



Supply Chain Risk Management

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An emerging and challenging research area, given the importance of supply chain management in practice, focuses on disruptions in supply chains from various reasons, also referred to as *supply chain risks*. Risk can be viewed as the product of frequency times consequence. This means that a high-frequency/low-consequence event, such as the regular fluctuation of currency exchange rates, can be viewed as similar to a low-frequency/high-consequence event, such as the sinking of a cargo ship charged with critical parts.

March & Shapira (1987) define supply chain risk as "the variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values". In practice, organizations typically perform a cost minimization analysis by incorporating most likely costs, demands and operating characteristics. But this sole focus on cost fails to capture certain risks associated with customers, suppliers and internal operations. Without taking into account the probability of changes of lead times, customer expectations, and the underlying cost drivers, firms might end up with supply chain designs that increase the vulnerability to and magnitude of supply chain risk.

The objective of the research conducted within the OPeR unit of MSL is to understand main supply chain risk sources, develop a taxonomy of supply chain risks and discover factors that differentiate risk exposure for supply chains that operate in different industries and / or have different design characteristics.

Insights from the Literature

When reviewing the literature on supply chain risk management, it is apparent that two major research streams are dominant. The one operates within an exploratory research logic, while the other focuses on mathematical modeling. In the first stream, researchers try to grasp and structure managerial issues related to supply chain risks and develop appropriate frameworks and tools. In the modeling stream, research is focused on developing, testing and refining models or devising decision rules for clearly defined instruments for risk management in the supply chain, for example contractual mechanisms.

Irrespective of research stream, much work is devoted to the *appropriate identification of supply chain risks*, the *main sources of uncertainty* that lead to risk exposure, and the *business processes or management tools* that can be used for mitigating those risks (Lee and Billington, 1992, Landeghem and Vanrae, 2002, Chopra and Sodhi 2004, Spekman and Davis, 2004, Hallikas et al, 2004).

As far as mathematical modeling is concerned, there is a substantial amount of work that uses analytical methods in order to provide optimal decisions regarding one or several aspects of supply chain performance. Stochastic programming techniques have been widely used in order to incorporate uncertainty into supply chain decisions (Ma et al 2002, Milner and Kouvelis 2005, Gupta and Maranas, 2003). Simulation has also been used to evaluate the impact on uncertainty under different assumptions concerning supply demand or operations (Garavelli, 2003). Last but not least, a number of models have been proposed that use contingency claims analysis in supply chain risk management. The real options framework has been used mainly for modeling flexibility in supply and operations (Billington, Johnson and Triantis, 2002, Karrad and Siddique, 2004, Kleindorfer and Wu, 2003).

Supply Chain Risk

Risk in supply chains stems mainly from uncertainty about future outcomes, in whatever form this may come, and their corresponding *probabilities* of occurrence. The distinction has to do with the drivers and factors that increase supply chain risk in each case. Those drivers can be further divided in industry specific or supply chain specific factors. In particular, not all supply chains are exposed to the same magnitude and types of risk. This depends largely on the industry in which they operate, as well as on the design of each supply chain (i.e., number of nodes, global vs. local operation, and so forth).

Based on the current literature, supply chain risks can be categorized into five main categories: demand, supply, process, network and environment related risks.

Risks related to demand side uncertainty emerge from the stochastic nature of the product demand and can be linked to specific product and market characteristics. On the other hand, supply side risks increase as the uncertainty upstream in supply chains increases and may be linked to specific supply disruptions and delays. Process risks are associated amongst others to manufacturing techniques, the degree of technological novelty, and the inherent variability in production processes.

Network related risks emerge from the necessity for collaboration and integration of all supply chain members. Surprisingly perhaps, risk in supply chains may increase as the members of the supply chain become more dependent on one another. Finally, supply chains are exposed to increased risks stemming from their external environment. Strikes, terrorist attacks, extreme weather conditions have already proved to be an important reason for delays and disruptions in supply chains.

Drivers of Increased Supply Chain Risk

After having categorized supply chain risks into the above five main categories, we can further identify drivers that increase risk for supply chains depending on the industry they operate in or on their specific design characteristics. Not all supply chains are exposed to the same types and magnitude of risks. This is largely dependent on a number of factors, which include industry specific factors (i.e., volatility of demand, product variety, etc.), as well as characteristics of individual supply chains (i.e., number of nodes, local vs. global operations, etc.). Which are those industry specific factors or even supply chain specific drivers that increase risk exposure for supply chains?

Industry specific factors that drive risk exposure for supply chains

Risk is inherent in supply chain design and operational decisions. Product or market characteristics, technology changes and operations management in each industry differentiate the risk faced by supply chains. For example, when time between the production and sales period is long, like in the case of durable consumer goods, risk of producing the wrong quantities to meet demand is increased. On the other hand, very short product lifecycles may also increase risk of obsolete inventory or insufficient capacity to meet demand. Moreover, sensitive product safety issues, stringent regulations for the market or industry function greatly influence supply chains in those industries. Limited sophistication of suppliers on planning and forecasting, long and variable supplier lead times are likely to lead to supply shortages and delays. Major changes in technology and constant technological innovation increase supply chain risk when Research & Development expenditures are severe or/and with very uncertain outcomes.

Supply chain characteristics that influence the nature and magnitude of risks faced by supply chains

Apart from industry features, a number of supply chain characteristics that have an impact on risk are evident. Design issues and network relationships are important as far as supply chain risk is concerned. These characteristics can be categorized in bigger groups that refer to demand, supply, operations management and design / coordination issues in a specific supply chain. For example, inadequate customer service definition between partners in supply chains may lead to coordination inefficiencies and subsequent customer loss. Similarly, inefficiencies may result from different level of sophistication in each supply chain node. Dependence on a small number of large suppliers or a small number of large customers, lack of trust and differences in culture, business logic and speed between supply chain partners are other indicative supply chain characteristics that are linked with increased risk.

Environmental circumstances that drive risk exposure for supply chains

Last but not least, the macroeconomic environment plays an important role in supply chain risk management and need to be further explained. Some industries are more vulnerable to environmental changes than others, but virtually all business sectors maintain a degree of dependence on greater macroeconomic developments. Political risk in foreign markets or currency exchange rate fluctuation may not be of concern for supply chains that operate locally but is of great importance for global supply chains. On the other hand, many industries depend on the tax and legal regulation that local governments decide upon. It is important to mention the great impact that environmental features such as extreme weather conditions and other catastrophic events may have on supply chain profitability and continuity, despite the fact that they cannot be classified as industry or supply chain specific factors. Such events, like the 9/11 terrorist attack in New York, may have tremendous impact on supply chain operations.

Conclusion

The literature is clear on the importance of supply chain risk issues. Risk factors analyzed previously may have an impact on every supply chain performance metric. Important differentiation factors of risk exposure for different supply chains appear to be product lifecycle, market structure, competition intensity, degree of technological innovation, operations flexibility and the stochastic nature of end product prices. Moreover, supply chain risk also depends on supply chain characteristics, such as the number of supply chain stages and nodes, the existence of common objectives for the whole supply chain, the different level of sophistication of supply chain members or the degree of globalization of supply chain activities. Global supply chains, for instance, are exposed to currency risk, while locally operating supply chains need not to worry about currency exchange rates.

Lack of trust amongst supply chain partners is another important factor for increased risk for the entire supply chain. Further research needs to focus on a quantitative research study on supply chain risk drivers and their subsequent modeling in order to verify the identified drivers of increased risk for supply chains in specific industries and / or with specific characteristics.

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