoring, single sourcing strategy is preferred (Linthorst and Telgen, 2007). Williamson, 1981 transaction cost economics framework also supports the single sourcing practices. Nevertheless, sole sourcing makes buying firms more dependent on a single supplier and that increases the risk of supplier opportunism. Pfeffer and Salancik (1978) have mentioned that by moving from single supplier option to multiple suppliers, an organization can reduce its degree of dependence on any one supplier. Further, under multiple sourcing strategy, the demand of buying firm is split between multiple suppliers and this creates continuous competition among suppliers and reduces the cost of goods and risks of supply disruption (Linthorst and Telgen, 2007). Instead of reviewing all the studies pertaining to sourcing strategies, we refer the studies of Treleven and Schweikhart (1998), Linthorst and Telgen (2007) and Costantino and Pellegrino (2010) who have presented the pros and cons of the sourcing strategies in details. The second category of literature focused on selecting the optimal number of suppliers to fulfill the buyer demand. Plethoras of studies (Agrawal and Nahmias, 1997; Bakos and Brynjolfsson, 1993; Weber et al., 2000; Kauffman and Popkowski Leszczyc, 2005; Jokar and Sajadieh, 2008 and Nam et al., 2009, etc.) have dealt with the problem of determining the right number of suppliers by comparing the sole, dual and multiple sourcing. In these studies, different analytical models have been developed for determining the right number and mix of suppliers for fulfilling the demand of the buyer.