



Uncertainty and supply chain risk: The moderating role of supply chain flexibility in risk mitigation



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ABSTRACT

In order to remain competitive in the market, firms are forced to expand their product offerings and offer high levels of customization, bringing about high uncertainty in their supply chain. Firms that face high environmental uncertainty are increasingly facing higher risks in terms of supply disruptions, production and delivery delays that ultimately result in poor operational performance. This study aims at understanding the antecedents of supply chain operational risk faced by firms and the conditions under which such risks can be mitigated. Using Indian data from the sixth edition of International Manufacturing Strategy Survey (IMSS) and structural equation modeling, we investigate the relationships between environmental uncertainty and supply chain risk and the moderating effect of supply chain flexibility. We identify appropriate types of flexibility to mitigate the three major aspects of supply chain risk: supply risk, manufacturing process risk and delivery risk. Our empirical investigation reveals that uncertainty in the supply chain leads to high supply chain risk; and in uncertain environments, supply and manufacturing flexibility help in reducing the supply and manufacturing process risks respectively. However, our results also indicate that, in emerging markets such as India where logistic infrastructure is less developed, internal capabilities alone may not be sufficient in reducing supply chain delivery risk. Our findings not only contribute towards filling certain gaps in the supply chain risk management literature, but also provide practicing managers and researchers a better understanding of the types of flexibility that can mitigate supply chain risk in different business environments.

1. Introduction

“In retrospect, yes, I sort of wish we had done it after the turn of the year. Customers wouldn't have had to wait as long as they did” said Tim Cook, the chief executive officer of Apple Inc., in response to the short supply of its redesigned iMac in 2012. “The new iMac was plagued with production issues when the desktop went on sale in December. It was reported that those issues came from a unique screen lamination process Apple has employed in its new design, allowing the desktop to sport a much thinner profile than its predecessor”.¹ Be it automobiles, mobile phones, computers or any high-end technology products, shorter life cycles necessitate frequent introduction of new products in order to survive in the industry. As a result, companies have to deal with significant uncertainties in the environment (Fisher, 1997; Lee, 2002), which makes the supply chains more complex (Merschmann and Thonemann, 2011). For example, frequent product introductions precipitate demand uncertainty, while wider range of products and higher level of customization in conjunction with advanced

technology requirements often create uncertainties in supply as well as production processes (Tang, 2006). Consequently, such firms are increasingly facing higher risks in terms of supply interruptions, production and delivery delays etc. which ultimately result in loss of reputation, lost sales and poor financial performance. A recent survey on global supply chain and risk management shows that repeated changes in product supply and manufacturing requirements because of frequent introduction of new products and less standardization of products and services as key drivers of supply chain complexity leading to increased supply chain risk (Pwc and MIT, 2013). Such risks are attributed to complex supply chains, occur frequently and are referred to as supply chain operational risk (Thun and Hoenig, 2011). In this paper, we study the driving and mitigating factors of supply chain operational risk.

Further, the increasing ramifications of supply chain risks on the performance of firms (Kleindorfer and Saad, 2005) has caught the attention of both academic researchers and industry practitioners in the field of supply chain management (Bogataj and Bogataj, 2007; Matsuo,

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¹ <http://forums.appleinsider.com/t/157148/tim-cook-admits-he-wishes-apple-had-held-launch-of-new-imac-until-2013>. Last accessed on 06.06.15.

2015; Li et al., 2015). Supply chain literature is replete with studies that point out how supply chain design could surge or reduce vulnerability of supply chains to risk. For instance, many researchers have argued that supply chain's susceptibility to risk is augmented by supplier dependence (e.g., Hendricks and Singhal, 2005; Jüttner, 2005), supplier concentration and global sourcing (e.g., Tang, 2006; Jüttner, 2005; Tang and Nurmaya Musa, 2011), focus on cost efficient supply chain (Wong et al., 2006) and lack of coordination among the supply chain network partners (Ojala and Hallikas, 2006). However, very few studies have identified mechanisms to tackle these vulnerabilities and mitigate supply chain risk (e.g., Vilko, J. P., & Hallikas, 2012; Wiengarten et al., 2015).

Supply chain flexibility is typically considered as a key solution to the rising uncertainty and competitiveness in the market. Several empirical studies have shown how supply chain flexibility in the presence of uncertain environments has contributed to better business performance (e.g. Martínez Sánchez and Pérez Pérez, 2005; Merschmann and Thoenemann, 2011). However, to our knowledge, studies that investigate the role of supply chain flexibility in mitigating supply chain risk empirically, have been very sparse. Tang and Tomlin (2008) for example study the significance of flexibility in mitigating supply chain risks using analytical modeling. Furthermore, while many practitioner surveys and industry based studies identify that flexibility is key to managing supply chain risk; it is not clear exactly how much and what type of flexibility is required to mitigate supply chain risks (Tang and Tomlin, 2008). Pujawan (2004) points out that firms should be prudent in evaluating the right amount of flexibility they require, since it is expensive to achieve high levels of flexibility. For instance, a 2013 survey on supply chain innovation shows that only 27% of the respondents considered flexibility as one of the top two key supply chain value drivers for their customer value proposition (Pwc and MIT, 2013). Therefore, it is imperative to understand and identify the contexts under which various types of flexibility would help reduce supply chain risk and test these conjectures through appropriate empirical investigations.

There have been many calls for more empirical research in the field of operations and supply chain management in the last decade, as this helps in theory building and verification (Flynn et al., 1990; Fisher, 1997), and strengthens the link between academics and practitioners in operations management (Steenhuis and Bruijn, 2006). While several case based studies (e.g., Hallikas et al., 2004; Tang, 2006) and conceptual studies (e.g., Trkman and McCormack, 2009; Tang and Nurmaya Musa, 2011) have been carried out in the area of supply chain risk identification and mitigation, empirical survey based research is still at a nascent stage. Thun and Hoenig (2011) and Sodhi et al. (2012) also point out the dearth of empirical investigation in the field of supply chain risk management. Therefore, there is a clear need for empirically establishing the linkages between various elements discussed above, such as supply chain flexibility, environmental uncertainty and supply chain risk in order to fill the gaps in operations and supply chain management empirical research.

The objective of this study therefore is to address these research gaps and to identify appropriate types of flexibility that can help mitigate supply chain risk. We study three major aspects of supply chain risk: supply risk, manufacturing process risk and delivery risk. Using data from 91 Indian manufacturing firms, and structural equation modeling, we investigate the relationships between environmental uncertainty and supply chain risk, and the moderating effects of supply chain flexibility. Emerging economies play a significant role in global trade and account for 50% of global output.² While they present enormous growth prospects, they also pose unique challenges primarily due to low maturity of supply chain processes.³ Given the critical role that emerging markets such as China and India are playing in global supply chains, it is

important to study the driving and moderating factors of supply chain risk in these geographical regions. We strongly believe that our findings not only contribute towards filling certain gaps in the SCRM literature, but also help practicing managers and researchers by providing a better understanding of the types of supply chain flexibility that can mitigate supply chain risk in different business environments.

2. Theoretical constructs and hypotheses development

Several different sources of uncertainty have been recognized in Supply Chain Management (SCM) literature (Ho et al., 2005; Trkman and McCormack, 2009) that create an uncertain business environment for firms. Davis (1993) for example proposes three main sources of supply chain uncertainty: demand, supply and technology. In our study, we consider a fourth dimension 'manufacturing uncertainty' (Ho et al., 2005), in addition to the three proposed by Davis (1993), to operationalize the environmental uncertainty construct.

Many different theoretical perspectives have contributed to the understanding of supply chain risk. Kumar et al. (2010) for example define supply chain risk as "the potential deviations from the initial overall objective that, consequently, trigger the decrease of value-added activities at different levels" (p 3717). Supply chain risk can also be broadly categorized into *disruption risk* and *operational risk* (Kleindorfer and Saad, 2005; Tang, 2006). While *disruption risks* are linked to circumstances such as natural calamities, terrorist attacks and labor strikes, *operational risks* are caused by high uncertainty and a lack of coordination between supply and demand (Lockamy and McCormack, 2010). *Operational risk* is also alluded to as internal supply chain risk (Thun and Hoenig, 2011). According to an industry study by Deloitte, the supply chain risks of "high tech industrial products, and diversified manufacturing industries" had become more costly owing to the complex nature of their supply chains and rapidly changing market needs leading to sudden changes in demand. Forty six percent of executives surveyed pointed out risks within the company-owned supply chain operations as a major concern (Marchese and Paramasivam, 2013). In the context of this study, we only focus on *operational risk* in supply chains. A conceptual framework representing how environmental uncertainty, and the various dimensions of supply chain flexibility and supply chain risk are related is shown in Fig. 1. The relationships between these constructs as depicted in the framework are discussed in more detail followed by corresponding hypotheses, in the subsections below.

2.1. Environmental uncertainty and supply chain risk

Firms that have a product line characterized by frequent introduction of new offerings, wider variety and higher level of customization find it difficult to predict the demand patterns of the products (Fisher, 1997; Lee, 2002; Lo and Power, 2010). While demand uncertainty, which primarily involves the unknowns related to product characteristics, is one of the major sources of uncertainty in the supply chain, there are other sources of uncertainty as well, including manufacturing and supply uncertainty (Ho et al., 2005). While innovative and highly customized product offerings help firms gain a sustainable competitive advantage (Calantone et al., 2010), these also result in higher complexity in the manufacturing and procurement processes of upstream suppliers, leading to higher uncertainty in the entire supply chain (e.g., Randall and Ulrich, 2001). Frequent changes in production technology not only increase complexity of manufacturing, but also forces technical modifications at the suppliers end as well. In addition, the greater changes in order size result in frequent changes not only in the firm's production but also in their supplier's production volume and mix. Supply uncertainty is therefore characterized by unforeseeable and unmanageable factors in the supply of materials mainly attributed to technological complexity (Davis, 1993), and manufacturing variability in product mix and volume.

Supply risk on the other hand is defined as the probable failure in the supply of goods in terms of "time, quality and quantity" resulting in incomplete orders (Kumar et al., 2010). The unpredictable market

² <http://www.fin24.com/Economy/Focus-on-emerging-markets-20130726>. Last accessed on 26.06.15.

³ <http://www.bvdinfo.com/industrynews/procurement-and-risk-management/supply-chains-key-to-emerging-market-growth/801614149>. Last accessed on 26.06.15.

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