Journal of Purchasing & Supply Management 23 (2017) 54–65

Contents lists available at ScienceDirect

Journal of Purchasing & Supply Management

journal homepage: www.elsevier.com/locate/pursup

# A proactive approach to supply chain risk management: Shifting orders among suppliers to mitigate the supply side risks

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ARTICLE INFO

*Article history:*
Received 1 February 2015
Received in revised form
20 March 2016
Accepted 7 April 2016
Available online 15 April 2016

*Keywords:*
Supply side risks
Procurement planning
Risk mitigation
Linear programming
Automotive industry

ABSTRACT

Globalization, e-trade, advanced technologies and emerging production techniques have increased supply chains' efficiency and added value. However, despite numerous advantages, these factors make supply chains more fragile and vulnerable to risks. For this reason, companies that perform supply chain risk management gain competitive advantage. In the past, supply chain managers mainly focused on reducing costs; but recently, they have begun to give importance to supply chain continuity and resiliency which have significant impacts on costs as well. Hence, conventional reactive planning has given way to proactive planning in supply chain risk management. In this study, the supply chain risk management process is investigated and a procedure is proposed in the risk mitigation phase. In the first stage of the proposed procedure, an initial procurement plan is obtained via a linear programming model, considering the cost criterion as the first priority. In the second stage, this plan is revised by including the risk criterion into the planning as the second priority. The aim of this procedure that enables proactive planning is to reduce the supply side risks. The model is tested with a hypothetical data set and the cost analysis is performed to evaluate the performance of the procedure. Finally, the whole supply chain risk management process including the proposed procedure is applied to an international automotive company.



## 1. Introduction

We face many risks in our daily life and consent to live with them to some level in order to survive and conduct activities. For instance, driving a car embodies the risk of accident and potential consequences of life and material loss. People accept these consequences for the sake of the driving benefits and they prefer safer cars, fasten seat belts and obey traffic rules to mitigate the probability and/or the adverse impacts of risky events. They could not simply refrain from driving their cars to avoid risks because using other transportation methods also involves some other risks.

As in human life, it is impossible to survive and make money without taking risk in business life as well. Companies also must accept some degree of risk and apply risk mitigation strategies to gain a competitive advantage and make profit. For example, increasing globalization and e-trade yields lower raw material or product costs especially when procured from the Far East and provides economies of scale. However, long supply chains (SC) and intercontinental transportation are subject to numerous risks arising from communication, geopolitical, cultural, transportation or legal complexities. If one or more of these risks emerge, firms are likely to encounter much higher costs rather than the financial advantage of supplying from intercontinental instead of local suppliers. Chopra et al. (2007) show that ignoring two kinds of risk sources as disruption and supply delays not only increases the use of more unreliable and cheap suppliers but also decreases the use of reliable suppliers. For example, Schmitt and Singh (2011) have expressed that one consumer packaged goods company's SC came to a halt due to a customs strike. When customs went on strike in a South American country, no raw materials could be shipped to their plant. While the plant had planned to carry three weeks' worth of raw material inventory, they happened to only have one weeks' worth on hand because additional material was in transit. Thus after a week, production shut down at that facility. This was a serious issue, as facility fixed costs and labor costs were still incurred. Only a few days' worth of production was not shipped on time, but the total cost to the company was estimated at a million dollars. This incident shows the importance of SC continuity and planning of facilities as back up for each other.

The art of risk management is not just in responding to *anti*cipated events but in building a culture and organization that can respond to risk and withstand unanticipated events (Coleman, 2011). Most companies recognize the importance of risk assessment

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http://dx.doi.org/10.1016/j.pursup.2016.04.002
1478-4092/

programs and use different methods, ranging from formal quantitative models to informal qualitative plans, to assess SC risks. However, most companies invested little time or resources for mitigating SC risks (Jianlin, 2011).

Although the number of academic studies on supply chain risk management (SCRM) has increased since the year 2000, use of quantitative models remained insufficient. Application of risk management by organizations has not been at the desired level. In a recent survey by Poirier and Quinn (2004), only one-third of the responding firms reported that they paid sufficient attention to SC vulnerability and risk mitigation actions. One finding is that the intellectual structure of the SCRM field made a statistically significant increase during 2000–2005 and evolved from passively reacting to vague general issues of disruptions towards more proactively managing SC risk from system perspectives (Tang and Musa, 2011). Ghadge and Dani (2012) have conducted a thorough study on the academic literature of the SCRM. They have noted that SCRM gathered more focus only after the 9/11 terrorist attacks in the USA and the radical increase is after 2004. According to this study which examines 120 papers published between 2000 and 2010; 54.16% are qualitative, 36.66% are quantitative and 9.16% are mixed regarding the research approach; 35.00% are risk identification, 14.33% are risk assessment, 5.83% are risk mitigation/control and 44.16% are holistic regarding risk management process; 56.33% are proactive, 23.33% are reactive and 20.83% are holistic regarding the risk mitigation approach.

Popular trends of our time such as lean manufacturing and JIT production, improving optimization techniques, shortening of product life, extending of transportation networks but shortening of lead times all expose SCs to more risks. Because of these reasons, firms should put more emphasis on the risk management process and create their procurement and production plans in the light of their risk assessment. A SC manager should consider every element of a SC while planning and executing SCRM. Since every member in a SC as a supplier, manufacturer, warehouse, retailer, customer etc. wants to achieve their own goals individually; the goal of one may increase the risk of another. A disruption in any part of a SC negatively affects every part of it. Hence, SC managers should see and evaluate the whole picture and navigate every member in one direction in terms of risk management. Risk criterion as well as cost criterion should be considered while making strategic decisions on significant issues regarding transportation routes, amount of production in each manufacturing facility, determination of risk attitude in case of a risk, and while choosing between two alternatives such as multiple versus single supplier, in-house versus global procurement.

A proactive planning procedure is proposed in this paper in light of these views. The main aim of this procedure is to take precaution against risky suppliers and to decrease the level of damage in case a disruption occurs. In a multi-supplier, multi or single manufacturer system, the initial procurement plan of a single commodity is obtained via the linear programming model with the objective of cost (purchasing and transportation cost) minimization. Then, risk assessments of all suppliers are conducted qualitatively and the risk profiles are obtained to be used in the second linear programming model that modifies the initial procurement plan. Since the identification of risk impact in terms of cost is very difficult prior to the occurrence of risk, including the risk criterion into a model in terms of cost is usually unrealistic. To prevent this handicap and reflect real world situations into a model more accurately, risk profiles are directly used to reflect the risk status of a supplier and to modify the initial procurement plan. The initial purchasing quantity of each supplier is proportioned to its risk profile and the product quantities to be maintained and to be transported to a less risky supplier are identified by this way. If the risk profile of a supplier is higher than the risk criteria of the purchasing company as a result of the risk evaluation, that supplier can be eliminated directly from the supplier base. Both the first and the second models are capacity constrained. If the unit purchasing cost of a certain supplier is low but that supplier is more risky than the others, the purchasing quantity planned via the cost minimization merely is proportioned to its risk profile and some of the products may be purchased from the relatively less risky supplier considering the capacity of that supplier. The product transfusions from risky suppliers to relatively less risky (reliable) suppliers are modeled as a network. If a disruption occurs, the severity of any risk on the purchasing company will be low by means of this pre-disruption preparation procedure owing to the fact that the product quantity is reduced in advance according to the risk profile of that supplier. The proposed procedure is theoretical and can be used by manufacturers/assemblers of all sectors procuring single product from multi-suppliers.

The remainder of this paper is organized as follows. Second part is literature review. In the third part, we identify the framework for the risk management process consisting of five phases and propose a proactive approach as a risk mitigation strategy. In the fourth part, the proposed model is tested and verified with a hypothetical data set and cost analysis is performed to evaluate the performance of the procedure. In the fifth part, the proposed procedure and the model is applied to an automotive company. In the last part, we discuss the results and conclude with suggestions for future work.

## 2. Literature review

Effective mathematical tools for analyzing and understanding appropriate supply chain risk management are attracting much attention due to increasing interest on supply chain vulnerabilities. Although the studies on supply chain risk management are mostly qualitative and empirical, there are also qualitative and model-based researches in literature. For example; Arntzen et al. (1995) implemented a mixed integer programming model that is used for determining optimal supplier relationship, optimal supply network design, optimal supplier order allocation and optimal supply contract. Camm et al. (1997) propose an integer programming model for Proctor and Gamble that deals with supply network design and supplier selection. Levy (1995) presents a simulation model to examine the impact of demand uncertainty and supplier reliability on the performance of different supply networks and supply contracts. Lee and Tang (1998a, 1998b) propose a stochastic inventory model to examine the tradeoff between the consignment and turnkey arrangements under demand uncertainty (Tang, 2006). Kouvelis and Rosenblatt (2002) have studied the design of global facility networks and presented a mixed integer programming model. They investigate essential design tradeoffs of such networks and incorporate government subsidies trade tariffs and taxation issues. Smith and Huchzermeier (2003) have studied the global supply chain and risk optimization, and showed how real options add value to global manufacturing firms (Goh et al., 2007). Bogataj and Bogataj (2007) develop a parametric linear programming approach for measuring supply chain risks in terms of lead time perturbations. Mark et al. (2007) present a stochastic model of the multi-stage global supply chain network problem, incorporating a set of related risks as supply, demand, exchange and disruption. The firm's objective is to maximize its global after-tax profit subject to capacity constraints in each plant and demand requirements in each market. Hopp and Yin (2006) used a nonlinear mixed integer programming (NLMIP) formulation to explain supply disruption caused by catastrophic failure. The aim of the study is minimizing total cost comprising of inventory and