

**AN INVESTIGATION INTO SUPPLY CHAIN RISK
MANAGEMENT IN SRI LANKA**

Kuda Liyanage Don Athalanka

159202N

Degree of Master of Business Administration in Supply Chain
Management

Department of Transport & Logistics Management

University of Moratuwa

Sri Lanka

August 2019

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Thesis submitted in partial fulfilment of the requirements for the
Degree Master of Business Administration in Supply Chain Management

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Name of the supervisor: Dr. Ranil Sugathadasa

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ABSTRACT

Supply chains are inherently vulnerable not only to individual organisational risks but also to the risks created by organisational inter-connections as well as the external environments in which they operate. On top of this, in recent years supply chains have been made more susceptible to disturbances by adoption of contemporary supply chain strategies such as global sourcing, outsourcing, lean manufacturing, high customisation of products, short product life cycles etc. As a result supply chain risk management and supply chain resilience have gained significant attention both in the industry and in academia all around the globe.

Main objective of this research was to serve as a foundational study into supply chain risk management landscape in Sri Lanka as prevalent in mid-2019. In order to achieve this objective, an investigation on the maturity of supply chain risk management processes at Sri Lankan organisations was carried out during the month of June in 2019. Study further extended to explore the practitioner perception on supply chain vulnerability and to examine the relationship among supply chain vulnerability, supply chain risk management maturity and supply chain resilience for the Sri Lankan context.

Focus of the study extended to cover Sri Lanka as a whole. Therefore, the population for this research was comprised of all individuals who were directly involved in supply chain risk management process at all Sri Lankan organisations. In order to suitably represent this population, graduates and students of the MBA in Supply Chain Management programme offered by University Moratuwa were selected as the primary sample for data gathering. An online questionnaire was sent out to 60 respondents representing the selected primary sample and requested them to forward the same to other potential respondents. Altogether 42 responses were received of which 39 were considered for analysis that comprised of a confirmatory factor analysis to validate the adopted theoretical model.

At the completion of the research it could be concluded that Sri Lankan supply chain professionals perceive vulnerability of Sri Lankan supply chains as being moderate. It could be further concluded that overall supply chain risk management process maturity in Sri Lanka is at a 'proactive' level where individual firms have succeeded in adopting formal standalone processes to counteract supply chain risks while failing to achieve significant integration across end-to-end supply chain. Finally it could be concluded that supply chain risk management process maturity positively influences supply chain resilience in the Sri Lankan context.

Keywords – supply chain risk management, supply chain risk management process maturity, supply chain resilience, supply chain vulnerability

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1. INTRODUCTION

A supply chain can be viewed as a network of organisations involved in moving a product or a service, together with related information and cash flows, between an origin and a destination. Due to this interconnected nature of organisations in a supply chain, supply chains are exposed not only to vulnerabilities of individual organisations but also to the vulnerabilities created by organisational inter-connections as well as the external environments in which the supply chains operate. (Jüttner, Peck, & Christopher, 2003). These environmental, network related and organisational vulnerabilities act as inherent risk sources for a supply chain.

On top of above inherent risk sources, in recent years supply chains have been made more susceptible to disturbances by adoption of contemporary supply chain strategies such as global sourcing, outsourcing, lean manufacturing, Just-In-Time inventory management, high customisation of products, short product life cycles etc. (Thun & Hoenig, 2011). Despite these supply chain strategies increasing the vulnerabilities of supply chains, they have proved immensely important in increasing the competitiveness of supply chains in terms of cost efficiency and customer satisfaction. As such, reversing these strategies is not a viable option for any supply chain aiming to remain competitive in this highly demanding environment. Rather, as a potential solution for aforementioned vulnerabilities of supply chains, both the industry and academia have turned their attention to areas of supply chain risk management and supply chain resilience. Following this global trend in supply chain research, this study attempts to understand the supply chain risk management and supply chain resilience landscape in Sri Lanka.

1.1. Objective of the Study

Main objective of this research is to serve as a foundational study into supply chain risk management landscape in Sri Lanka as prevalent in mid-2019 by

- Exploring the perception on supply chain vulnerability among Sri Lankan supply chain management professionals.

- Understanding the maturity of supply chain risk management process among Sri Lankan organisations.
- Understanding the relationships among supply chain vulnerability, supply chain risk management process maturity and supply chain resilience with respect to Sri Lankan organisation.

1.2. Significance of the research

Although supply chain risk management and supply chain resilience have been gaining significant recent attention in academia globally, most of the research work done has mainly focused on the theoretical development of the subject. As such it appears that there is a lack of empirical work done in the areas of supply chain risk management and supply chain resilience. (Thun & Hoenig, 2011; Ghadge, Dani & Kalawsky, 2010). Limited number of empirical studies conducted has been mainly in the contexts of developed countries. (Tukamuhabwa, Stevenson, Busby, & Zorzini, 2015). Therefore, there is clearly a need for conducting empirical research work on supply chain risk management and supply chain resilience in the context of developing countries. This study attempts to address that need by attempting to understand the supply chain risk management and supply chain resilience landscapes in the Sri Lankan context.

External vulnerabilities such as political unrest, terrorism and adverse weather conditions have been common place in Sri Lanka during last quarter century. Further lack of supply chain visibility due to limited adoption of advanced supply chain technologies and moderate maturity in general supply chain management practices make Sri Lankan supply chains susceptible to supply chain network related vulnerabilities as well. These together with common intra-organisational vulnerabilities such as machine breakdowns and strikes have posed significant risks to efficient and effective functioning of Sri Lankan supply chains. Therefore, an attempt to understand the maturity of supply chain risk management in Sri Lanka is a sensible effort both from academic and industrial perspectives.

Furthermore, Sri Lanka as country plays an integral role in a few significant global supply chains such as apparel, tea, graphite, computer software etc. This makes it more significant for us to understand the Sri Lankan supply chain risk management landscape as it could have an impact on a global scale.

1.3. Scope of the research

The scope of this study encompasses understanding of Sri Lankan supply chain practitioner perception of the level of vulnerability in respective supply chains, establishing the level of maturity in supply chain risk management processes at Sri Lankan organisations and establishing if there is a relationship between the maturity of the supply chain risk management and the level of supply chain resilience.

Since, to the best of author's knowledge, there has not been a previous study of similar nature in Sri Lankan context, the study has not been confined to any particular industry sector. Instead an attempt has been made to gather data from a cross section of industries. This unconstrained industry focus is expected to provide the greatest level of exploration into supply chain risk management subject matter in Sri Lanka. Furthermore, data gathering exercise will exclusively focus on supply chain professionals holding degree level academic/ professional qualifications or professionals holding at least executive level ranks in their respective organisations. This will ensure that the data gathered is of greater relevance and validity to form an understanding on the supply chain risk management and supply chain resilience landscape in Sri Lanka.

1.4. Overview of thesis

Remainder of this thesis is lined up as follows.

Chapter 2 comprehensively reviews existing literature in the areas of supply chain risk management and supply chain resilience to form the theoretical background for the study.

Chapter 3 explains the methodology adopted to conduct this study. Details pertaining to research model design, data gathering method, sample design and data analysis methods are explained in this section.

Chapter 4 of the thesis focuses on carrying out data analysis methods outlined in the previous chapter, on the selected set of data. It includes relevant descriptive analysis and hypothesis testing to evaluate the conceptual model developed.

Chapter 5 discusses in detail the findings of the analysis carried out in Chapter 4.

Chapter 6 summarises the findings and conclusions of the study. It also extends to capture the limitations of the study and to make recommendations for future studies.

2. LITERATURE REVIEW

2.1. Risks in Supply Chains

2.1.1. Definition

Heckmann, Comes and Nickel (2015), while acknowledging the difficulty in clearly determining the origins of the word ‘risk’, maps it back to a Greek navigation term ‘rhizikon’ which describes the need to avoid difficulties at sea. Taking a cue from this naval context and applying it to commercial context, they have identified risk as a term expressing “fear that economic activities lead to the loss or devaluation of an important asset or a decrease in the performance of a business” (Heckmann, Comes & Nickel, 2015, p.121). Similarly, Rao and Goldsby (2009) have acknowledged that there is no commonly accepted definition of risk in the literature. They have further identified that the efforts to conceptualise risk in the literature have taken two main approaches. One of those approaches regards risk as a variation from the expected outcomes and the other consider risk as the combination of the probability for a loss with its negative impact towards an individual or a firm. (Louis & Pagell, 2018). Encapsulating both the approaches, March and Shapira (1987) have defined risk as “the variation in the distribution of possible outcomes, their likelihood and their subjective values” (p.1404). Following this definition, for the purpose of this study, risk is understood as the unwanted variation from the expected outcomes that may cause loss to an individual or a firm.

Following above definition of risk by March and Shapira (1987), Jüttner, Peck and Christopher (2003) have defined supply chain risk as “the variation in the distribution of possible supply chain outcomes, their likelihood and their subjective values” (p.204). They have further extended this definition to stress that supply chain risks comprise “any risk for the information, material and product flows from original supplier to the delivery of final product for the end user” (p.204). It is clear that by this definition Jüttner, Peck and Christopher have attempted to define supply chain risk in its broadest sense covering all flows along the end-to-end supply chain. This definition of supply chain risk has been well accepted in the literature, and

many authors have built on it in defining supply chain risk. (Louis & Pagell, 2018). Accordingly, Louise and Pagell (2018) have defined supply chain risk as “the unwanted negative deviation from expected outcomes that can adversely affect supply chain operations and may result in detrimental consequences to focal firm”. For the purpose of this study supply chain risk is understood in accordance with above definition of Louis and Pagella (2018).

2.1.2. Supply Chain Risk Drivers and Sources

Various attempts have been made in the literature to identify drivers behind supply chain risks. One such attempt made by Ivanov, Tsipoulanidis and Schönberger (2018) has tried to classify a few of the recent supply chain disturbances according to their drivers. They have identified seven such drivers, namely, Terrorism/ Piracy, Natural disasters, Man-made disasters, Political crisis, Financial crisis, Strikes and Legal contract disputes. Similarly Thun and Hoenig (2011) have recognised contemporary supply chain features such as increased competition among supply chains, complex product offerings to satisfy a range of customers, lengthy and complex supply chains due to globalisation, lean supply chain practices, increasing trends towards outsourcing and single sourcing as drivers in supply chain risks in recent years.

On top of these attempts to understand supply chain risk drivers, further efforts have been made to group these supply chain risk drivers into common sources. Accordingly Thun and Hoenig (2011) have recognised two sources of supply chain risks for the cross-company supply chain context as “upstream” and “downstream” risk sources. Manuj and Mentzer (2008) have identified supply risk, demand risk, operating risk, information security risk, macroeconomic risk, political risk, competitive risk and resource risk as risk sources. Out of those risk sources supply, demand, operating and information security risks can be considered pure supply chain risk sources. However, for the purpose of this study the supply chain risk source classification forwarded by Jüttner, Peck and Christopher (2003) is adopted. They have identified three supply chain risk sources, namely, environmental risk sources, network related risk sources and organisational risk sources. This

classification, despite capturing the complexities of supply chain operational interdependencies among organisations and environments, still remains simple to understand and execute practice. Figure 2-1 below supports the visualisation of this classification.

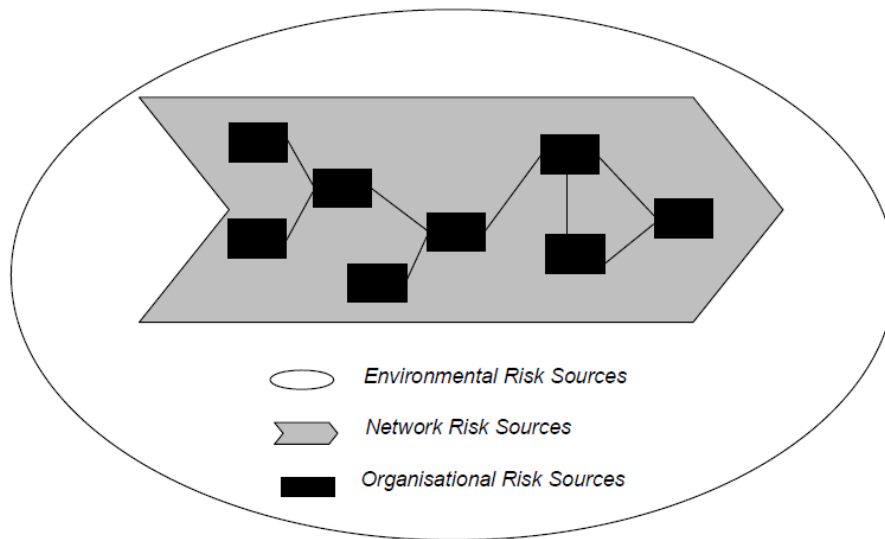


Figure 2-1: Risk sources in supply chain (Source: Jüttner, Peck and Christopher 2003)

Environmental risk sources are concerned with any uncertainties arising from interaction between supply chain and environment such as socio-political actions and acts of god. Organisational risk sources are concerned with intra-organisational uncertainties such as strikes, machine failures and IT system malfunctioning etc. Network related risk sources are concerned with risks and risk drivers arising due to inter-organisational interactions within a supply chain. These may include lack of ownership, chaos and inertia etc.

2.1.3. Supply Chain Risk Consequences

Jüttner, Peck and Christopher (2003) have broadly recognised the consequences of supply chain risks as variances in the supply chain outcome variables such as cost, quality, delivery, innovation etc. According to this recognition it is clear that the consequences of supply chain risks are concerned with the very delivery of strategic objectives of a supply chain and thereby delivery of overall organisational objectives.

Ivanov, Tsipoulanidis and Schönberger (2018) have termed the consequences of supply chain risks as disturbances that may affect operations, processes, plans, goals and strategies. By this recognition also it is clear that the consequences of supply chain risks could have a strategic level impact to a supply chain and by extension to an organisation as a whole. Thun and Hoenig (2011), while citing empirical evidences of giant global automakers such as Toyota, Ford and Land Rover, have established that consequences of supply chain risk could include financial losses, negative corporate image, loss in demand and damages in security and health. This recognition of Thun and Hoenig (2011) is well in line with the works done by Hendricks and Singhal (2005) who have, after studying 885 supply chains disturbances concerning listed organisations in the USA, established that organisations impacted by supply chain disturbances have recorded on average 6.92% lower sales growth, 10.66% higher growth in costs and 13.88% higher growth in inventories. They have further established that studied organisations have suffered significantly lower operating incomes, return on sales and return on assets compared to unaffected organisations. Furthermore, there are evidences in the literature of organisations that were not at all able to recover from such a supply chain disturbances and had to face insolvency. (Tukamuhabwa, Stevenson, Busby, & Zorzini, 2015). Therefore, it is clear that consequences of supply chain risks are of detrimental nature not simply to manage supply chain demand and supply but also to very existence of an organisation.

Despite the absence of empirical evidence relating to supply chain risk consequences in Sri Lankan context, it would not be far from reality to assume that the consequences would be similarly detrimental as in the global context.

2.2. Supply Chain Risk Management

2.2.1. Definition

Risk management in general can be understood as a methodological approach to managing uncertainty outcomes. Many authors, both in academia and industry, have attempted to define risk management and to introduce risk management tools/

approaches. (Oliveira, Marins, Rocha, & Salomon, 2017). One such effort made by the Institute of Risk Management has defined risk management as “a process whereby organisations methodically address the risks attaching to their activities with the goal of achieving sustained benefit within each activity and across the portfolio of all activities” (The Institute of Risk Management, 2002, p.2). Further, they have recognised adding maximum sustainable value to all activities of an organisation as the objective of a properly governed risk management process. (The Institute of Risk Management, 2002). The importance of the subject has been so well understood that even the International Standard Organisation (ISO) has introduced a standard outlining guidelines for risk management: ISO 31000. Figure 2-2 below presents the risk management process introduced in ISO 31000.

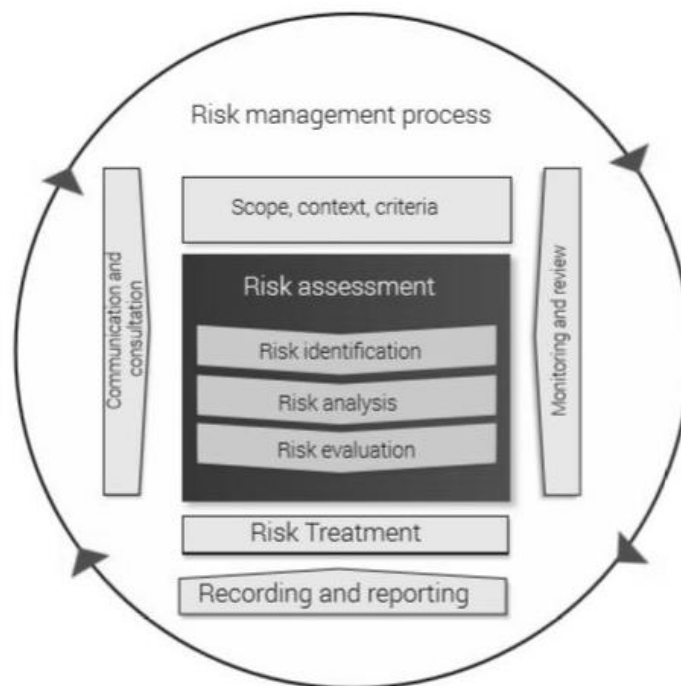


Figure 2-2: Risk management process (Source: ISO 31000)

Establishing scope, context and criteria acts as the overall backdrop of the process against which the whole process will unfold. Risk identification aims to generate comprehensive list of risks from different sources. Risk analysis attempts to establish negative consequences and probability of occurring related to risks identified in risk identification step. Risk evaluation is concerned with establishing treatment priorities for each of the risks based on the analysis done in previous step. Risk identification,

analysis and evaluation put together are known as the risk assessment stage of the risk management process. Risk treatment step is concerned with establishing potential options to deal with risks. These potential options could include avoidance, acceptance, alteration, sharing or retaining strategies. Monitoring & review, recording & reporting and communication & consultation activities are present to enhance the process to improve the outcome.

In addition to above risk management process, ISO 31000 standard have outlined risk management framework as shown in the Figure 2-3 below.



Figure 2-3: Risk management framework (Source: ISO 31000)

As can be seen from Figure 2-3, leadership and commitment has been recognised with central importance in effective risk management over other elements of design, implementation, evaluation, improvement and integration. Together those elements form the risk management framework.

Mostly following above mentioned academic and practitioner work on general risk management, a significant number of efforts have been made on the area of supply chain risk management (SCRM) as well. (Oliveira, Marins, Rocha, & Salomon, 2017). Jüttner, Peck and Christopher (2003) have defined SCRM as “the identification and management of risks for the supply chain, through a co-ordinated

approach among supply chain members, to reduce supply chain vulnerability as a whole” (p. 206). Considering above definition it is clear that the process/ activities involved in SCRM is identical to those of general risk management but the differentiation is in the scope in which they are practiced. SCRM specifically focuses on supply chain related risks concerning the whole supply chain and as such management efforts extend beyond organisational boundaries to collaborate with all supply chain member. On the other hand general risk management considers a wider range of risks such as financial, market etc. but its coverage is mostly confined within organisational boundaries.

Following above definition of SCRM, a number of efforts have been made in the literature to develop SCRM tools to be put in practice. One such tool developed by Harland, Brenchley and Walker (2003) have identified mapping supply network, identify risks and their current location, assessing risks, managing risks, forming collaborative supply network risk strategies and implementing supply network risk strategies as steps in an iterative process for SCRM. This model is presented in Figure 2-4 below.

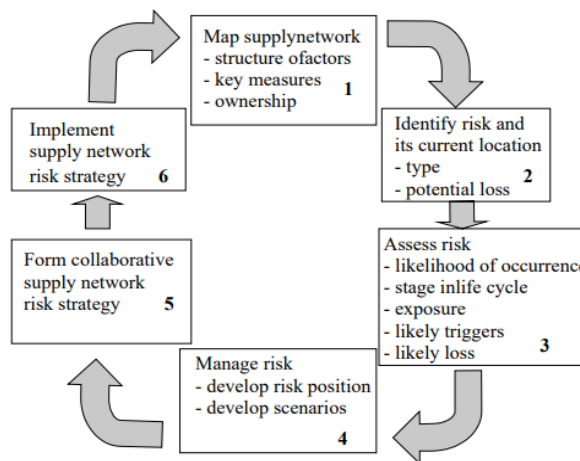


Figure 2-4: Supply network risk tool (Source: Harland, Brenchley & Walker, 2003)

By comparing above Figure 2-4 with Figure 2-2 on page 10, it is clear that the steps in SCRM tool by Harland, Brenchley and Walker (2003) closely follow the steps in general risk management process outlined in ISO 31000, except for the extension beyond organisational boundaries to collaboratively decide and implement risk

strategies. This is a common observation for most of the SCRM tools in the literature. (Oliveira, Marins, Rocha, & Salomon, 2017). Accordingly Oliveira *et al.* (2017), after having carried out a comprehensive literature review on SCRM process and tools, have concluded that SCRM process can be harmonised with the ISO 31000 standard for general risk management. Therefore, for the purpose of this study, SCRM process is considered in conjunction with the risk management process detailed in ISO 31000 with specific focus on supply chain related risks and covering an end-to-end supply chain scope.

2.2.2. Supply Chain Risk Management Strategies

As identified in section 2.2.1, definition and implementation of risk management strategies is an important integral part of a SCRM process. As such in this section an attempt is made to understand a few SCRM strategies found in the SCRM literature.

Jüttner, Peck and Christopher (2003) have recognised risk management strategies as strategic moves an organisation deliberately undertake to mitigate the uncertainties identified from various risk sources. Extrapolating on this idea, SCRM strategies could be identified as conscious efforts organisations make to control the negative supply chain consequences arising from supply chain risk sources either by minimising those uncertainties or by reducing them. Tang (2006) has introduced four basic strategies to SCRM, namely, supply management, demand management, product management and information management. Supply management strategies attempt to address uncertainties arising from supply side fluctuations and demand management strategies deal the same way with demand side fluctuations. Product management strategies attempt to reduce complexities in product offering and thereby attempt to reduce related uncertainties while information management attempts to reduce uncertainties relating to information flow. Figure 2-5 below demonstrates this model graphically.

In another attempt to understand SCRM strategies, Ivanov *et al.* (2018) have suggested that decisions regarding SCRM strategies could be made at multiple

levels depending on the uncertainty factor/ risk source. This representation is summarised in Table 2-1 below.

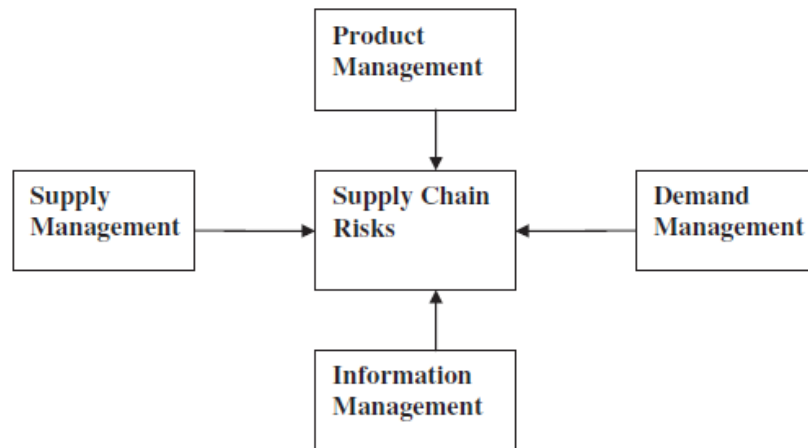


Figure 2-5: Four basic approaches to managing supply chain risks (Source: Tang, 2006)

Table 2-1: Uncertainty factors and measures for their handling in supply chains

Decision-making level	Uncertainty factors	Handling measures
Strategic	Multiple management goals Terrorism, piracy Financial and political crises Natural disasters	Multi-criteria analysis techniques supply chain security management Liquid assets reserves Strategic material inventories Market diversification and outsourcing Product lines' flexibility and modularity
Tactical and operational	Weak coordination Stockless processes Weak control of cargo security Technological breaks Human errors	Safety stocks and time buffers Reserves of supply chain capacities supply chain coordination, monitoring, and event management

(Source: Ivanov, Tsipoulanidis, & Schönberger, 2018)

As can be understood from above attempts to outline SCRM strategies, it is clear that there needs to be a multilevel decision making approach on how best to manage supply chain risks depending on the supply chain risk source respective risks arising from.

2.2.3. Supply Chain Risk Management Maturity Model

Since its first introduction in the field of quality management, maturity models have gained significant interest, both among academics and practitioners, in many disciplines such as information technology, software development, technology, innovation, product design, operation management etc. (Mendes Jr, Leal, & Thomé, 2016; Netland, Alfnes, & Fauske, 2007). In general maturity models attempt to measure the achievements relating to activities, processes or organisations against a well accepted set of best practices related to the activity, process or organisation being measured. By doing so, maturity models and tests provide a directional guidance for improvements to whatever that is being measured. As such maturity models and tests play a significant role of pragmatic importance in continuous improvement efforts of activities, processes or organisations. Fraser, Moultrie and Greogry (2002) have identified having multiple levels of maturites (between three to six) with each level comprisig of several dimensions and containing descriptions for respective maturity levels as a common trait of maturity models. Further, they have identified three types of maturity models, namely, Likert-like questionnaires, maturity grids and Capability Maturity Model (CMM)-likes. Of those types Likert-like models are supposed to be the simplest form while CMM-like models are the most sophesticated of the three. (Fraser, Moultrie, & Greogry, 2002).

Similarly to other diciplines, supply chain diciplien too has embrased the use of maturty models to benchmark activities, processes, organisations or even entire supply chains. Use of maturity models can be seen in diffenent areas of supply chain management such as supplier managemet, supply chain integration, supply chain planning, green supply chain management and in general supply chain management etc. (Mendes Jr, Leal, & Thomé, 2016; Childerhouse, Böhme, Deakins, & Disney, 2011; Netland, Alfnes, & Fauske, 2007; Lapide, 2005). Despite this wide use of maturity models in supply chain, use of maturity models in SCRM is not common place within academic literature. However, Supply Chain Risk Leadership Council (SCRLC), a cross industry council working to create and promote best practices in SCRM, has presented a SCRM process maturity model. This grid type maturity

model attempts to establish the maturity level an organisation has achieved in managing its supply chain risks by assessing the depth and breadth of SCRM Leadership, SCRM Planning, SCRM Implementation, SCRM Evaluation and SCRM Improvement. In order to assess how well each of the above attributes are practised within the organisation, SCRLC propose to measure the depth and the breadth of 23 activities/ sub processes. Table 2-2 below, illustrates how these 23 activities/ sub processes are connected to each of the main five attributes.

Table 2-2: Mapping of activities/ sub-processes to main attributes in SCRLC maturity model

Main Attribute	Sub-process/ Activity
SCRM Leadership	Executive Leadership
	Governance
	Functional Leadership
	Resources & Commitment
	Programme Communication
SCRM Planning	Supply Chain Mapping
	Context & Operational Environment
	Stakeholder Identification
	Risk Tolerance Identification
	Risk Categories Identification
	Business Impact Identification
	Event Likelihood & Consequence
	Risk Prioritisation
	Risk Treatment Identification
	Stakeholder Consultation
SCRM Implementation	Risk Monitoring
	Risk Treatment Execution
	Event Communication
SCRM Evaluation	Programme Metrix
	Performance Review
	Audit / Drill / Test
SCRM Improvement	Continuous Improvement
	Change Management

(Source: SCRLC website)

There are five maturity levels defined for each of the above twenty three activities/ sub-processes depending on the nature of formality in which the activity/ sub-process

is being practised and the level of integration along the supply chain for the same. Each of these maturity levels are well defined in the grid format so that there is little room for ambiguity. SCRLC SCRM maturity model in full detail is presented in Appendix I of this thesis.

As can be seen from Table 2-2 above, five main attributes the SCRLC SCRM maturity model attempts to measure are well in line with the risk management process and framework outlined in ISO 31000. As such, for the purpose of this study, SCRLC SCRM maturity model will be used as the basis for determining the maturity in SCRM process in Sri Lanka.

2.3. Supply Chain Resilience

Due to its multi-disciplinary and multi-dimensional nature, the concept of resilience has been defined differently within different disciplines. (Ponomarov & Holcomb, 2009; Ponis & Koronis, 2012; Kamalahmadi & Parast, 2016). In its most generic term, Oxford English Dictionary defines resilience as the “capacity to recover quickly from difficulties; toughness” or as the “ability of a substance or object to spring back into shape; elasticity”. (Oxford University Press, 2019). In terms of enterprise resilience, Sheffi & Rice Jr. (2005) have defined resilience as “the ability to bounce back from a disruption” (p.41). Extending from the concept of enterprise resilience, the concept of ‘supply chain resilience’ has come on to life and there has been a notable number of studies carried out in this area since its inception. Kamalahmadi and Parast (2016), after having reviewed 100 publications in the area of supply chain resilience have defined the same as “the adaptive capability of a supply chain to reduce the probability of facing sudden disturbances, resist the spread of disturbances by maintaining control over structures and functions, and recover and respond by immediate and effective reactive plans to transcend the disturbances and to restore the supply chain to a robust state of operation”. (p. 121). As can be seen from above definition, supply chain resilience is not purely a reactive strategy but it also has an element of proactiveness attached to it. Therefore, in simple terms supply chain resilience can be viewed as the quality of a supply chain to be prepared for an unexpected event, to resist and to respond efficiently should an event materialise and

to recover from it to ensure sustainable competitive advantage. This definition of supply chain resilience is presented in Figure 2-6 below.

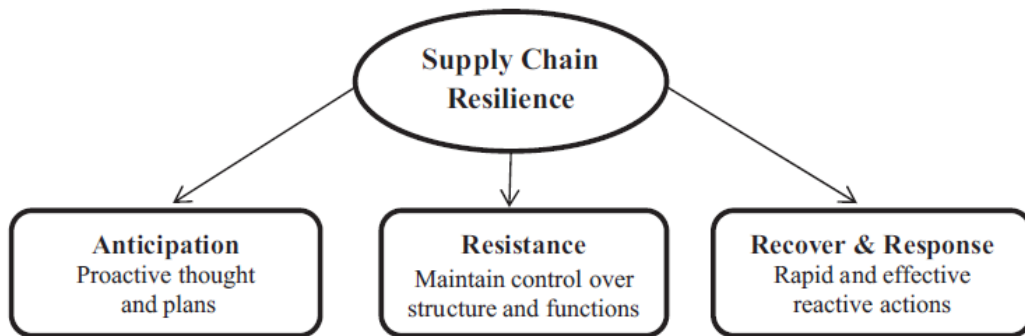


Figure 2-6: Supply chain resilience (Source: Kamalahmadi & Parast, 2016)

3. RESEARCH METHODOLOGY

3.1. Methodological Approach - Overview

After having identified research objectives and having carried out a comprehensive literature review into areas of SCRM and supply chain resilience, the next step was to set up the underlying theoretical framework for the research. This included establishing a set of hypothesis and a conceptual model, developed based on the literature review conducted, to answer the research questions identified. This was then followed up by establishing the data collection methodology for the research which included determining the sample for data collection and the tool for data collection. After having collected the data and having carried out necessary cleansing, next was to determine and apply appropriate data analysis methods on collected data to test the developed hypothesis, while ensuring reliability and validity of the findings. More on each of the above steps are discussed in detail in the remainder of this chapter.

3.2. Hypothesis and Conceptual Model Development

The literature review carried out clearly provided evidence that there has been a recent increase in the vulnerability of supply chains and this increase in vulnerability has in turn resulted in increasing attention towards SCRM efforts globally. (Jüttner, Peck, & Christopher, 2003; Tang, 2006; Thun & Hoenig, 2011; Louis & Pagell, 2018). By extension of this understanding, it could be argued that the level of vulnerability of supply chains to different supply chain risk sources could influence the maturity of SCRM processes in respective organisations/ supply chains. Based on this argument the first hypothesis to be tested in this research was developed as below.

H1: Supply chain vulnerability positively influences SCRM process maturity.

The SCRM maturity model studied in the literature review was indicative of that more mature the SCRM process was more resilient the supply chain turned out to be. (Supply Chain Risk Leadership Council, 2017). Similar sentiment was to be

found among other reviewed literature as well. (Ivanov, Tsipoulanidis, & Schönberger, 2018). In line of this thinking, second hypothesis to be tested in this research was developed as below.

H2: SCRM process maturity positively influences supply chain resilience.

After having established above two hypothesis it was intuitive to argue that there could be a relationship between the supply chain vulnerability and the supply chain resilience as well. Therefore, a third hypothesis to be tested in this research was developed as below.

H3: Supply chain vulnerability positively influences supply chain resilience.

Both to explore the practitioner perception on supply chain vulnerability as per first objective of the research and to measure the vulnerability of supply chains for testing **H1** and **H3** above, supply chain risk sources introduced by Jüttner, Peck and Christopher (2003) were considered. Accordingly the respondents were asked to indicate the level of susceptibility of respective supply chains to environmental, network and organisational risk sources.

In order to measure the SCRM process maturity for the purpose of generally understanding it for the Sri Lankan context as per second objective of this research and to test **H1** and **H2** above, maturity model proposed by SCRLC was considered. Accordingly the respondents were asked to indicate the level of maturity respective SCRM process has reached against 23 observed variables. These 23 observed variables were converging to five first order latent variables (namely SCRM Leadership, SCRM Planning, SCRM Implementation, SCRM Evaluation and SCRM Improvement) which were then converging onto one second order latent variable, namely SCRM process maturity.

In order to measure supply chain resilience to test **H3** above and thereby to understand the relationship between SCRM and supply chain resilience as per third objective of this research, respondents were asked to provide feedback on anticipation, resistance, recovery and response aspects of supply chain resilience as suggested by Kamalahmadi and Parast (2016).

Figure 3-1 below attempts to graphically capture the summary of hypothesis and conceptual model development discussed above in section 3.2.

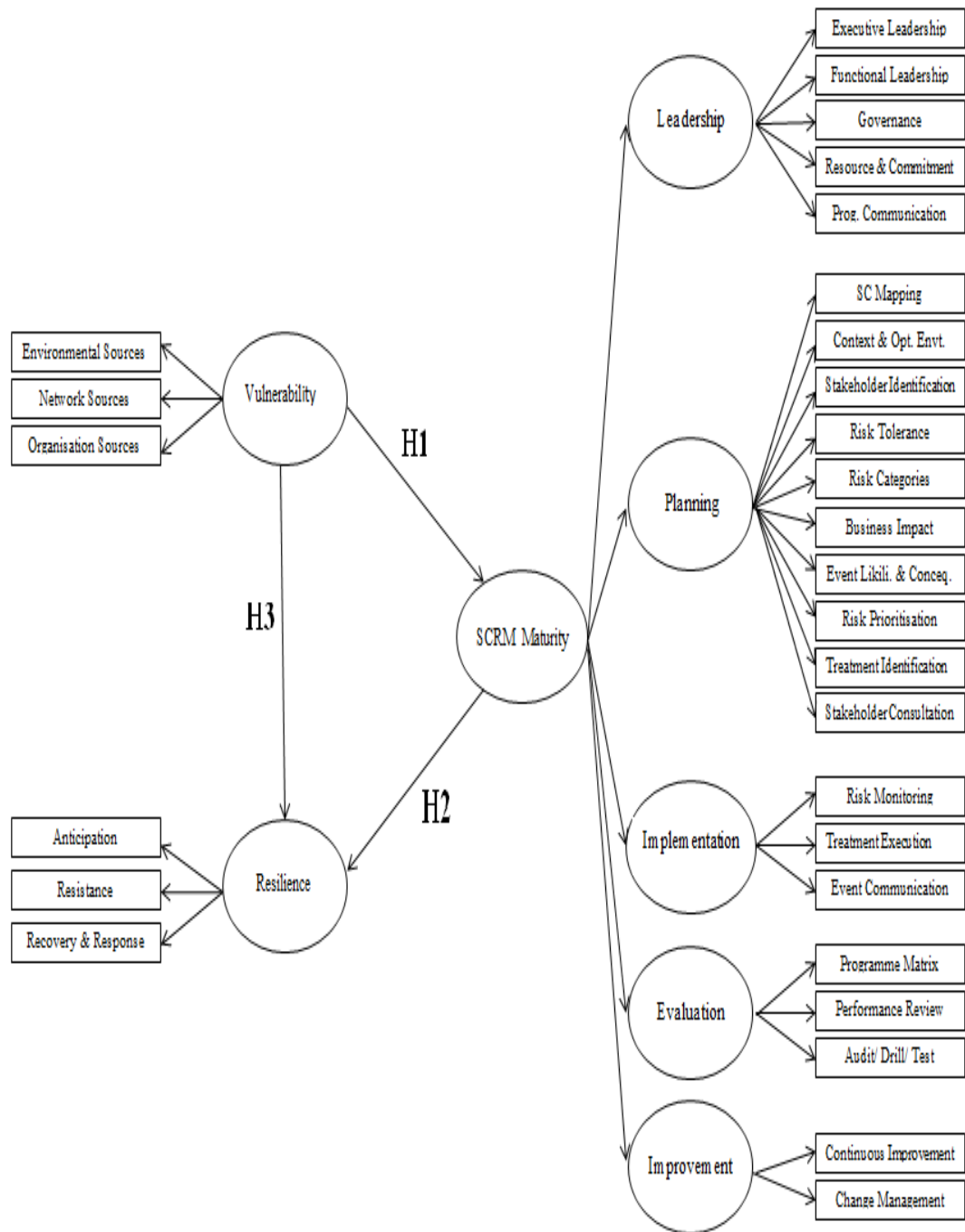


Figure 3-1: Conceptual model of the research

3.3. Data Collection

3.3.1. Sample Selection

Targeting an entire population for data gathering is almost impossible in most of the research work and sampling is the more efficient and affordable alternative in such circumstances. However, despite it being a pragmatic approach to data collection, if sampling is not done properly it could have a detrimental impact on the quality of the research. (Sekaran, 2003). As such selecting a sample that is properly representative of the population to be studied is of paramount importance in designing a research.

For the purpose of this study, the population was comprised of all individuals who were either directly responsible for the SCRM process or were directly involved in it at all Sri Lankan organisations, commercial and otherwise. Given the sheer scale of this population, targeting all of them for data collection was certainly not a viable option. Therefore, the need for sampling was apparent. Further, it was difficult to identify exact individuals at each organisation who were directly responsible for/involved in SCRM process. Given these complications it was decided to select a set of supply chain professionals representing a cross section of industries together with acceptable levels of education and industry experience as the sample for gathering data related to SCRM. The graduates and the students of the Master of Business Administration in Supply Chain Management programme offered by University of Moratuwa appeared fitting for this description. To be eligible for this MBA programme, candidates had to be holding a bachelor's degree with at least three years of experience in supply chain related work. Therefore the selected candidates for the programme could be assumed to be of having a clear understanding of the SCRM process even if they were not directly involved in the process. Accordingly 60 individuals representing three batches of the programme were targeted as the primary sample for data gathering for this research.

However, given that the rate of response to this type of studies is never 100%, targeting only those 60 individuals posed a threat on getting an adequate number of responses to conduct a valid analysis. Therefore, an attempt was made to get through

to a secondary sample by getting the primary sample to introduce suitable individuals for the study. However, the acceptance of information from the secondary sample was conditioned to cleansing by considering the respondents' functional experience in supply chain management.

3.3.2. Data Collection Tool

Considering the profiles of the respondents and given the time constraints, it was decided to use a structured online questionnaire as the primary data collection tool for this research. Questionnaires are regarded as an efficient and effective tool for data gathering, particularly in studies where there is clarity on the variables to be measured. (Sekaran, 2003). Given that the theoretical framework of this research provided a clear understanding as to what needs to be measured and how it would be done, administering an online questionnaire was a valid and acceptable approach for data gathering for this research. The exact questionnaire used in this study is provided in Appendix II while the basic structure and the content of the same are described in the paragraphs below.

Section One of the questionnaire contained five questions that were intended to provide background information on the respondent and the respondent's organisation. While the variables measured in this section were mostly of descriptive nature, they served a secondary purpose as control variables in the case of cleansing the responses from the respondents of the secondary sample.

Section Two of the questionnaire contained the core questions relating to major variables studied in this research. First question of Section Two attempted to measure the vulnerability of the respondent's supply chain to environmental, network and organisational risk sources. Respondents were requested to mark the level of vulnerability of their supply chains to each of the above risk sources on a five-point Likert scale. Second question of Section Two attempted to measure the maturity of the respondent's SCRM process. Respondents were requested to mark the maturity level each of the 23 measured variables in SCRM maturity model by SCRLC have reached with respect to their organisations. Third question of Section Two attempted

to measure the level of supply chain resilience displayed by respondent's supply chain. Respondents were requested to mark the level of risk anticipation, resistance, recovery and responsiveness of their respective supply chains on a five-point Likert scale.

3.4. Data Analysis Methods

As mentioned earlier, the objectives of this research were to explore the practitioner perception on supply chain vulnerability in Sri Lanka, to understand the maturity of SCRM process among Sri Lankan organisations and to understand the relationships among supply chain vulnerability, SCRM and supply chain resilience for the Sri Lankan context. In order to fulfil the first two of these objectives, carrying out descriptive analysis on practitioner perception on supply chain vulnerability and on SCRM process maturity would have been sufficient. Similarly, carrying out correlation analysis to test the established hypothesis would have sufficed to serve the third objective. However, prior to moving into these primary analysis methods it is essential to carry out some preliminary analysis on the collected data to establish the reliability and the validity of the primary results. Therefore, below analysis procedure was followed during the analysis phase of this research.

Firstly, to increase the reliability of input data, the responses were screened for missing data and outliers. Then, to ensure the sample adequacy Kaiser-Meyer-Olkin (KMO) index and the value of Bartlett's Test of Sphericity were calculated. This was then followed up by a confirmatory factor analysis (CFA) on the established theoretical framework for the study. Despite the fact that this framework was based on a comprehensive literature review, conducting the CFA to establish convergent validity was still necessary as it had not been applied to the Sri Lankan context previously. In order to validate the reliability of the study, Cronbach's Alpha coefficient was calculated. This coefficient is a measure of internal consistency of a data set and higher the value of this, more reliable the result of the study would be. IBM SPSS and SPSS AMOS were the principle tools used for all above analysis. Obtained results are discussed in next chapter.

4. RESEARCH FINDINGS

4.1. Data Screening and Sample Demographics

A total of 42 responses were received within three weeks' time since the questionnaire was first sent on 3rd June 2019. Out of those responses three received from the secondary sample had to be omitted from analysis as they did not meet prerequisites in terms of either employment function or employment hierarchy. Demographics of the 39 responses considered for the analysis are shown below.

- Respondent split according to targeted samples:

As can be seen from Figure 4-1 below, 72% of the responses considered for analysis were from the primary targeted sample consisting of Supply Chain Management MBA graduates and students from University of Moratuwa. In absolute terms this 72% corresponded to 28 responses, resulting a response rate of 47% relating to primary sample.

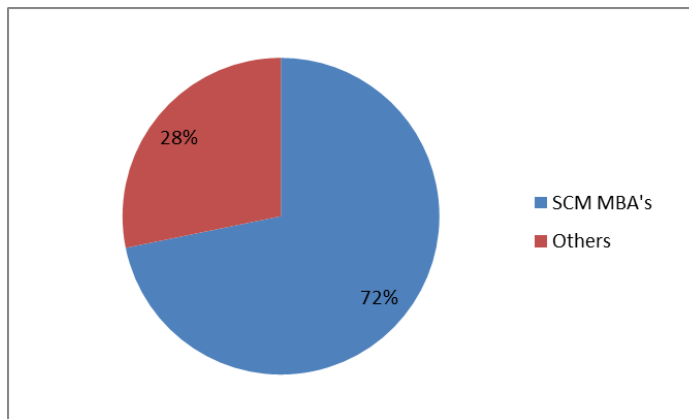


Figure 4-1: Respondent split according to targeted samples

- Respondent split according to industry:

Figure 4-2 below demonstrates the industry cross section relating to the selected respondents. As can be seen from the chart, Logistics/ Transportation sector was the single most represented industry in the responses and this was not a surprising observation given that the MBA is offered by the Department of Logistics and Transportation. Strong representations from Food, Beverage & Tobacco; Textile; Chemical & Pharmaceutical and Retail industries too were observed. Therefore, it

was not unreasonable to consider that received responses represented a wider industry cross section without being dominated by a particular industry.

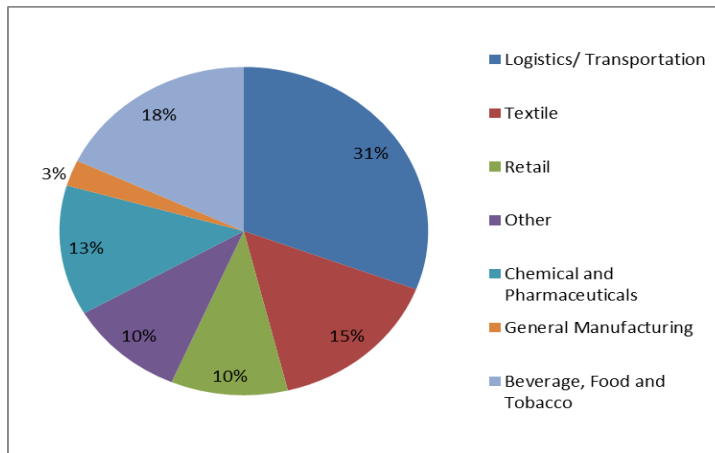


Figure 4-2: Respondent split according to industry

Table 4-1 below displays the absolute number of responses received according to respective industry verticals.

Table 4-1: Respondent split according to industry

Industry	Respondents
Logistics/ Transportation	12
Beverage, Food and Tobacco	7
Textile	6
Chemical and Pharmaceuticals	5
Other	4
Retail	4
General Manufacturing	1

- Respondent split according to employment function:

As can be seen from Figure 4-3 below, it is clear that the majority of the respondents were from Supply Chain/ Operations functions of their respective organisations. Based on this observation it was reasonable to assume that 74% of the respondents had a considerable exposure into their respective SCRM processes when answering the questionnaire. The remaining 26% representing other functions were all either

MBA graduates or students in Supply Chain Management and therefore, they could also be assumed as having a fair understanding of respective SCRM processes.

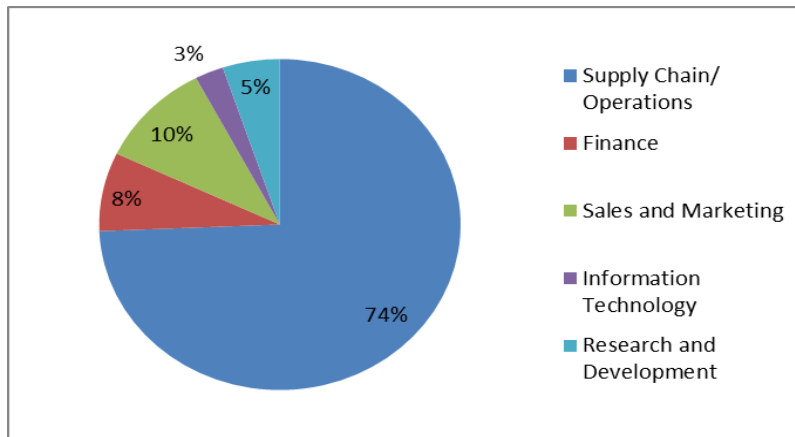


Figure 4-3: Respondent split according to employment function

- Respondent split according to employment hierarchy:

Figure 4-4 below demonstrates the respondent split according to their employment hierarchy. As can be seen from the figure, more than half the respondents are from Senior/ Middle Manager level while another 40% of the respondents are from Junior Manager/ Executive level. Therefore, it can be assumed that there is a balanced representation in the responses as far as the employment hierarchy is concerned.

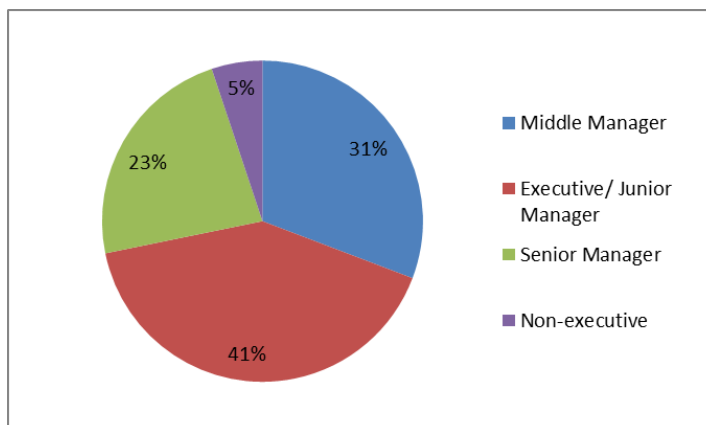


Figure 4-4: Respondent split according to employment hierarchy

4.2. Confirmatory Factor Analysis

Prior to conducting the CFA, KMO index and the value of Bartlett's Test of Sphericity were calculated to evaluate the sample adequacy for factor analysis. These values are shown in Table 4-2 below. As can be seen from the table KMO index was 0.665 and the Bartlett's Test of Sphericity had returned a significant result, both indicating adequate sample size for factor analysis.

Table 4-2: Sample adequacy measures

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.665
Bartlett's Test of Sphericity	Approx. Chi-Square	1204.202
	df	406
	Sig.	.000

Having established the sample adequacy for factor analysis the next step was to construct the structural model in SPSS AMOS 24.0 to carry out the CFA. In order to do this, observed variables were labelled as shown in Table 4-3 below.

Table 4-3: Observed variable labels for CFA

Variable	Label
Organisational Uncertainties	VULN1
Network Uncertainties	VULN2
Environmental Uncertainties	VULN3
Executive Leadership	LEAD1
Governance	LEAD2
Functional Leadership	LEAD3
Resources & Commitment	LEAD4
Programme Communication	LEAD5
Supply Chain Mapping	PLAN1
Context & Operational Environment	PLAN2
Stakeholder Identification	PLAN3
Risk Tolerance Identification	PLAN4
Risk Categories Identification	PLAN5
Business Impact Identification	PLAN6

Event Likelihood & Consequence	PLAN7
Risk Prioritisation	PLAN8
Risk Treatment Identification	PLAN9
Stakeholder Consultation	PLAN10
Risk Monitoring	IMPL1
Risk Treatment Execution	IMPL2
Event Communication	IMPL3
Programme Metrix	EVAL1
Performance Review	EVAL2
Audit / Drill / Test	EVAL3
Continuous Improvement	IMPR1
Change Management	IMPR2
Anticipation	RESI1
Resistance	RESI2
Recover & Response	RESI3

Following this notation, a structural model for SCRM Maturity was drawn in SPSS AMOS and the CFA was executed. This is shown in Figure 4-5 below.

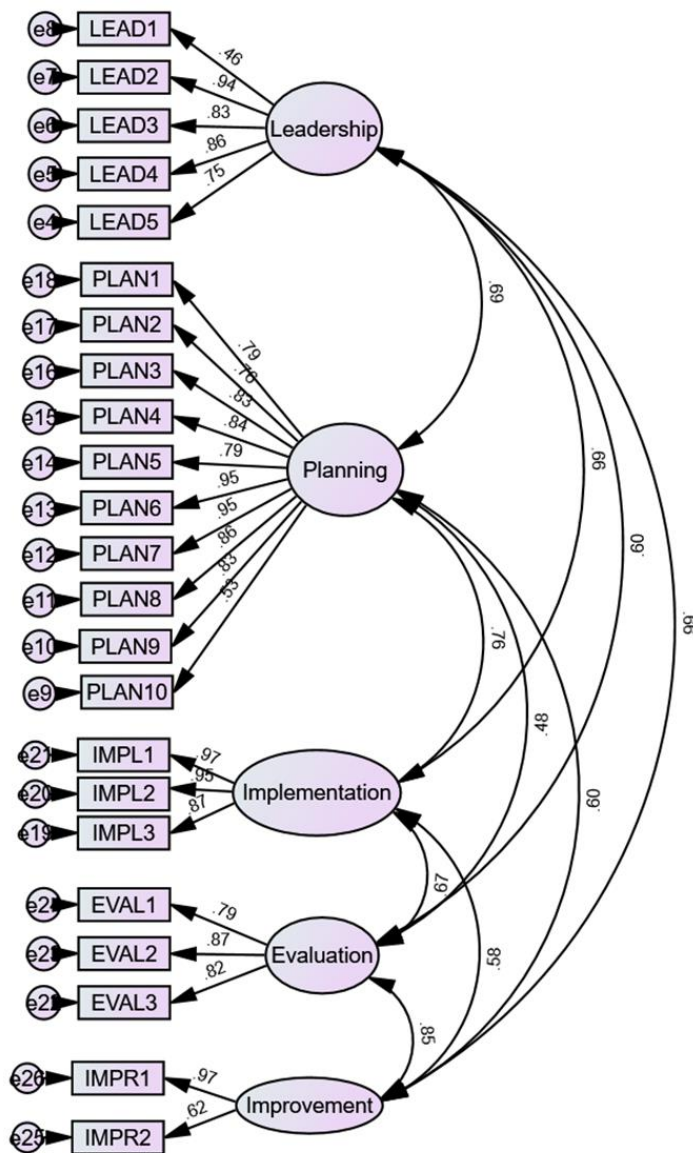


Figure 4-5: CFA for initial SCRM Maturity model

As can be seen from Figure 4-5 above, except for LEAD1, PLAN10 and IMPR2, all other observed variables have resulted in loadings greater than 0.7 on their respective latent variables indicating acceptable convergent validity. Latent variables ‘Evaluation’ and ‘Improvement’ have shown significantly high regression compared to others at 0.85 indicating poor divergent validity for the model. Resulted Goodness of Fit indicators for above initial model were poor and are summarised in Table 4-4 below.

Table 4-4: Goodness of Fit indicators for initial model

CMIN	DF	CMIN/DF	GFI	CFI
542.621	220	2.466	0.519	0.669

Considering all these indicators, the model was modified removing low loading observe variables LEAD1, PLAN10 and IMPR2 and combining high covariant latent variables ‘Evaluation’ and ‘Improvement’. Resulted model and respective loadings are shown in Figure 4-6 below.

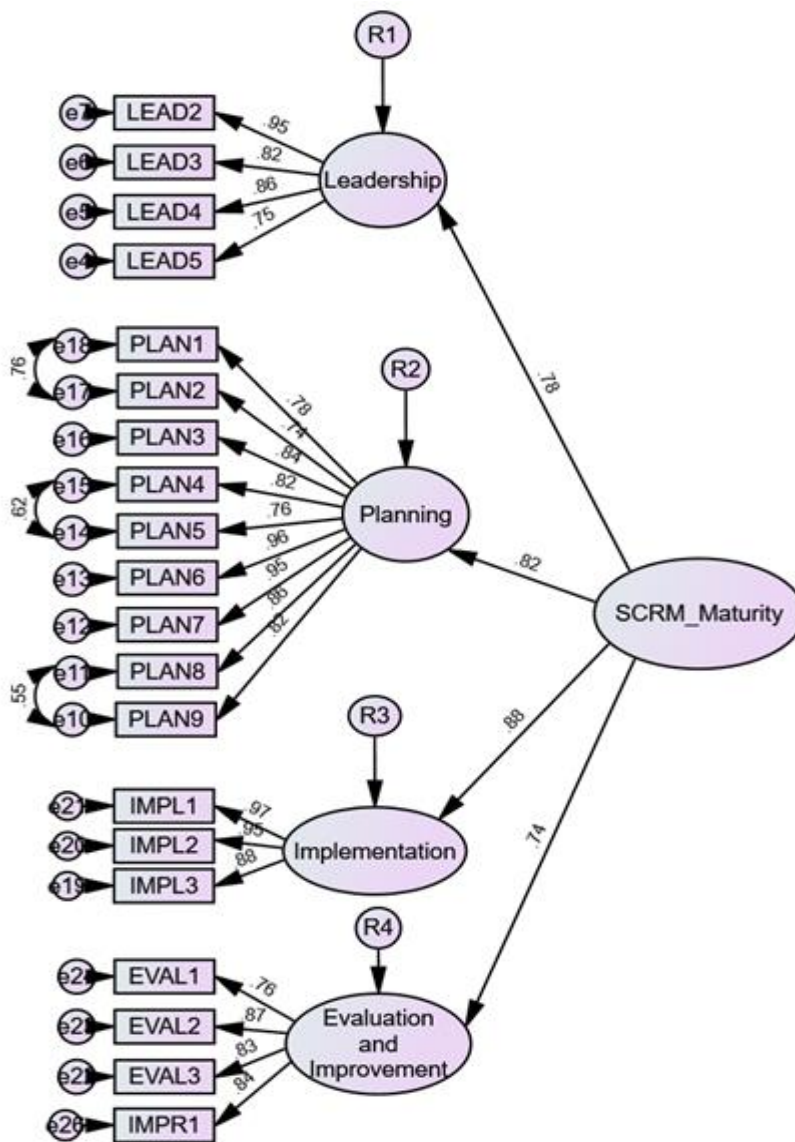


Figure 4-6: CFA for modified SCRM maturity model

As a result of above modifications there was a clear improvement in the Goodness of Fit indicators and these are tabulated in Table 4-5 below.

Table 4-5: Goodness of Fit indicators for modified model

CMIN	DF	CMIN/DF	GFI	CFI
303.564	163	1.862	0.614	0.844

Despite above values in Table 4-5 being only barely acceptable as proof of Goodness of Fit, by comparing Tables 4-4 and 4-5 it was clear that there has been a significant improvement in all indicators as a result of the modifications made to the model. Therefore, it was decided to proceed with this modified model for further analysis.

Having validated the SCRM Maturity model the next step was to include all other variables relating to supply chain vulnerability and supply chain resilience to the modified SCRM Maturity model to capture the full conceptual model of the study as presented in Figure 3-1. This model and the resulted loadings are presented in Figure 4-7 on Page 33. As can be observed from the figure all loadings were above 0.7 indicating acceptable convergent validity for the model.

4.3. Reliability Measures

Having assessed and modified the model for validity, next step was to establish the reliability of the study. To serve this purpose Cronbach's Alpha was calculated for modified model consisting of 26 observed variables. Obtained result is shown in Table 4-6 below.

Table 4-6: Reliability statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
0.958	26

As can be read from the Table 4-6 the obtained Cronbach's Alpha values was well above the generally accepted value of 0.6 and as such indicated high reliability for findings of the study.

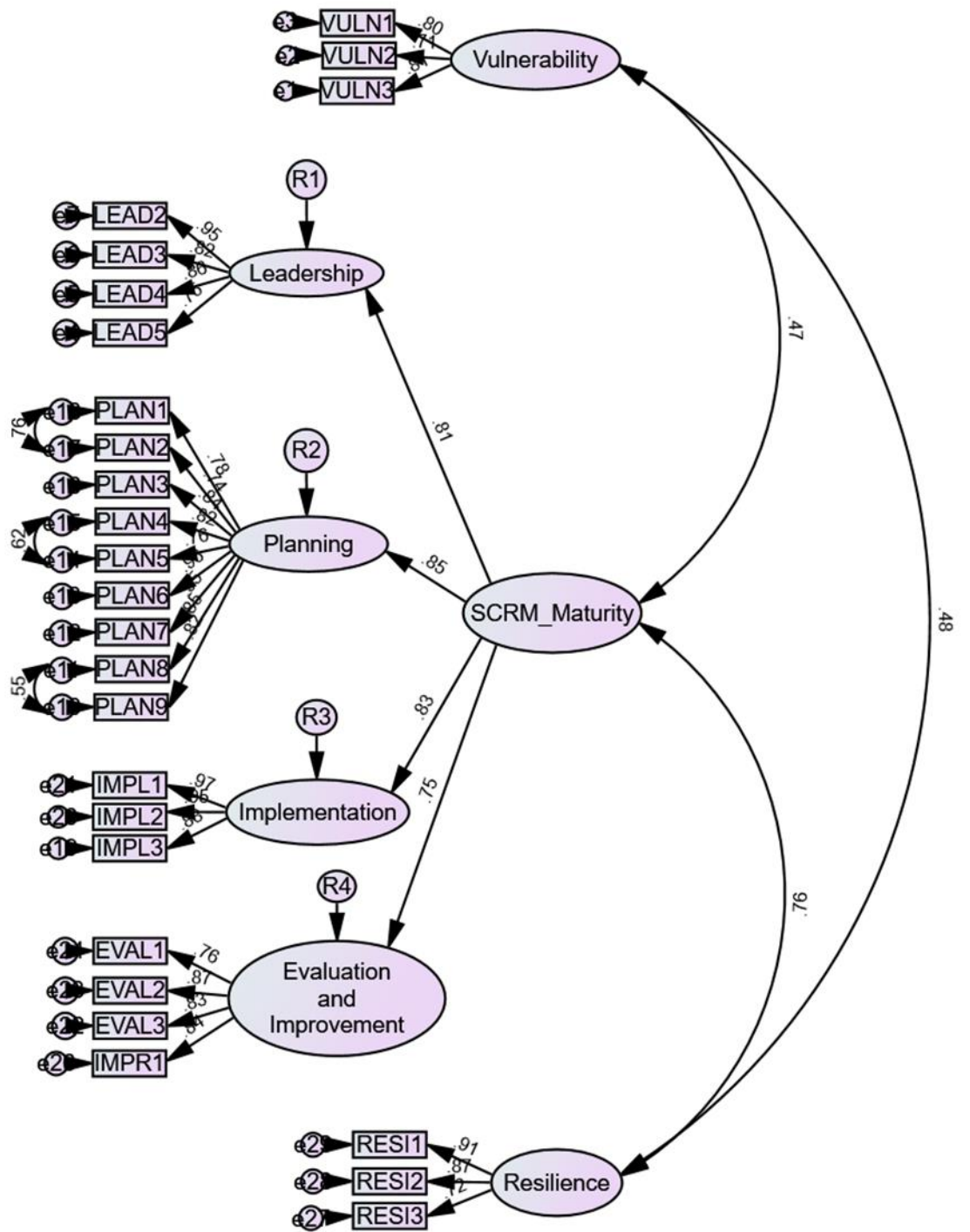


Figure 4-7: CFA for full model

4.4. Descriptive Analysis

In this section of the report sample descriptors relating to 26 observed variables and respective latent variables are discussed to understand their nature.

4.4.1. Supply Chain Vulnerability

Figure 4-8 below summarises the findings relating to practitioner perception on supply chain vulnerability in Sri Lanka. As can be seen from the figure, respondents have recognised environmental uncertainties as the most significant risk source that their supply chains are vulnerable to. Internal organisational uncertainties have been recognised as the least concerning while network risk sources have been recognised to be having a moderate impact. Overall, as per the participants in this study, Sri Lankan supply chains appear to be moderately vulnerable to organisational, network and environmental risk sources.

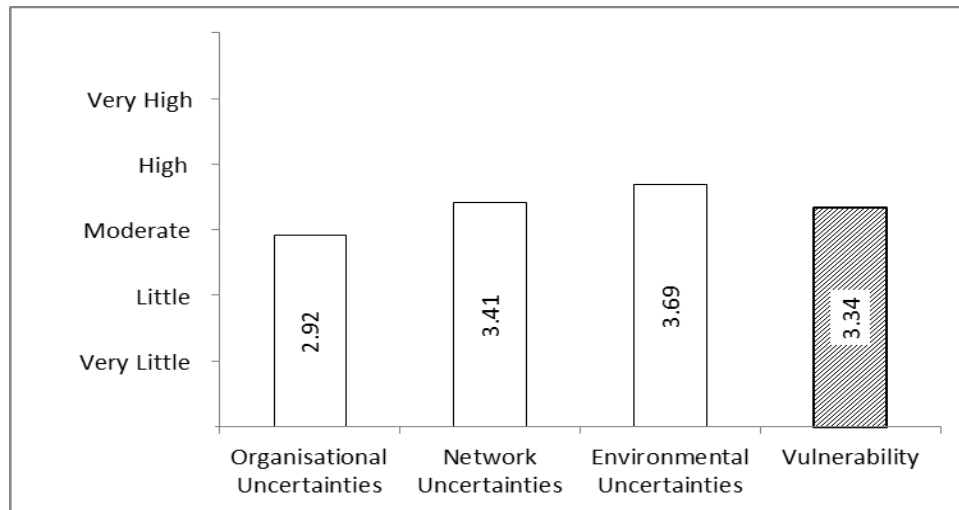


Figure 4-8: Vulnerability of Sri Lankan supply chains

Table 4-7 below displays the industry-wise results obtained for practitioner perception on supply chain vulnerability in Sri Lanka. As could be seen from the table, across all the industries supply chain vulnerability has been recognised as being between moderate to high levels. Beverage, Food and Tobacco industry has shown the highest level of supply chain vulnerability as perceived by practitioners in the respective industry (this is disregarding loosely categorised ‘Other’ industries).

Table 4-7: Industry-wise supply chain vulnerability

Industry	N	Minimum	Maximum	Mean	Std. Deviation
Logistics/ Transportation	12	1.00	5.00	3.11	1.08
Beverage, Food and Tobacco	7	3.00	4.67	3.67	0.54
Textile	6	2.33	4.67	3.44	0.86
Chemical and Pharmaceuticals	5	1.33	3.67	3.07	1.01
Other	4	3.00	5.00	3.75	0.88
Retail	4	1.67	3.67	3.17	1.00
General Manufacturing	1	3.67	3.67	3.67	-

4.4.2. SCRM Maturity in Sri Lanka

4.4.2.1. SCRM Leadership

Figure 4-9 below summarises the findings relating to leadership attribute in SCRM maturity model. As can be seen from the figure, the average scores for individual activities have fallen within the range of 3.08 to 3.82, producing a moderate value of 3.40 for overall leadership attribute. As per the participants in this study, SCRM governance activity appears to be the weakest individual activity under leadership attribute while SCRM programme communication activity is the strongest.

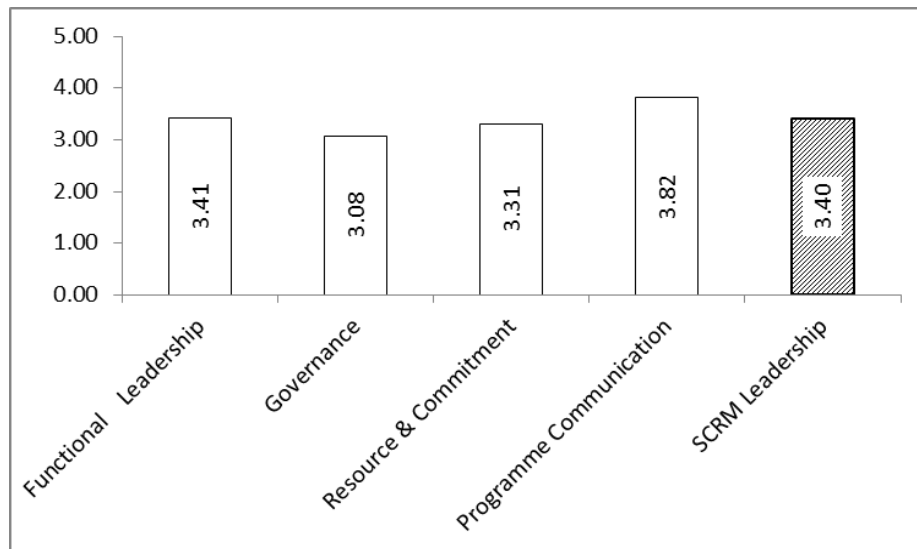


Figure 4-9: SCRM leadership in Sri Lanka

4.4.2.2. SCRM Planning

Figure 4-10 below summarises the findings relating to planning attribute in SCRM maturity model. As can be seen from the graph, the resultant value for overall planning attribute has averaged at 3.42 indicating a moderate level maturity in SCRM planning. Except for the two activities, risk tolerance identification and risk category identification, all other individual activities under planning attribute have recorded values in the same range as the overall score of 3.42.

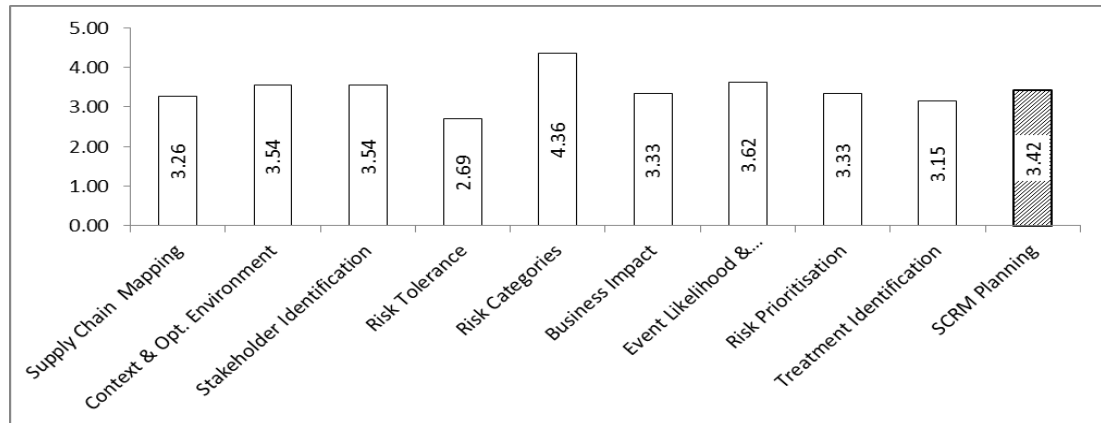


Figure 4-10: SCRM planning in Sri Lanka

4.4.2.3. SCRM Implementation

Figure 4-11 below summarises the findings relating to implementation attribute in SCRM maturity model. As can be seen from the figure, the average scores for individual activities have fallen within the range of 3.08 to 3.36, producing a moderate value of 3.19 for overall attribute. As per the participants in this study, risk treatment execution activity appears to be the weakest individual activity under implementation attribute while event communication activity is the strongest.

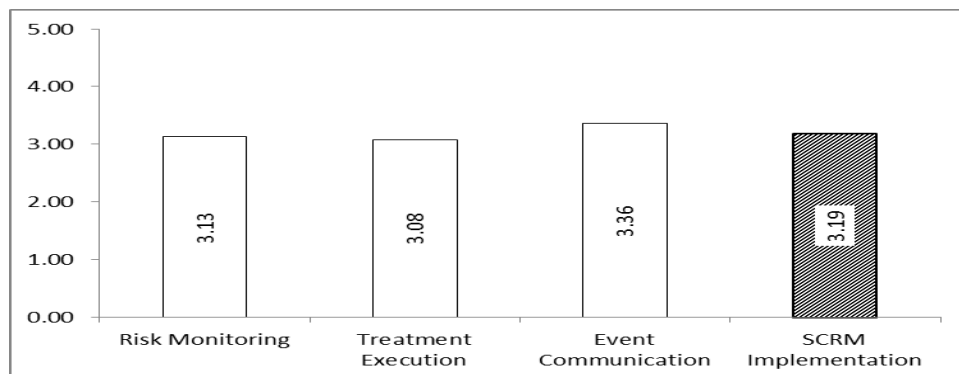


Figure 4-11: SCRM implementation in Sri Lanka

4.4.2.4. SCRM Evaluation and Improvement

Figure 4-12 below summarises the findings relating to evaluation and improvement attribute in SCRM maturity model. As can be seen from the graph, the resultant value for overall evaluation and improvement attribute has averaged at 2.88 indicating a low level maturity in SCRM evaluation and improvement. All individual activities under this attribute have recorded values in the same range as the overall.

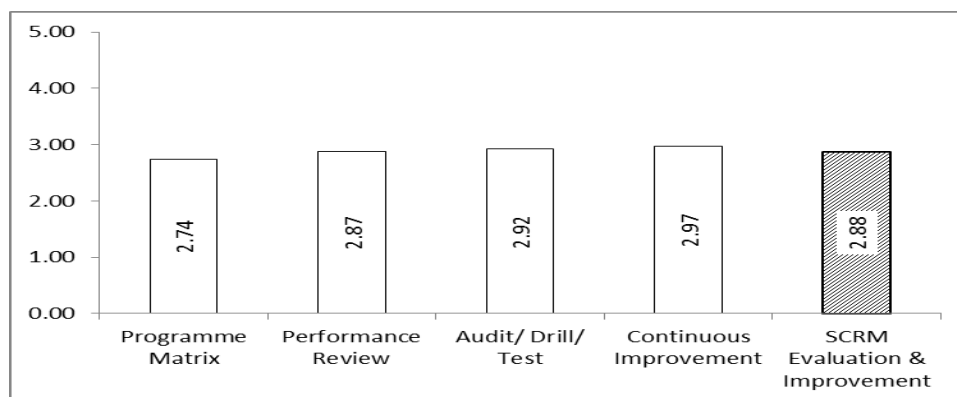


Figure 4-12: SCRM evaluation and improvement

4.4.2.5. Overall SCRM Maturity

Figure 4-13 below summarises the findings of this study relating to overall SCRM maturity in Sri Lanka. As can be seen from the figure, scores for SCRM leadership, SCRM planning and SCRM implementation attributes have averaged to values slightly above 3.0, indicating a ‘proactive’ level of maturity. Score for SCRM evaluation and improvement attribute has averaged to a value marginally below 3.0, indicating only an ‘aware’ level of maturity. Considering these levels of maturities for individual attributes in SCRM maturity model, it appears that overall SCRM maturity in Sri Lanka is at ‘proactive’ level.

Further, Table 4-8 displays the industry-wise maturity results obtained for the main attributes in SCRM maturity model. As could be seen from the table (barring the General Manufacturing industry which had only been represented by a single respondent) Textile industry has shown the highest average SCRM process maturity. Beverages, Food and Tobacco industry and Chemical and Pharmaceutical industry have shown surprisingly low levels of SCRM process maturities.

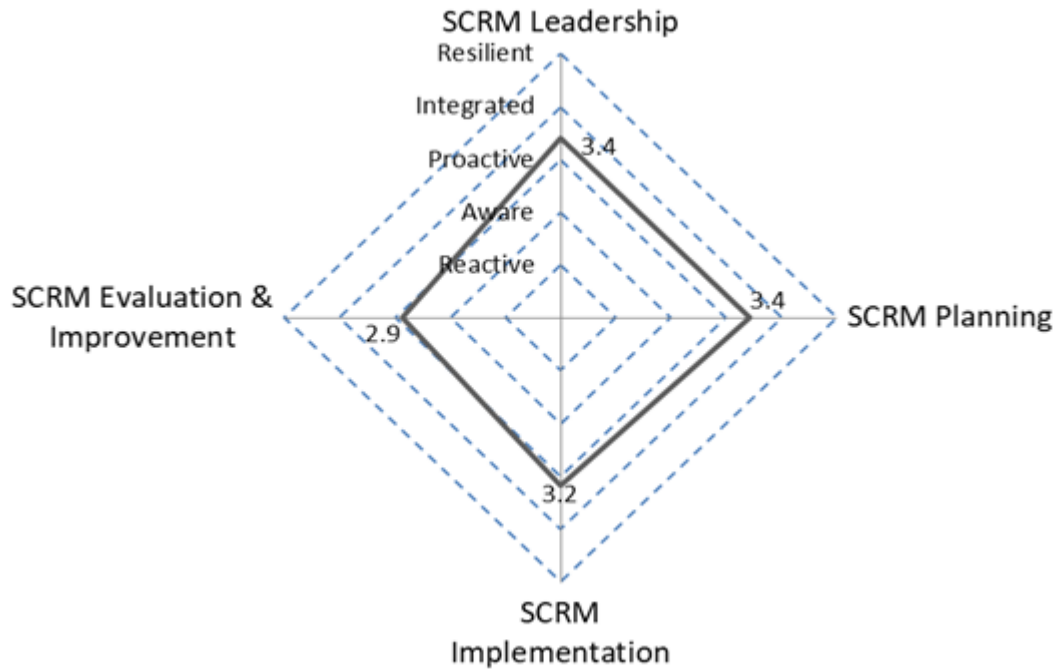


Figure 4-13: SCRM maturity in Sri Lanka

Table 4-8: Industry-wise SCRM maturity in Sri Lanka

Industry	SCRM Attribute	N	Minimum	Maximum	Mean	Std. Deviation
Logistics/ Transportation	SCRM Leadership	12	2.00	4.50	3.27	0.86
	SCRM Planning		2.22	4.78	3.68	0.92
	SCRM Implementation		2.00	5.00	3.64	0.97
	SCRM Evaluation & Improvement		1.25	4.75	2.98	1.32
Beverage, Food and Tobacco	SCRM Leadership	7	2.25	5.00	3.25	0.99
	SCRM Planning		2.11	4.11	3.33	0.78
	SCRM Implementation		1.33	4.67	2.62	1.13
	SCRM Evaluation & Improvement		1.25	4.25	2.43	0.95
Textile	SCRM Leadership	6	2.50	4.50	3.88	0.77
	SCRM Planning		2.11	4.11	3.50	0.73
	SCRM Implementation		1.67	5.00	3.11	1.24
	SCRM Evaluation & Improvement		1.75	4.25	3.25	0.91
Chemical and Pharmaceuticals	SCRM Leadership	5	2.00	4.50	3.05	1.07
	SCRM Planning		2.00	3.78	2.96	0.76
	SCRM Implementation		2.00	4.00	2.87	0.80
	SCRM Evaluation & Improvement		2.00	3.50	2.55	0.57

Other	SCRM Leadership	4	2.50	5.00	4.00	1.22
	SCRM Planning		1.44	4.67	3.11	1.74
	SCRM Implementation		2.00	4.67	3.25	1.10
	SCRM Evaluation & Improvement		2.50	3.00	2.75	0.29
Retail	SCRM Leadership	4	2.00	4.50	3.19	1.03
	SCRM Planning		2.00	4.33	3.44	1.01
	SCRM Implementation		2.33	4.33	3.25	1.07
	SCRM Evaluation & Improvement		2.25	4.25	3.31	0.83
General Manufacturing	SCRM Leadership	1	3.50	3.50	3.50	-
	SCRM Planning		4.11	4.11	4.11	-
	SCRM Implementation		3.33	3.33	3.33	-
	SCRM Evaluation & Improvement		3.00	3.00	3.00	-

4.4.3. Supply Chain Resilience

Figure 4-14 below summarises the findings relating to overall supply chain resilience in Sri Lanka. As can be seen from the figure, respondents have recognised recovery and response aspect of resilience to be the weakest in Sri Lankan context while anticipation and resistance aspects to be slightly better than the former. Accordingly, as per the respondents to this study, it appears that Sri Lankan supply chains are moderately resilient overall.

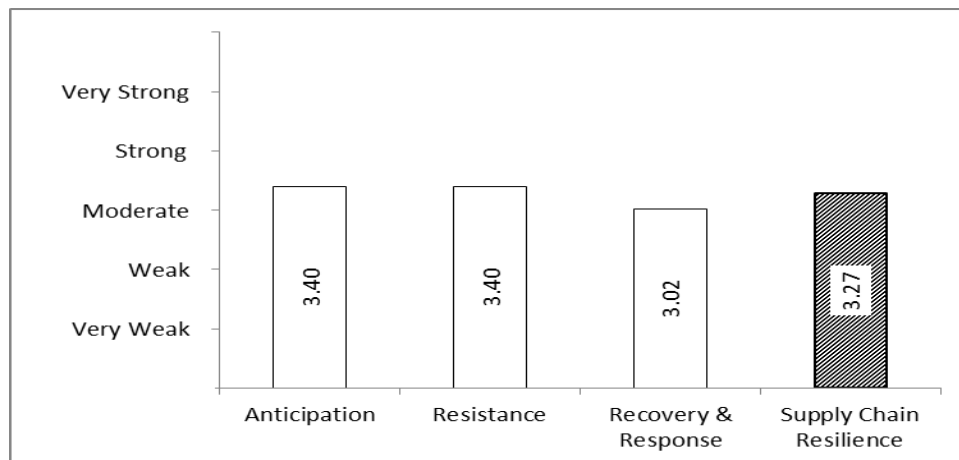


Figure 4-14: Supply chain resilience in Sri Lanka

Table 4-9 below displays the industry-wise results obtained for supply chain resilience in Sri Lanka. As can be seen from the table, Beverages, Food and Tobacco industry has generated the highest mean results in terms of supply chain resilience in Sri Lanka while Chemical and Pharmaceutical industry generating the poorest results among the industry representation.

Table 4-9: Industry-wise supply chain resilience

Industry	N	Minimum	Maximum	Mean	Std. Deviation
Logistics/ Transportation	12	2.30	4.57	3.42	0.78
Beverage, Food and Tobacco	7	2.77	4.57	3.68	0.74
Textile	6	1.87	4.13	3.23	0.92
Chemical and Pharmaceuticals	5	1.43	3.70	2.23	0.93
Other	4	2.77	5.00	3.68	1.09
Retail	4	2.30	3.70	3.35	0.70
General Manufacturing	1	2.30	2.30	2.30	-

4.5. Regression Analysis

Table 4-10 below summarises the regression coefficients for relationships among supply chain vulnerability, SCRM maturity and supply chain resilience for Sri Lankan context. As can be observed with the values in the table, there appears to be positive relationships among all three relationships. However, the regression estimates obtained for relationships between supply chain vulnerability & SCRM maturity and between supply chain vulnerability & supply chain resilience are below 0.5, suggesting weak correlations for those relationships. Therefore, only the relationship between SCRM maturity and supply chain resilience could be considered to be displaying a strong positive relationship.

Table 4-10: Regression analysis for SC vulnerability, SCRM maturity and SC resilience

			Estimate
Vulnerability	<-->	SCRM_Maturity	0.467
Resilience	<-->	SCRM_Maturity	0.763
Vulnerability	<-->	Resilience	0.478

5. DISCUSSION

This section of the report attempts to make interpretations to the findings obtained in Section 4 to further understand the reasons behind those observations.

5.1. Practitioner Perception on Supply Chain Vulnerability in Sri Lanka

As could be seen from the Figure 4-8 in section 4.4.1, Sri Lankan supply chain practitioners appear to perceive overall supply chain vulnerability in Sri Lanka as being moderate. While it is possible that this result could have partly been influenced by central tendency of responses that is always inherent in these types of studies, substance of this observation could not be neglected entirely. Therefore, the variety of industries represented in the study could be considered one valid reason for this observation. It is understandable that different industries would operate with supply chains of varying degrees of complexities and accordingly respective industry practitioners would perceive vulnerability differently to one another. However, when industry-wise results were observed it was visible that there were only minor variations to one another in terms of perceived supply chain vulnerability. Given this, barring the central tendency of responses, the observation of moderate level supply chain vulnerability could only be considered a genuine perception among Sri Lankan supply chain practitioners.

Regardless of the overall level of vulnerability, another interesting observation that could be made from Figure 4-8 was the practitioner perception on the significance of different risk source to susceptibility of their supply chains. Across all industries environmental risk sources had been recognised as the most significant while organisation risk sources as the least significant. This observation is a clear indication that supply chain practitioners in Sri Lanka are comfortably confident about internal organisational uncertainties that are mostly under their own preview while being particularly sceptical over environmental uncertainties over which they have next to nothing control. Therefore, it appears there is a clear relationship between perceived seriousness of uncertainties and the level of control the respondent have over those uncertainties. Given this, it was encouraging to a certain

degree to see that practitioners had demonstrated some level of confidence on network related uncertainties indicating a certain level of trust among supply chain partners in Sri Lanka.

Considering the industry-wise supply chain vulnerability figures tabulated in Table 4-7, relatively high vulnerability results for Beverage, Food and Tobacco industry and Textile industry could be attributed to the common traits these industries share such as seasonality of products, cross border supply chains, outsourcing etc.

5.2. SCRM Maturity in Sri Lanka

As could be seen from the Figure 4-13 in section 4.4.2.5, overall SCRM maturity in Sri Lanka appear to be at ‘proactive’ level maturity according to SCRLC model of SCRM maturity. Similar to supply chain vulnerability observations, no significant variations among industry-wise results were observed relating to SCRM maturity as well. Only exception to this was the General Manufacturing industry which had recorded a nearly ‘integrated’ level of maturity. But this industry had been represented by a single respondent and as such it was not possible to generalise the result to industry as whole. Therefore, once again barring the potential central tendency, obtained ‘proactive’ level of maturity can be seen as evidence to significant formal yet internally focused initiatives to SCRM undertaken by Sri Lankan organisations. In other words despite individual members in Sri Lankan supply chains taking formal standalone initiatives to SCRM, there has been little success in integrating the end-to-end supply chain by adopting supply chain-wide SCRM initiatives. Therefore, there clearly is a significant opportunity for Sri Lankan supply chains to make improvements into integration of SCRM initiatives.

Turning the attention to individual attributes in SCRM maturity, leadership, planning and implementation attributes have displayed proactive level maturity similar to overall SCRM maturity. This can be considered positive evidence to that Sri Lanka being more proactive in SCRM as a country. Results for leadership and planning attributes are particularly encouraging in this respect. However, evaluation and improvement attribute have displayed a level of maturity lagging to the overall

SCRM maturity, indicating that there needs to be more attention paid to this area of SCRM. This is particularly important considering that any process that is not been evaluated and improved on continuous basis would generate diminishing returns over time.

Considering industry-wise SCRM process maturity results tabulated in Table 4-8, high levels of maturities for Textile industry could partly be attributed to the fact that industry had been predominately represented in this study by a few large and well organised firms. Another possible reason for high level SCRM process maturities for Textile industry could be due to strong SCRM drive of highly powerful and process driven global customers Sri Lankan Textile industry serves. It is possible that these global customers demanding stronger SCRM focus and initiatives from their suppliers in Sri Lanka and that could in turn drive the maturity of SCRM for the industry to a higher level. Poorer results for SCRM process maturities for Beverage, Food and Tobacco industry could partly be attributed to the fact that the industry had been represented by a mix of firms with varying scales of operations. Relatively large standard deviations for each of the SCRM attributes as shown in Table 4-8 could be considered evidence to support this hypothesis. However, it still is a surprising result given there was a sizeable representation from large multinational players who supposedly should adopt more mature SCRM processes.

5.3. Supply Chain Resilience in Sri Lanka

As could be seen from the Figure 4-14 in section 4.4.3, overall supply chain resilience in Sri Lanka had been recognised as being moderate. When the industry-wise resilience scores were compared all except for Beverage, Food and Tobacco industry had resulted scores comparable to overall moderate level resilience. Beverage, Food and Tobacco industry had displayed a fairly stronger level of resilience to the Sri Lankan average. One reason for this stronger result from Beverage, Food and Tobacco industry could be due to the sizeable representation of that industry by large multinational companies which are rich in resources both financially and process-wise. As such they could be in a much stronger position to build redundancies and flexibilities to their supply chains make them more resilient

as advocated by Sheffi & Rice Jr. (2005). Further, Beverage, Food and Tobacco industries mostly use standard raw materials in their processes making their operations more flexible. This could be another reason for high resilience results generated for that industry. However, since the number of responses from the said industry to this particular study was limited, more industry specific studies will have to be conducted prior to generalising above hypothesis.

Examining the individual attributes of supply chain resilience, both anticipation and resistance attributes had generated better than moderate results, once again indicating that Sri Lankan supply chains are proactive in supply chain resilience front as well. However, response and recovery attribute had been noticed to be lagging behind the other two attributes demonstrating results at a much poorer level. This observation once again could be attributed to lack of resourcefulness of the Sri Lankan organisation in general to recover from supply chain disturbances.

5.4. Relationships among Supply Chain Vulnerability, SCRM Maturity and Supply Chain Resilience

As shown in Table 4-6 in section 4.5, all calculated regression coefficients for supply chain vulnerability, SCRM maturity and supply chain resilience demonstrated a positive relationship. However, only the resultant coefficient for SCRM maturity and supply chain resilience could be considered satisfactory evidence of significant relationship. Therefore, the validation of the three hypotheses developed in section 3.2 were as below.

H1: Supply chain vulnerability positively influences SCRM process maturity.	Not supported
H2: SCRM process maturity positively influences supply chain resilience.	Supported
H3: Supply chain vulnerability positively influences supply chain resilience.	Not supported

Despite it being intuitive to assume that more vulnerable a supply chain is perceived to be, more mature the risk management efforts would be with regards to such a supply chain, that hypothesis had not been supported by the data gathered in this study. Same goes with the hypothesis on supply chain vulnerability and supply chain resilience as well. Therefore, at the conclusion of this research only the positive relationship between SCRM maturity and supply chain resilience could be accepted as prevailing.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

After having carried out the analysis and having obtained the findings as described in sections 3 and 4 of this thesis respectively, the conclusions of the research can be summarised against each of the research objectives as below.

- Practitioner perception on supply chain vulnerability in Sri Lanka:

It can be concluded that Sri Lankan supply chain professionals perceive vulnerability of supply chains in Sri Lanka as being moderate. This perception was evident across all industries that had been represented in this study. Further, as per practitioner perception, environmental uncertainties can be recognised as the most perilous source of supply chain risks for the Sri Lankan context.

- SCRM process maturity in Sri Lanka:

It can be concluded that overall SCRM process maturity in Sri Lanka is at a 'proactive' level where individual firms have succeeded in adopting formal standalone processes to counteract supply chain risks while failing to achieve significant integration across end-to-end supply chain. This observation was valid for all industries that had been represented in this study. Also considering four individual sub-processes in SCRM process, it could be concluded that the highest attention is needed in the area of SCRM evaluation and improvement where the archived maturity was the lowest for Sri Lankan context.

- Relationships among supply chain vulnerability, SCRM process maturity and supply chain resilience in Sri Lanka:

The analysis carried out provided clear evidence for a positive relationship between SCRM process maturity and supply chain resilience. Therefore, it can be concluded that SCRM process maturity positively influences supply chain resilience in the Sri Lankan context.

6.2. Limitations of the Study and Recommendations for Future Research

The objective of this research was to gain a preliminary understanding of the SCRM landscape in Sri Lanka as a whole. As such the scope of the study attempted to cover a cross section of industries rather than focusing on a particular industry or a selected set of industries. Despite this approach of considering a wide range of industries serving the objective of this particular study, it also resulted in limiting some of the in-depth analysis/ understandings that could otherwise have been possible with a single/ limited industry focus. This could be considered a major limitation of this research.

The selected sample for this research comprised of supply chain professionals with middle to senior level industry experience and graduate level educational background. Given this, it was valid to assume that they would have a reasonable understanding of their organisations' SCRM processes. However, it was not possible to evaluate how directly they were involved in with the actual SCRM process itself. Therefore, it is possible that the validity and the reliability of the results obtained in this research could have been improved if the sample was comprised exclusively of professionals directly involved in the SCRM process. This can be considered another limitation of this study.

Given the time and resource constraints, the data collection for the research was entirely based on a questionnaire. Questionnaires, despite being an efficient method of data gathering, are known to be susceptible to response biases such as extreme response bias, central tendency bias, social desirability bias etc. Further, given that there had to be three waves of emails reminding the respondents to complete the questionnaire there could also be an element of non-response bias too embedded in the responses. Therefore, considering all this, data collection method adopted in this study could be considered a limitation of the study.

Therefore, considering all above limitations of this research, a case study base approach could be recommended for future empirical research in this area, where the researcher could conduct in depth interviews with professionals directly involved in

SCRM process in a specific organisation or an industry sector. It is the belief of the author that this study could serve as the base for any such case study research carried out in the future. Furthermore, a more detailed study of supply chain resilience in Sri Lanka to encapsulate supply chain resilience strategies etc. too could be considered for future research relating to this study.

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APPENDIX I – SCRLC SCRM MATURITY MODEL

Category	Sub-category	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
		Reactive	Aware	Proactive	Integrated	Resilient
1. Leadership	1A. Executive Leadership	No supply chain risk management leadership defined.	Functional managers have responsibility for leading risk management within their domain.	SCRM has senior management support, but leadership is found at functional levels.	SCRM has senior management leadership functionally defined and is coordinated across functions.	SCRM has a senior management defined leadership role and active engagement of management is enterprise-wide.
	1B. Line/Functional Leadership	Individuals assume responsibility when an event is triggered.	SCRM activities is led by affected pre-designated functional managers.	SCRM activities are coordinated through supply chain manager(s) with focus on management within the functions.	SCRM activities are lead by a collaborative team of functional managers with focus on internal management including critical supply chain partners.	SCRM is coordinated across the enterprise including multi-tier critical supply chain partners with defined roles and responsibilities.
	1C. Governance	No supply chain risk management framework.	Functional managers use risk management frameworks appropriate for their function with no cross function coordination.	SCRM is coordinated across functional units with defined roles of key internal supply chain stakeholders.	SCRM is governed by a cross-functional well defined framework including critical supply chain partners.	Supply chain risk management framework is well defined across the enterprise including multi-tier critical supply chain partners.
	1D. Resources & Commitment	No designated supply chain risk management resources.	SCRM resources are identified within functional units and risk management is considered a collateral duty.	SCRM resources designated for functional units. Accountability and resource allocation within functional level.	SCRM has committed resources with well defined roles and responsibilities on a cross-functional level and considering critical supply chain partners.	SCRM is embedded within the organization's culture and seen as a value added activity with appropriate resources committed. Enterprise-wide accountability and resource allocation considered as part of regular fiscal allocations.
	1E. Program Communication	No defined internal or external SCRM communication.	Informal SCRM communication occur within the functional units.	Formal SCRM communications occur within functional units. Supply chain partner communications occur as they relate to individual functions.	Integrated SCRM communications and consultation across functional units and includes critical supply chain partners.	Enterprise-wide communication and consultation includes multi-tier critical supply chain partners.
2. Planning	2A. Supply Chain Mapping	No supply chain mapping.	Informal supply chain mapping occurs.	Formal process for supply chain mapping within product lines.	Supply chain mapping completed on critical products and includes critical supply chain partners and interdependencies across product lines.	End to end supply chain mapping conducted across critical products on an ongoing basis, are readily available and include critical interdependencies.

2B. Context and Operating Environment	No identification of SCRM context or operating environment.	Informal process for identifying SCRM context and operating environment within product lines.	Formal process for identifying SCRM context and operating environment within product lines.	Formal process for identifying SCRM context and operating environment across product lines and includes critical supply chain partners and interdependencies.	SCRM context and operating environment is understood enterprise-wide as well as by multi-tiered critical supply chain partners.
2C. Stakeholder Identification	Internal and external stakeholders not identified.	Internal SCRM stakeholders identified within product line.	Formal process established to identify key SCRM stakeholders.	Key SCRM stakeholders identified including those related to critical supply chain partners and interdependencies.	All SCRM stakeholders identified and actively engaged in SCRM planning process.
2D. Risk Tolerance	No risk criteria established.	Risk criteria is identified for specific current and past events.	SCR criteria is established for specific current and past events and anticipated risks. Functional leaders consulted in establishing risk criteria.	SCR criteria are established across the SC based upon organization's objectives.	SCR criteria is established across the SC based upon organization's objectives, continually reviewed for relevance, and endorsed by senior management.
2E. Risk Categories	No risk categories identified for types of risk.	Risk identified for specific issues, typically related to past events, or warnings highlighted by governments or the media.	Risks identified internally for specific issues within product lines.	Risks identified internally and externally across supply chain.	Comprehensive identification of risk categories covering risks related to tangible and intangible risk assets. Identification is aligned with the overall enterprise objectives.
2F. Business Impact	No formal process for threat, vulnerability or criticality analysis.	Informal process for analyzing threat, criticality and vulnerability.	Formal process for analyzing threat, criticality and vulnerability utilized throughout internal supply chain.	Formal process with internal and external stakeholders for analyzing threat, criticality and vulnerability utilized.	Comprehensive and integrated process for conducting threat, vulnerability and criticality analyzes across the enterprise and its supply chain.
2G. Event Likelihood and Consequence	No formal process for analyzing likelihood and consequence to determine level of risk.	Informal process in place for analyzing likelihood and consequence to determine level of risk.	Formal risk analysis process in place for analyzing internal likelihood and consequence based upon risk criteria to determine level of risk utilized.	Formal risk analysis process in place for analyzing internal and external likelihood and consequence based upon risk criteria to determine level of risk utilized.	Comprehensive documented and integrated process for analyzing likelihood and consequence to determine level of risk across the enterprise and supply chain.
2H. Risk Prioritization	No formal process to evaluate or prioritize risk.	Informal process in place to evaluate or prioritize risk.	Formal process in place to evaluate or prioritize internal risk.	Formal process in place to evaluate or prioritize internal and external risk.	Comprehensive and integrated process in place to evaluate or prioritize across the enterprise aligned with the business objectives of the organization.
2I. Risk Treatment	No formal process for determining risk treatment strategy.	Informal process in place to determine risk treatment strategy, but shared within risk management function and/or specific product line supply chain stakeholders.	Formal process in place to determine risk treatment strategy developed in collaboration with internal supply chain stakeholders.	Process in place to determine risk treatment strategy developed in collaboration with internal and external supply chain stakeholders.	Comprehensive documented and integrated process to determine risk treatment strategy across the enterprise and its supply chain.

	2J. Stakeholder Consultation	No consultation with stakeholders.	Informal consultation with limited specific internal stakeholders.	Formal process for communication and consultation throughout internal organization.	Formal process for communication and consultation throughout organization to include supply chain partners. Communication and consultation with external stakeholders is conducted as part of the risk assessment process.	Formal and ongoing communication and consultation with internal and external stakeholders (including sub-tier supply chain partners.)
3. Implementation	3A. Risk Monitoring	No risk monitoring. Events become known when impact to business is realized.	Risk monitoring for specific identified issues, typically related to past events, or warnings highlighted by governments or the media. Risk is monitored in individual functions, but there is a lack of cross function monitoring and warning.	Resources are designated for specific functions to monitor risks in their functions and escalate when appropriate. Formal early warning detection system in place for real time threats within supply chain functions.	Risk are actively monitored across organization including Tier-1 supply chain partner base. Formal early warning detection system in place for real time threats across the supply chain.	Systematic approach for early warning risk and threat detection (includes supply chain partners and interdependencies) to communicate threats to the organization which can trigger risk treatment plans to prevent, mitigate or respond to the threat.
	3B. Risk Treatment	No formal risk treatment processes.	Risk treatments focus on addressing issues identified from past events. Risk treatment processes emphasis response and recovery but lack an effort to address root causes and taking pre-emptive measures.	Risk treatment process emphasis response and recovery. Proactive measures are introduced to better respond and recover. Risk treatment approaches are siloed along disciplines with separate efforts for security, crisis, and business continuity management. These separate efforts interface with tier one supply chain partners.	Risk treatment process emphasis an integrated approach to anticipate, prevent, protect, mitigate, response and recovery by eliminating silos and coordinating disciplines in a single coordinated risk management effort. A pre-emptive capacity using an approach to anticipate, prevent, protect and mitigate potential undesirable or disruptive events, include supply chain partners, is being developed.	Risk treatment processes emphasize an adaptive capacity and pre-emptive measures within the organization and its supply chain. Risk treatment based upon creating and protecting value to the organization. Risk treatment is based upon a multi-disciplinary and unsiloed approach.
	3C. Event Communication	No communication procedures. Communication not coordinated with internal or external stakeholders and is typically one-way communication which is reactive in nature. Driven by demands for information.	Communication and consultation procedures are establish with internal stakeholders based on experiences with past incidents and identified needs for information sharing and warnings. Communication is not cross function.	Two-way communication and consultation procedures are establish with internal and external stakeholders (including key supply chain partners and government). Procedures are established for communications with internal and external stakeholders including information sharing and warnings.	Integrated communication and consultation procedures are establish with internal and external stakeholders (including supply chain partners and government) based on output from the risk assessment. Communication protocols for normal and disruptive events are established for internal and external stakeholders.	An integrated capacity using all available technologies communications and consultation with external stakeholders (supply chain, government and community) is fully implemented and tested. Communication capacity tested and verified and contingencies are in place for internal and external stakeholders in the event of a disruption.

4. Evaluation	4A. Program Metrics	No supply chain risk management metrics to measure the impact of an event to the organization.	Supply chain risk management indicators and metrics have been defined based on information needs on previous events. Post event review of response and recovery times to specific events.	Supply chain risk management indicators and metrics are defined based on past events and risk assessment. Metrics are function based and do not evaluate impact to the the enterprise.	Supply chain risk management indicators and metrics are defined based on the risk assessment process and the organizational's overall objectives. Metrics measure the effectiveness of risk treatment programs and include critical supply chain partners.	Supply Chain metrics are integrated with the over all risk management metrics of the organization. Risk assessment and risk treatment effectiveness is analyzed on a multi-tiered perspective to determine the best return on investment for adaptive, proactive and reactive risk management strategies. Metrics highlight how organizations can minimize the likelihood of an event or the consequences of an event in the extended supply chain.
	4B. Performance Review	No performance review conducted.	Performance review conducted within functions.	Program performance metrics are established to assess the effectiveness of risk programs within functions. Gaps between plan and actual performance are identified.	Program performance metrics are established to assess the effectiveness of risk programs across the enterprise to include critical supply chain partners. Performance review emphasizes root cause of deviations and identifying opportunities for improvement.	Program performance metrics are established to assess the effectiveness of risk programs across the enterprise.
	4C. Audit / Drill / Test	No audits / drills performed.	Informal audits / drills are conducted within specific functional units based upon known risks from previous events.	Periodic audits / drills conducted internally to assess the resiliency of the functional units to risks.	Periodic audits / drills conducted to assess the resiliency of across functional units to include critical supply chain partners to risks suppliers.	Periodic audits / drills conducted to assess the resiliency across the enterprise to include multi-tier supply partners, emergency responders, and critical interdependencies to risks.
5. Improvement	5A. Continuous Program Improvement	No formal improvement/learning program in place.	Program improvements based on shortcomings identified from previous events.	Program improvements based upon forward looking risk assessment at the functional unit level.	Program improvements based on cross-functional unit reviews of risk treatments including critical supply chain partners.	Continually monitoring for opportunities for improvement throughout the enterprise and the supply chain.
	5B. Change Management	No change management system in place.	Change management initiated after disruptive events.	Formal change management system is in place within functional units.	Formal cross-functional change management system is in place including critical supply chain partners.	Formal enterprise-wide change management system is in place including critical multi-tier supply chain partners. Change management is inherit throughout organization's culture to promote opportunities for improvement.

APPENDIX II – QUESTIONNAIRE

An Investigation into Supply Chain Risk Management Maturity in Sri Lanka

Dear Ma'am/ Sir,

I am Athalanka Kudaliyanage and I am an MBA student attached to the Department of Transport and Logistics, University of Moratuwa. As my final year research project, I am conducting an investigation into supply chain risk management maturity in Sri Lanka. Questionnaire below was designed to gather primary data for my research work and I invite you to kindly contribute to my research by completing the same.

The questionnaire will require approximately 15-20 minute of your valuable time and participation is strictly voluntary. All information provided by you will be treated with strict confidentiality and will be used only for academic purposes. The results of this study would be published in academic journals and conferences but it would not reveal the identity of either yours or your organisation.

Should you need any further clarifications please be kind to contact me on 0777347257 or email at athalanka@gmail.com.

Thanks in advance for your support.

Yours faithfully,
Athalanka Kudaliyanage

* Required

1. Email address *

Section 1

This section attempts to understand background information relating to your organisation. Kindly select the most appropriate answer for each of the questions below.

2. 1. Which industry sector does your organisation operate in? *

Mark only one oval.

- Beverage, Food and Tobacco
- Chemical and Pharmaceuticals
- Textile
- General Manufacturing
- Retail
- Logistics/ Transportation
- Healthcare
- Leisure
- Agribusiness/ Plantation
- Construction
- Other: _____

3. 2. What is the average annual turn-over of your organisation? (Rs. Billion) *

Mark only one oval.

- < 1
- 1 - 5
- 5 - 10
- 10 - 15
- > 15

4. 3. How many employees are directly employed by your organisation? *

Mark only one oval.

- < 100
- 100 – 200
- 200 – 1000
- 1000 – 5000
- > 5000

5. 4. In which functional area are you employed in your organisation? *

Mark only one oval.

- Supply Chain/ Operations
- Sales and Marketing
- Finance
- Information Technology
- Human Resource
- Research and Development
- Other: _____

6. 5. In which hierarchical level are you employed in your organisation? *

Mark only one oval.

- Non-executive
- Executive/ Junior Manager
- Middle Manager
- Senior Manager

Section 2

This section of the questionnaire attempts to understand your perception on the vulnerability of your supply chain and how mature your Supply Chain Risk Management (SCRM) process is. Kindly select the most appropriate answer for each of the questions below.

7. 6. How vulnerable is your supply chain to below mentioned uncertainties. *

Mark only one oval per row.

	Very little	Little	Moderate	High	Very High
Intra-organisational uncertainties such as product characteristic, processes designs, IT complexities etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Intra-supply chain uncertainties such as demand fluctuations, supply fluctuations, supply chain length and design etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External uncertainties such as government regulations, terrorism, natural disasters etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. 7. With respect to supply chain risk management process of your organisation, kindly indicate the maturity level each of the below attributes have reached *

Mark only one oval per row.

	No executive leadership commitment across the supply chain	Limited executive commitment within the organisation	Strong executive leadership internally but no executive leadership from external supply chain	Strong internal executive leadership with limited external executive leadership	Strong executive leadership along end-to-end supply chain
Executive Leadership	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. *
Mark only one oval per row.

	No SCRM framework	Internal functional level SCRM framework	Internal organisation level SCRM framework	SCRM framework inclusive of key external supply chain partners	SCRM framework covering end-to-end supply chain
Governance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. *
Mark only one oval per row.

	No functional leadership. Individuals assume responsibility.	Limited functional leadership within the organisation	Strong functional leadership within the organisation but no functional leadership externally	Strong functional leadership within the organisation with limited external commitment	Strong functional leadership along end-to-end supply chain
Functional Leadership	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. *
Mark only one oval per row.

	No resource allocation	Limited resource allocation at internal organisational level	Committed resource allocation internally with no commitment from external supply chain	Committed resource allocation internally with limited resource from external supply chain	Committed resource allocation along end-to-end supply chain
Resources & Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

12. *
Mark only one oval per row.

	No communication internally or externally	Informal internal communication only	Formal internal communication only	Formal internal communication and informal external communication	Formal communication along end-to-end supply chain
Program Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. *
Mark only one oval per row.

	No supply chain mapping	Informal mapping of internal supply chain only	Formal mapping of internal supply chain only	Formal mapping of internal supply chain and informal mapping of external supply chain	Formal mapping of end-to-end supply chain
Supply Chain Mapping	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. *
Mark only one oval per row.

	No supply chain context and operating environment identification	Informal identification of internal supply chain context and operating environment only	Formal identification of internal supply chain context and operating environment only	Formal internal identification and informal external supply chain context identification	Formal identification of supply chain context and operating environment along end-to-end supply chain
Context and Operating Environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

15. *
Mark only one oval per row.

	No supply chain stakeholder identification	Informal identification of internal supply chain stakeholders only	Formal identification of internal supply chain stakeholders only	Formal internal stakeholder identification and informal external stakeholder identification	Formal identification of stakeholders along end-to-end supply chain
Stakeholder Identification	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

16. *
Mark only one oval per row.

	No risk tolerance identification internally or externally	Informal identification of internal risks tolerance only	Formal identification of internal risk tolerances only	Formal internal risk tolerance identification and informal external risk tolerance identification	Formal identification of supply chain risk tolerances along end-to-end supply chain
Supply Chain Risk Tolerance Identification	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17. *
Mark only one oval per row.

	No risk category identification internally or externally	Informal identification of internal risks category only	Formal identification of internal risk category only	Formal internal risk category identification and informal external risk category identification	Formal identification of supply chain risk category along end-to-end supply chain
Supply Chain Risk Category Identification	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. *
Mark only one oval per row.

	No business impact identification internally or externally	Informal identification of internal business impact only	Formal identification of internal business impact only	Formal internal business impact identification and informal external business impact identification	Formal identification of business impact along end-to-end supply chain
Business Impact Identification (of identified supply chain risks)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

19. *
Mark only one oval per row.

	No event likelihood and consequence identification internally or externally	Informal identification of internal event likelihood and consequence only	Formal identification of internal event likelihood and consequence only	Formal internal event likelihood/ consequence identification and informal external event likelihood/ consequence identification	Formal identification of event likelihood and consequence along end-to-end supply chain
Event Likelihood and Consequence Identification	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

20. *
Mark only one oval per row.

	No prioritization of risks internally or externally	Informal prioritization of internal risks only	Formal prioritization of internal risks only	Formal internal risk prioritization and informal external risk prioritization	Formal prioritization of supply chain risks along end-to-end supply chain
Risk Prioritization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

21. *
Mark only one oval per row.

	No risk treatment strategy determination internally or externally	Informal determination of internal risk treatment strategies only	Formal determination of internal risk treatment strategies only	Formal internal risk treatment strategy determination and informal external risk treatment strategy determination	Formal determination of risk treatment strategies along end-to-end supply chain
Risk Treatment Strategy Determination	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22. *
Mark only one oval per row.

	No stakeholder consultation internally or externally	Informal consultation of internal stakeholders only	Formal consultation of internal stakeholders only	Formal internal stakeholder consultation and informal external stakeholder consultation	Formal consultation of stakeholders along end-to-end supply chain
Stakeholder Consultation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

23. *
Mark only one oval per row.

	No monitoring of risks internally or externally	Reactive internal monitoring of risks	Proactive internal monitoring of risks	Proactive internal risk monitoring and reactive external risk monitoring	Proactive monitoring of supply chain risks along end-to-end supply chain
Risk Monitoring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

24. *
Mark only one oval per row.

	No risk treatment strategy execution internally or externally	Reactive execution of internal risk treatment strategies only	Proactive execution of internal risk treatment strategies only	Proactive internal risk treatment strategy execution and reactive external risk treatment strategy execution	Proactive execution of risk treatment strategies along end-to-end supply chain
Risk Treatment Strategy Execution	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

25. *
Mark only one oval per row.

	No communication of events internally or externally	Reactive communication of events internally	Proactive communication of events internally	Proactive internal event communication and reactive external event communication	Proactive communication of supply chain events along end-to-end supply chain
Event Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

26. *
Mark only one oval per row.

	No performance indicators defined internally or externally	Only lagging indicators are defined internally	Both leading and lagging indicators are defined internally	Leading and lagging internal indicators and lagging external indicators	Both lagging and lagging indicators are defined along end-to-end supply chain
CRM Performance Indicators	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

27. *
Mark only one oval per row.

	No performance review internally or externally	Informal review of internal performance only	Formal review of internal performance only	Formal internal performance review and informal external performance review	Formal review of performance along end-to-end supply chain
SCRM Performance Review	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

28. *
Mark only one oval per row.

	No audit/ drill/ test internally or externally	Informal internal audits/ drills/ tests only	Formal internal audits/ drills/ tests only	Formal internal audits/ drills/ tests and informal external audits/ drills/ tests	Formal audits/ drills/ tests along end-to-end supply chain
SCRM Audit / Drill / Test	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

29. *
Mark only one oval per row.

	No continuous improvement efforts internally or externally	Reactive improvement efforts internally	Proactive improvement efforts internally	Proactive internal improvement efforts and reactive external improvement efforts	Proactive continuous improvement efforts along end-to-end supply chain
Continuous Improvement	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

30. *
Mark only one oval per row.

	No change management system internally or externally	Reactive change management system internally	Proactive change management system internally	Proactive internal change management and reactive external improvement efforts	Proactive change management along end-to-end supply chain
Change Management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

31. 8. How would you rate your supply chain on below mentioned aspects. *

Mark only one oval per row.

	Very Poor	Poor	Moderate	Good	Very Good
Anticipating and having proactive plans for an unexpected events	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resisting an unexpected event by maintaining control over structure and function	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Responding to and recovering from an unexpected event rapidly and effectively	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

End of Questionnaire. Thank you very much for your participation.

APPENDIX III – FACTOR LOADINGS AND CORRELATIONS FOR FINAL MODEL

Standardized Regression Weights:

		Estimate
Leadership	<--- SCRM_Maturity	.806
Planning	<--- SCRM_Maturity	.846
Implementation	<--- SCRM_Maturity	.832
Evaluation_and_Improvement	<--- SCRM_Maturity	.747
VULN3	<--- Vulnerability	.812
VULN2	<--- Vulnerability	.705
VULN1	<--- Vulnerability	.795
LEAD5	<--- Leadership	.752
LEAD4	<--- Leadership	.857
LEAD3	<--- Leadership	.820
LEAD2	<--- Leadership	.948
PLAN9	<--- Planning	.824
PLAN8	<--- Planning	.854
PLAN7	<--- Planning	.952
PLAN6	<--- Planning	.963
PLAN5	<--- Planning	.761
PLAN4	<--- Planning	.816
PLAN3	<--- Planning	.838
PLAN2	<--- Planning	.737
PLAN1	<--- Planning	.778
IMPL3	<--- Implementation	.875
IMPL2	<--- Implementation	.946
IMPL1	<--- Implementation	.972
EVAL3	<--- Evaluation_and_Improvement	.826
EVAL2	<--- Evaluation_and_Improvement	.866
EVAL1	<--- Evaluation_and_Improvement	.765
IMPR1	<--- Evaluation_and_Improvement	.837
RESI3	<--- Resilience	.720
RESI2	<--- Resilience	.866
RESI1	<--- Resilience	.906

Correlations:

		Estimate
Vulnerability <-->	SCRM_Maturity	.467
Resilience <-->	SCRM_Maturity	.763
Vulnerability <-->	Resilience	.478

APPENDIX IV – SUMMARY DESCRIPTIVE ANALYSIS

Descriptive Statistics						
		N	Minimum	Maximum	Mean	Std. Deviation
VULN1	Organisational Uncertainties	39	1	5	2.92	1.061
VULN2	Network Uncertainties	39	1	5	3.41	1.019
VULN3	Environmental Uncertainties	39	1	5	3.69	1.055
	Vulnerability	39	2.92	3.69	3.34	0.389
LEAD2	Functional Leadership	39	2	5	3.41	1.044
LEAD3	Governance	39	1	5	3.08	1.133
LEAD4	Resource & Commitment	39	2	5	3.31	1.030
LEAD5	Programme Communication	39	2	5	3.82	1.023
	SCRM Leadership	39	3.08	3.82	3.40	0.311
PLAN1	Supply Chain Mapping	39	1	5	3.26	1.141
PLAN2	Context & Opt. Environment	39	1	5	3.54	1.047
PLAN3	Stakeholder Identification	39	2	5	3.54	1.047
PLAN4	Risk Tolerance	39	1	4	2.69	0.863
PLAN5	Risk Categories	39	2	5	4.36	0.903
PLAN6	Business Impact	39	1	5	3.33	1.264
PLAN7	Event Likelihood & Consequences	39	1	5	3.62	1.091
PLAN8	Risk Prioritisation	39	1	5	3.33	1.132
PLAN9	Treatment Identification	39	1	5	3.15	1.182
	SCRM Planning	39	2.69	4.36	3.42	0.446
IMPL1	Risk Monitoring	39	1	5	3.13	1.151
IMPL2	Treatment Execution	39	1	5	3.08	1.036
IMPL3	Event Communication	39	1	5	3.36	1.063
	SCRM Implementation	39	3.08	3.36	3.19	0.150
EVAL1	Programme Matrix	39	1	5	2.74	1.093
EVAL2	Performance Review	39	1	5	2.87	1.128
EVAL3	Audit/ Drill/ Test	39	1	5	2.92	1.133

IMPR1	Continuous Improvement	39	1	5	2.97	1.112
	SCRM Evaluation & Improvement	39	2.74	2.97	2.88	0.099
RESI1	Anticipation	39	1	5	3.40	1.08
RESI2	Resistance	39	1	5	3.40	1.04
RESI3	Recovery & Response	39	1	5	3.02	0.93
	Supply Chain Resilience	39	3.02	3.40	3.28	0.218