Robust Supply Chain Risk Management

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INTRODUCTION

Supply chain risk management is an increasingly important activity due to the process of globalization and outsourcing which carriers an additional requirement of coordination among the supply chain participants. In these complex supply chains the performance of its participants is affected by the actions of other members of the supply chain, by regulators, and by technological change, for example (Oliveira, 2012).

Nonetheless, Chopra and Sodhi (2004) have reported that most companies develop plans to protect against high-probability risks in their supply chains but ignore high-impact low-likelihood risks, whose likelihood and impact is difficult to estimate. For this reason, it is crucial to use techniques to estimate and consider uncertain disruption parameters. Robust optimization (Kouvelis, Kurawarwala, & Gutierrez, 1992; Mulvey,Vanderbei, & Zenios, 1995; Tang, 2006 b; Sheffi & Rice, 2005; Hahn & Kuhn, 2012; Gulpinar & Oliveira, 2012) aims to find solutions that are feasible under all the possible values assumed by the parameters. The policy computed using robust optimization is optimized to take into account these uncertainties.

In this chapter we revise the literature on supply chain risk management, including risk assessment, risk perception and risk management policies, and we survey the robust optimization methods proposed in the literature to address these issues.

SUPPLY CHAIN DISRUPTION RISKS

In this section we revise the concept of supply chain risk management (SCRM) and the different approaches for classification of risks in supply chains. Tang (2006 a) has defined SCRM as the coordination between the supply chain members in order to guarantee profitability and continuity.

There are different supply chain risk classifications. For example, Chopra and Sodhi (2004) have categorized supply chain risks into disruptions, delays, systems, forecast intellectual property, procurement, receivables, inventory, and capacity. In their definition, disruption risks include natural disasters, labour disputes, supplier bankruptcy, war and terrorism, and dependency on a single source of supply. Tang (2006 a) has categorized supply chains risks in two types: operational and disruption risks. Operational risks are related to the existing problems such as uncertain demand, uncertain supply, and uncertain cost. On the other hand, disruption risks concern the major disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, terrorist attacks, and economic crises such as currency devaluation or strikes. In addition, he mentions that the business impact associated with disruption risks is much larger than the operational risks.

Furthermore, as shown in Figure 1, typically, the risk assessment and management process follows several steps. First the risk analyst needs to assess the frequency and consequences of the risk factors; then he needs to decide on the risks that are not acceptable and take the required measures to improve them. Finally, there is always a residual level of risk that the manager accepts to

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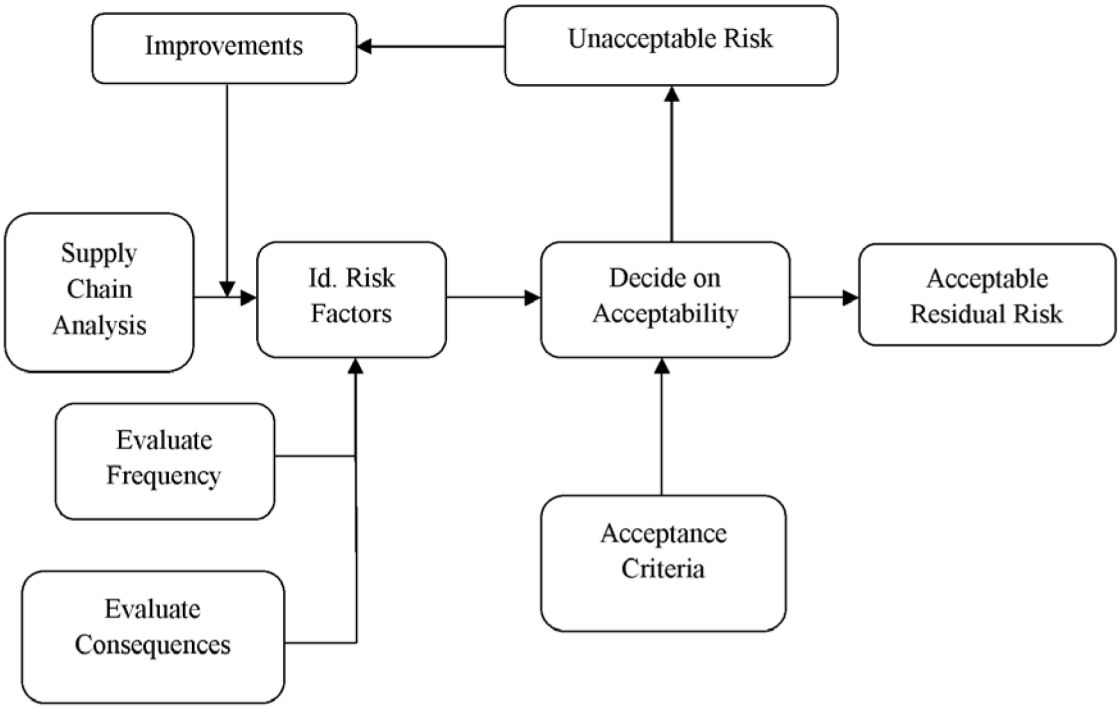
Figure 1. The risk assessment and management process



live with as it may be more expensive to tackle than its perceived consequences.

One important area of risk analysis, due to the complexity of the risk assessment exercise, is catastrophic risk. Kunreuther and Useem (2009) have argued that, regardless of the risk assessment methodology, there are always four basic elements for assessing the catastrophic risks (as represented in Figure 2): a) hazard, e.g., hurricanes, terrorism or pandemics; b) the inventory of properties, humans, and the physical assets which are exposed to risk; c) the vulnerability of the structures or people at risk; and d) the human and property loss after measuring of vulnerability. It is beneficial to separate the losses into direct and indirect losses while dealing with catastrophes in this model. Direct losses contain fatalities, financial losses, and the cost to repair a construction, or re-establish a service. Indirect losses have longer impacts in the future like slower growth, lost income, and company bankruptcies.

In the next section we review several methods used for supply chain disruption risk management, as this is a very important catastrophic risk at which supply chains are possibly exposed, emphasising robustness methods, and providing a framework for disruption risk analysis in supply chains.

ROBUST SUPPLY CHAIN DISRUPTION RISK MANAGEMENT

In this review we focus on supply chain disruptions, as these are at the top of the management concerns (see Figure 3), and are fundamentally different from the risks arising from machine failures or demand uncertainty, as they completely stop the production flow and typically persist for longer (Kleindorfer & Saad, 2005); for these reasons, the impact of supply chain disruptions can be catastrophic, although their likelihood is very low. As can be seen in Figure 3, which we adapted from Makowski, Papier, and Walter (2012), supply chain