THE SUPPLY CHAIN UNCERTAINTY AND RISK MEASUREMENT DEVELOPMENT

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Abstract
Due to the globalization, increased supply chain network complexity, higher customer expectations, shorter product and technology life cycles, and unstable environment, today’s supply chain now face more uncertainties and risks than ever. Supply chain uncertainties and risks already became major obstacles in achieving on time delivery, increasing customer satisfaction, improving the efficiency and reducing costs. Therefore, managing supply chain uncertainty and risk has become a priority issue in supply chain. Uncertainties and risks are interchangeable and inseparable. The study theoretically proposes four major categories of supply chain uncertainty and risk: (1) logistics uncertainty and risk, (2) information uncertainty and risk, (3) customer-related uncertainty and risk, and (4) environmental uncertainty and risk, in logistics and transport service industries. The purpose of this paper is to provide a reliable and appropriate measurement tool to assess the supply chain uncertainties and risks in logistics and transport industries. In developing the research instrument different sources were used including an intensive literature review on supply chain uncertainty and risk and interviews with both supply chain and logistics academics and managers from world leading logistics companies. Using the instrument enables the firms to identify and assess the various supply chain uncertainties and risks holistically in logistics and transport industries. This would also result in the development of a practical guidance for supply chain uncertainty and risk management in the industries.

Keywords: Supply chain uncertainty and risk, Risk management, Risk assessment, Supply chain management and logistics.
Introduction

Supply chain uncertainty and risk have been widely recognised as an issue in today’s supply chain and logistics (Miller, 1992; Davis, 1993; Prater, 2005; Lee, 2002; Rodrigues et al., 2010). Both supply chain uncertainty and risk influence decision makers in the supply chain resulting in ineffectiveness and inefficiency (Vorst and Beulens, 2002), which ultimately affect the organizational performance. According to Sanchez-Rodrigues et al. (2008), "Risk is a function of outcome and probability and hence it is something that can be estimated. If the probability that an event could occur is low, but the outcome of that event can have a highly detrimental impact on the supply chain, the occurrence of that event represents a considerable risk for the chain. Uncertainty occurs when decision makers cannot estimate the outcome of an event or the probability of its occurrence” (Sanchez-Rodrigues et al., 2008, p. 390).

It is important that smooth operations of every link in the supply chain should be taken care of. Supply chain risk and uncertainty in the functioning of any of the links may lead to delays and bottlenecks and may hamper the performance output of the supply chain (Patil et al., 2012). Supply chain risk management is one of the fastest growing areas in logistics research (Andreas and Carl Marcus, 2012). And supply chain uncertainty management is not a new concept, a considerable amount of research has been undertaken on uncertainty in supply chain management (Davis, 1993; Mason-Jones and Towill, 1998; Prater et al., 2001; Rodrigues et al., 2008; Simangunsong et al., 2012).

Effective risk management is driven by both theory and practice. Risk management best practices can only emerge when the theories and models are proved in a real world environment (Lam, 2003). The concepts of supply chain risk management and supply chain uncertainty management are very similar (Simangunsong et al., 2012). For example, Manuj and Mentzer (2008) summarize the existing literatures from supply chain and related disciplines to suggest a five-step process for supply chain risk management. Those five steps include (1) risk identification, (2) risk assessment and evaluation, (3) selection of appropriate risk management strategies, (4) strategy implementation, and (5) mitigation of supply chain risks. Aven (2011) and Simangunsong et al. (2012) argue it is essential to identify and verify the sources of risk and uncertainty in supply chain risk and uncertainty management and mitigate them. Moreover, risk management has the same perspective as a coping with uncertainty strategy (Simangunsong et al., 2012).

One of the main objectives in the uncertainty and risk management is to measure these uncertainties and risks (Aven, 2011). The most important aspect of risk management is the integration of risk into a company’s culture and values, risk management targets should be included among corporate goals, and major corporate initiatives should incorporate risk assessment and risk mitigation strategies (Lam, 2003). This paper attempts to provide an accurate and reliable measurement to assess supply chain uncertainty and risk. It enables the firms to identify and assess the various supply chain uncertainties and risks holistically in logistics and supply chain. The measurement can be used by both academics and practitioners as a guidance for supply chain uncertainty and risk management.

Literature review

Uncertainty and Risk
According to Oxford English Dictionary, risk is the possibility of loss, injury, or other adverse or unwelcome circumstance; a chance or situation involving such a possibility. The general definition of uncertainty is the quality of being uncertain in respect of duration, continuance, occurrence, etc.; liability to chance or accident. Another definition of uncertainty under Economics is a business risk which cannot be measured and whose outcome cannot be predicted or insured against.

In an attempt to distinguish difference between risk and uncertainty, Knight (1921) argues that uncertainty is risk that is immeasurable, and that the risk is defined as uncertainty based on well-grounded probability. Miller (1992) posits that risks in business refers to unanticipated variation or negative variation which may influence business performance such as revenues, costs, profit, market share, and uncertainty refers to the unpredictability of environmental or organizational variables that impact business performance or the insufficient information about these variables.

Generally speaking, risks and uncertainties occur because people do not have sufficient knowledge to understand exactly what will happen in the future. People may use the best techniques and do every possible analysis, but there is always unknown about future events. There is a very close relationship between risk and uncertainty, because uncertainty increase the possibility of risk occurrence, and risk is a consequence of uncertainty (Aven, 2011). In other words risk occurs because of uncertainty about the future, this uncertainty means that unexpected events may occur, and when these unexpected events occur, they cause some kind of damage (Waters, 2011).

There is an interesting statement about risk and uncertainty - "Risk is if people don’t know what will happen next, but people do know what the distribution looks like. Uncertainty is if people don’t know what will happen next, and people do not even know what the possible distribution looks like" (Ritcho, 2012). This statement reflects a similar understanding of Knight (1921), in other words uncertainty is not able to be forecasted or expected beforehand.

**Supply Chain Uncertainty and Risk**

Risk and uncertainty is a major topic in the supply chain literature (Prater, 2005; Davis, 1993; Sanchez-Rodrigues et al., 2008; Simangunsong et al., 2012). The definition of supply chain uncertainty was given by Vorst and Beulens (2002) as follows.

“Decision-making situations in the supply-chain in which the decision-maker does not know definitely what to decide as he / she is indistinct about the objectives; lacks information about (or understanding of) the supply-chain or its environment; lacks information processing capacities; is unable to accurately predict the impact of possible control actions on supply-chain behavior; or lacks effective control actions (non-controllability)” (Vorst and Beulens, 2002, p. 413).

March and Shapira (1987, p. 1404) define “risk as the variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values”. The supply chain risks comprise “any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user” (Jüttner et al., 2003, p. 200).

Supply chain uncertainty and risk usually are interchangeable in practice (Peck, 2006; Jüttner et al., 2003; Ritchie and Brindley, 2007). Jüttner et al. (2003), Peck (2006) and Prater (2005) suggest that the difference between supply chain uncertainty and risk is blurred to the extent that it is not important to distinguish. Many supply chains risks are related to the uncertainty and they are inseparable (Prater, 2005; Simangunsong et al., 2012; Sanchez-Rodrigues et al., 2008; Rodrigues et al., 2010; McManus and Hastings, 2006). However,
some researchers suggest that risk is only associated with issues that may lead to negative outcomes, e.g. Miller (1992), Peck (2006), and Wagner and Bode (2008). Technically, although risk and uncertainty are two different concepts (Peck, 2006; Simangunsong et al., 2012; Rodrigues et al., 2010; Sanchez-Rodrigues et al., 2008; Knight, 1921), for managers, it is important to consider and manage them together in a real world environment. In this paper, supply chain uncertainty and risk is defined as the impacts, consequences, unexpected outcome and/or problems may harm the logistics performance.

Supply chain uncertainty and risk are complex notions that come in many different forms and may include supply chain uncertainty and risk sources, risk consequences and risk drivers (Christopher and Lee, 2004; Manuj and Mentzer, 2008; Rodrigues et al., 2008). It is significant to categorize the different types of supply chain uncertainties and risks in terms of the actual industries and businesses. Different industries and businesses may have different sources and drivers of supply chain uncertainties and risks.

Hult et al. (2010) illustrate uncertainty inherent in the supply chain had an exogenous element for any given participant. For managers, risk is a threat that something might happen to disrupt normal activities or stop things happening as planned (Waters, 2011). In addition many other distinct sources of uncertainty had received insufficient attention in supply chain (Prater, 2005).

Overall, although there are some differences between uncertainty and risk in a deeper level analysis, it is not indispensable to distinguish them, because supply chain uncertainty and risk usually are interchangeable in practice (Peck, 2006; Jüttner et al., 2003; Ritchie and Brindley, 2007). More importantly, in a real-world environment, managers have to face both supply chain uncertainty and risk and manage them simultaneously. Therefore, this study does not focus on distinguishing the uncertainty and risk. Instead, the research considers the ways to measure both uncertainties and risks simultaneously without separate them in supply chain.

The Four Categories of Supply Chain Uncertainties and Risks

Based on extensive literature review on logistics and supply chain management, four categories of supply chain uncertainties and risks have been developed in this paper. These four categories include: 1) logistics uncertainty and risk, 2) information uncertainty and risk, 3) customer-related uncertainty and risk and 4) environmental uncertainty and risk (Murugesan et al., 2013; Simangunsong et al., 2012; Sanchez-Rodrigues et al., 2010).

Measure of supply chain uncertainties and risks is one of the important parts of supply chain uncertainty and risk management (Aven, 2011). Supply chain uncertainty and risk in transport is a part of contingent uncertainty and risk models (Sanchez-Rodrigues et al., 2008). It is ineffective and inefficient to investigate and measure every single source of contingent uncertainties and risks, due to different companies may have different uncertainties and risks. However it is possible to measure the impacts under the same category of supply chain uncertainties and risks in the separate companies, because the same category of supply chain uncertainties and risks may cause common problems in companies. It is easy for managers to monitor and manage these uncertainties and risks. Therefore, the supply chain uncertainties and risks are measured by their impacts of uncertainties and risks, which obstruct the logistics process.

Logistics Uncertainty and Risk

Logistics is described as a time-sensitive process of flow of goods and information from a point of origin to a destination point (Christopher, 1998), and supply chain
uncertainties and risks in this paper are concentrated on logistics and transport service providers. Logistics uncertainty and risk can broadly be categorized as the potential disturbances to the flow of goods, information, and money (Ellegaard, 2008). In this paper, logistics uncertainty and risk is defined as weakness, faulty, error, loss and/or unexpected outcome may influence normal logistics-related activities/processes in transport service providers. The variables of logistics uncertainty and risks in literature include delays, transport network, storage, carrier strength and freight (Rodrigues et al., 2008; Simangunsong et al., 2012; Hauser, 2003).

Information Uncertainty and Risk

In this paper information uncertainty and risk is defined as information-related unexpected incidents; outcome and/or problems may influence information in time, accuracy and availability in logistics and transport service providers. Information is the aider in the smooth functioning of the supply chain. The sources of information uncertainty and risk identified in literature include information delays, unavailability of information, information infrastructure, and information and communication issues. (Guo et al., 2006; Cucchiella and Gastaldi, 2006; Blackhurst et al., 2008; Sanchez-Rodrigues et al., 2010).

Customer-related Uncertainty and Risk

Customer-related uncertainty and risk are most likely occurred between the logistics service providers and customers. It is difficult to draw a clear boundary between different uncertainties and risks. However in this paper, the definition of customer-related uncertainty and risk is a part of supply chain uncertainty and risk, which mainly originate from customer side rather than companies, may cause disputes and/or influence the normal logistics operations in logistics service providers. Due to the nature of transport and logistics industry, receivers and senders play an equal important role in the industry. Therefore it is important to consider both receivers and senders together. In literature, there are various customer-related uncertainties and risks include: unanticipated customer, reputation, forecast error, delays to customer, receivable risks. (Manuj and Mentzer, 2008; Sodhi and Lee, 2007; Chopra and Sodhi, 2004; Sodhi and Tang, 2012).

Environment Uncertainty and Risk

Uncertainty and risk can arise due to the interactions between the supply chain network and its external environment/events. The environment uncertainty and risk have been considered widely in previous studies (Simangunsong et al., 2012). It is significant to think about the environment uncertainty and risk, most environment uncertainty and risk are unavoidable, such as road congestions/closures and natural disaster. Therefore the logistics service providers have to consider these factors beforehand. In this study, we consider the environment uncertainty and risk form these five factors include: labor, road congestion, natural disasters, fuel price, and regulations. (Blackhurst et al., 2008; McKinnon and Ge, 2004; Sanchez-Rodrigues et al., 2010; Simangunsong et al., 2012).

Instrument Development

In developing the research instrument a wide range of sources were used. Measuring supply chain uncertainty and risk was based on the actual logistics and transport industry operations, previous studies and interviews with supply chain and logistics academics and
practitioners in the Australian logistics and transport industry. An extensive literature review is conducted to identify supply chain uncertainty and risk variables. And a pilot study is undertaken to refine and categorize these variables via supply chain and logistics academics and managers who had extensive experience working in transport and logistics industry.

In this paper, the instrument development focuses on the logistics and transport service providers. Usually, three major parties - logistics and transport service providers, consignors and consignees, are involved in a logistics and transport service. The first three categories of uncertainties and risks originated from the major parties in a logistics transaction; the last one is from external environment.

29 supply chain uncertainty and risk variables have been identified in this paper. The instrument is shown in Table I. Measurement validity included face validity, concurrent validity, and content validity are developed in this paper. All members from Chartered Institute of Logistics and Transport Australia (CILTA) are invited to review the variables and provide comments. The final result of the supply chain uncertainty and risk scale will be presented in a research paper soon.

Conclusion

For managers, they have to manage all kinds of supply chain uncertainties and risks in a real-world environment. Therefore, a reliable and appropriate instrument does not only enable academics to perform a further research on supply chain uncertainty and risk, but also allow managers to have a holistic view of supply chain uncertainty and risk, so that the managers can make a decision effectively and efficiently. Furthermore, both supply chain risk and uncertainty management strategies request a reliable and appropriate uncertainty and risk scale for assessment of supply chain uncertainty and risk in industries (Aven, 2011). Therefore, it is significant to develop a systematic measurement tool to assess the supply chain uncertainties and risks.

Over the past decade, some authors started paying attention to supply chain risk and uncertainty in transport and logistics operations (Sanchez-Rodrigues et al., 2010; Rodrigues et al., 2008). Supply chain risk and uncertainty in logistics and transport can broadly be categorized as the potential disturbances to the flow of goods, information and money (Ellegaard, 2008). For example, Sanchez-Rodrigues et al. (2010) state transport-related uncertainty and the main drivers impacting the sustainability and transport operations are delays, variable demand / poor information, delivery constraints and insufficient supply chain integration. Vorst and Beulens (2002) identify sources of uncertainty for supply chain redesign strategies. Rodrigues et al. (2008) develop a logistics-oriented uncertainty model - the logistics uncertainty pyramid model, which includes five sources of uncertainty related to suppliers, customer, carrier, control system and external environment. Sanchez-Rodrigues et al. (2010) evaluate the causes of uncertainty in logistics operations. Obviously, we need a reliable and appropriate instrument for assessing the supply chain uncertainties and risks in logistics and transport industries.

Supply chain uncertainty and risk can be categorized in terms of different perspectives (Christopher and Peck, 2004). This paper provides a contribution to the supply chain uncertainty and risk literature, a reliable and appropriate instrument for assessing the major uncertainties and risks in the logistics and transport industry. The instrument also could be used for prioritization of these uncertainties and risks based on their impacts with respect to the overall supply chain uncertainties and risks. This would improve the effectiveness and efficiency of supply chain uncertainty and risk management in a particular logistics and transport company, and help the managers to focus their attention and develop uncertainty
and risk management strategies based on the relative importance of supply chain uncertainty and risk variables in their companies.

Table I. Supply Chain Uncertainty and Risk Variables for Logistics and Transport Service Providers

<table>
<thead>
<tr>
<th>Uncertainty / Risk Variables</th>
<th>Sources</th>
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</thead>
<tbody>
<tr>
<td><strong>Logistics Uncertainties and Risks</strong></td>
<td>Murugesan et al., 2013; Rodrigues et al., 2008; Simangunsong et al., 2012; Hauser, 2003</td>
</tr>
<tr>
<td>1. Inadequate operational strength</td>
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<td>2. Storage issues</td>
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<td>3. Delays in pickup/delivery</td>
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<td>4. Poor design of company’s transportation network</td>
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<td>5. Improper packaging and marking details</td>
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<td>6. Damages due to accident/improper stacking/sorting</td>
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<td>7. Breakdown of equipment, trucks and/or vans</td>
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<td>8. Processes errors</td>
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<td>9. Lost/missing freight</td>
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<tr>
<td><strong>Information Uncertainties and Risks</strong></td>
<td>Murugesan et al., 2013; Simangunsong et al., 2012; Guo et al., 2006; Cucchella and Gaudelli, 2006; Blackhurst et al., 2008; Sanchez-Rodriguez et al., 2010</td>
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<tr>
<td>1. Delay or unavailability of the delivery information</td>
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<td>2. Incorrect information</td>
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<td>3. Poor communication between company and drivers</td>
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<td>4. Breakdown of external/internal IT system, mobile phones and/or computers</td>
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<tr>
<td>5. Poor security of information system</td>
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<td>6. Poor information sharing within company</td>
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<td>7. Information confusion</td>
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<tr>
<td><strong>Customer-related Uncertainties and Risks</strong></td>
<td>Murugesan et al., 2013; Mannj and Mentre, 2008; Sodhi and Lee, 2007; Chopra and Sodhi, 2004; Sodhi and Tang, 2012</td>
</tr>
<tr>
<td>1. Delays due to customer’s mistakes</td>
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<td>2. Customers refusing the freight charge</td>
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<td>3. Customers changing the preference</td>
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<td>4. Inaccurate forecast of customers’ freight volume</td>
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<tr>
<td>5. Poor communication between company and customer</td>
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<td>6. Damages due to customers’ faults</td>
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<td>7. Complexity of process</td>
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<td>8. Higher customer expectation</td>
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<tr>
<td><strong>Environment Uncertainties and Risks</strong></td>
<td>Murugesan et al., 2013; Blackhurst et al., 2008; McKinnon and Ge, 2004; Sanchez-Rodriguez et al., 2010; Simangunsong et al., 2012</td>
</tr>
<tr>
<td>1. Labor/driver shortage</td>
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<td>2. Road congestion/closures</td>
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<tr>
<td>3. Weather/natural disasters/industrial action</td>
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<td>4. Unstable fuel price</td>
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<tr>
<td>5. Uncertainty due to government laws/regulations</td>
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</table>
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