School of Marketing

Supply Chain Sustainability and Resilience: the Case of Apparel Industry in Bangladesh

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Declaration

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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Md Maruf Hossan Chowdhury

10th December 2014

Dedication

To

My loving family

My parents &

My wife: Jusy

Acknowledgements

In the name of Allah, the Most Gracious and the Most Merciful

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ABSTRACT

Global supply chains today are experiencing myriads of challenges due to the multiplicity of disruption risk drivers. Organizations and their supply chains need to have the ability to cope with emerging threats, to adapt quickly in time of crisis and turbulence, and to satisfy stakeholders' requirements in a consistent fashion. It is imperative that supply chains identify the vulnerabilities and develop the resilience capabilities to reduce the probability and impact of the foreseen or unforeseen disruptive events. Similarly, the apparel industry of Bangladesh needs to also develop proactive and reactive capabilities to reduce the chance of disruptions, to respond quickly to the crisis and to recover quickly from the existing critical conditions. Failure to develop resilience at the right time may be a cause of huge financial loss for the whole supply chain which may ultimately erode sustainability in the long run. The existing literature on supply chain risk management lacks an empirically validated model for supply chain resilience to address the supply chain vulnerability and to ensure long-term sustainability in the supply chain. With this backdrop, the present study aims to develop a model of supply chain resilience and sustainability by reviewing the literature on supply chain vulnerability, resilience and supply chain sustainability.

Based on an extensive literature review an initial model is proposed which was justified through the lens of the resource-based view (RBV) and stakeholder theory. The constructs and their hypothesized relationships are conceptualized. As supply chain vulnerability and resilience is context-specific, the constructs and variables of the initial research are contextualised and validated by a qualitative field study.

This research thus adopted the 'mixed method' methodology which embraces both qualitative and quantitative approaches. In the qualitative phase, using a semi-structured interview protocol, the field study data were collected from 15 supply chain decision makers of apparel manufacturing companies and accessory manufacturing companies (suppliers) in Bangladesh. Data obtained from the field study have been analysed using the content analysis technique with the help of the NVivo software package. From the findings of the content analysis, a field study model was developed. Then, based on the comparison of the conceptual model and the field study model, a comprehensive and final research model was developed which was subject to

empirical validation by the quantitative research approach and thus aligned with the notion of mixed methods research.

In the quantitative phase, a total of 296 usable survey responses were obtained from apparel producers and their suppliers in Bangladesh. Collected data were analysed by using the partial least square (PLS)-based structural equation modelling (SEM) technique.

The findings of this research confirmed that supply chain resilience is reflected by the dimensions of: supply chain capability, supply chain design, supply chain readiness, and response and recovery, while supply chain vulnerability is comprised of the dimensions of hazard, strategic, financial, operational, infrastructural and demand–supply vulnerability. It is also ascertained that resilience is a critical factor to reduce vulnerability and to ensure social, environmental, economic and operational sustainability in the supply chain.

This current research has both theoretical and practical implications. Modelling supply chain sustainability and resilience as well as developing measures for supply chain resilience and vulnerability in a single framework is a unique initiative by far in the literature. Thus, this research enriches the body of knowledge on supply chain risk management literature.

The factors and variables obtained from this research will assist supply chain managers to identify and measure supply chain vulnerabilities and resilience capabilities to overcome disruptive events. It will also assist the managers to develop the social, environmental and economic sustainability of supply chains by developing a resilient approach to vulnerabilities. Overall, this study will facilitate managers in ensuring resilience and sustainability of the supply chain in the context of the apparel supply chain in Bangladesh. However, the study's implications are also significant for other countries in a similar institutional and industrial context.

Publications from this dissertation

1. Chowdhury, M. M. H. and M.A. Quaddus. 2014. "Impact of buyer-supplier relational practices on supply chain resilience and supply chain performance" In Proceedings of *the Australia and New Zealand Marketing Academy (ANZMAC 2014) Conference,* Brisbane, Australia.

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4. Chowdhury, M. M. H., M. N. A. Dewan, M. Nuruzzaman, and M. A. Quaddus. 2013. Supply chain readiness, response and recovery for supply chain resilience to vulnerabilities: A study on ready-made garment industry of Bangladesh. In proceedings of the *3rd International Forum and Conference on Logistics and Supply Chain Management (LSCM).* Bali, Indonesia.

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6. Chowdhury, M. M. H., M. N. A. Dewan, M. M. Hossain, and M. A. Quaddus. 2012. An AHP-QFD integrated approach for mitigating barriers of corporate sustainability. In proceedings of the *26th Annual Australian and New Zealand Academy of Management Conference*. Perth, Australia.

7. Chowdhury, M. M. H., M. N. A. Dewan, and M. A. Quaddus. 2012. Resilient sustainable supply chain management – A conceptual framework. In proceedings of *the 7th International Conference on E-Business (ICE-B 2012)*. Rome, Italy.

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9. Chowdhury, M. M. H., M. N. A. Dewan, and M. A. Quaddus 2012. Supply chain sustainability through complying buyers' requirements in apparel industry: A fuzzy QFD approach. In proceedings of the *26th Annual Australian and New Zealand Academy of Management Conference*. Perth, Australia.

10. Chowdhury, M. M. H., M. Nuruzzaman, M. N. A. Dewan, and M. A. Quaddus 2012. An AHP integrated QFD approach for mitigating upstream supply chain barriers: A study on Ready-Made Garment (RMG) industry of Bangladesh. In proceedings of the *26th*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Supply chains are often exposed to numerous disruptions. Sources of disruptions inherent in a system can manifest themselves in a number of vulnerabilities (Pettit, Croxton, and Fiksel 2013; Wu, Blackhurst, and Chidambaram 2006). Sometimes the impact of disruption is very high if it magnifies and if it has a confounding impact on the whole rubric of the supply chain (Wu, Blackhurst, and Chidambaram 2006). The consequences are even worse if disruption is reported in the media which may result in rapid fall of the stock price. For example, Toyota lost over 17% of its value after the announcement of a power disruption (Kachi and Takahashi 2011). Therefore, managing supply chain risk is a critical success factor for supply chain managers. However, mere attempts to use traditional risk management approaches are not enough in the era of highly uncertain and turbulent changes (Pettit, Croxton, and Fiksel 2013; Jüttner and Maklan 2011). Organizations need a proactive and resilient approach to combat the challenges arising from turbulent changes and disruptions (Jüttner and Maklan 2011) because resilience is the capacity of an enterprise to survive, adapt and grow in the face of turbulent change (Fiksel 2006). Such a proactive and resilient approach is indispensable for achieving supply chain sustainability (Ponomarov and Holcomb 2009). It is noteworthy that resilience is context-specific and depends on the magnitude of vulnerabilities (Korhonen and Seager 2008). Therefore, it is essential for organizations to identify and measure specific risks and vulnerability aiming at designing the required resilience capabilities in the wake of widespread disruptions (Zsidisin and Ellram 2003; Wu, Blackhurst, and Chidambaram 2006).

The focus of this study is designing a resilient and sustainable supply chain in the context of the apparel industry of Bangladesh, the second largest exporter in the world (BGMEA 2012). The industry is facing frequent disruptions arising from numerous sources such as political instability, labour unrest, interruption in utility supply, dependence on imported material etc. (Ahmed 2009; Islam and Deegan 2008; Chowdhury, Sarker, and Afroze 2012; Haider 2007) which are challenging the sustainability of the industry. The existence of such disruptive events and the resultant consequences have spurred renewed concerns for supply chain resilience (SCR). Therefore, the primary motivation is to investigate the vulnerabilities in the apparel

supply chain of Bangladesh and to develop resilience capability for reducing those vulnerabilities as well as for ensuring long-term sustainability of the supply chain.

Despite the multiplicity of supply chain vulnerability and its severe consequential impact on the supply chain sustainability, a comprehensive model to address supply chain vulnerability, resilience and sustainability as well as their interrelationships has not yet been explored (Pettit, Fiksel and Croxton 2010). Therefore, this study addresses the existing voids in the literature and presents an integrated model of supply chain sustainability and resilience. The proposed model endeavoures to illuminate sustainability as an outcome of supply chain resilience (SCR) in the face of turbulence and vulnerability. The dimensions of supply chain resilience and supply chain vulnerability have been exposed and validated. It also explicates the relationship between supply chain resilience and supply chain vulnerability as well as the antecedent constructs of supply chain resilience, that is, supply chain orientation, learning and development, and supply chain risk management. Therefore, the research seeks to extend the theoretical and empirical evidence regarding the dimensions of supply chain vulnerability and resilience as well as the structural relationships among the constructs: i) supply chain vulnerability, ii) supply chain resilience and iii) sustainability.

1.2 RESEARCH PROBLEM

The apparel industry is an economic propeller of Bangladesh's economy as it accounts for 78.6% of the country's export earnings (BGMEA 2012) and is credited with generating direct employment of more than four million people and indirect employment for several million others. Despite its huge potential, the industry is struggling with numerous supply chain (SC) disruptions such as labour unrest for the violation of human rights, poor working environment, political instability, interruption in utility supply, inefficiency in customs and port management, disruption in timely supply of fabrics and other accessories, increased competition and inefficiency in operations (Islam and Deegan 2008; Islam, Bagum, and Choudhury 2012; Haider 2007). Furthermore, increased lead time and cost due to disruptions in the procurement and shipment of goods (Nuruzzaman 2009), lack of linkages and coordination among related industries in the value chain, dependence on imported inputs, limited variety of finished products (Haider 2007; Ahmed 2009) and the fall in orders due to the global economic downturn are the issues of high concern for the apparel supply chain of Bangladesh.

The consequences of the disruptions are huge: for instance, the apparel industry of Bangladesh loses $26.15 million per day due to the problems in supply chain functions caused by political instability (Asia News Network 2013). Moreover, the preferential access to the United States (US) market has been cancelled due to the poor safety standard in production plants as building collapses in apparel factories have caused the deaths of more than 1100 workers (Fibre2fashion News Desk 2013). These disruptions have a chain effect on all the members in the supply chain network including the international buyers (retail chains) and suppliers. Moreover, due to these disruptions, the growth of apparel exports from Bangladesh has fallen from 23% in 2005-06 to 15% in 2008-09 (Chowdhury, Sarker, and Afroze 2012). In fact, the sustainability of the whole supply chain is being challenged. In the wake of such a critical state in the apparel supply chain, developing resilience capabilities is vital to reduce the probability and the impacts of disruptive events.

Despite the multiplicity of numerous disruptions in the apparel industry, proactive approaches to mitigate those disruptions are not very visible. Some of the organizational actions such as quality improvement, cost minimisation, product diversification, lead-time reduction, market diversification, lean practices and skill development training are suggested by previous studies (Dowlah 1999; Ferdousi and Ahmed 2009; Ahmed 2009; Haider 2007) to increase the competitiveness of the industry. Ahmed (2009), Haider (2007) and Nuruzzaman (2009) address government actions such as developing port and infrastructure, uninterrupted utility supply, corruption-free environment and political stability to combat the challenges and disruptions in the industry. However, these actions are not enough to mitigate the challenges and disruptions and, specifically, those disruptions with high uncertainty and high impact. Usually, this raises the question as to how to mitigate the disruptions. The existing literature suggests a more proactive and resilient approach to successfully combat the challenges in supply chains (Pettit, Croxton, and Fiksel 2013; Sheffi and Rice 2005; Christopher and Peck 2004). However, a comprehensive resilient approach to overcome supply chain vulnerabilities is rare (Pettit, Croxton, and Fiksel 2013; Ponomarov and Holcomb 2009). This study, therefore, identifies a comprehensive approach for supply chain resilience and vulnerability to mitigate disruptions in the context of the apparel supply chain of Bangladesh.

An enquiry into the theoretical lenses with which to explain the organizational actions for mitigating supply chain vulnerability reveals that the spirit of the resource-based view (RBV) (Wernerfelt 1984; Barney 1991) supports proactive organizational action

and a resilient approach for mitigating vulnerabilities arising from uncertainties and disruptive events. Aragón-Correa and Sharma (2003) in their "contingent resource-based view (C-RBV) of proactive corporate environmental strategy" argue that the organization's proactive environmental attempt to mitigate environmental uncertainties and complexities is a valuable dynamic capability of a firm. Wernerfelt (1984) argues that anything that is distinctive and inimitable can be considered as a resource and strength of a firm. Aligned with the RBV, the proactive capability of mitigating disruptions in the organization and its supply chain is a distinctive and unique capability of an organization. However, the aim of developing such capabilities is not only to mitigate disruptions but also to ensure sustainability of the organization in the long run because one of the aims of a resilient system is achieving sustainability (Fiksel 2003; Fiksel 2006). According to Freeman (1984), an organization shall plan its action considering the interest of stakeholders. Aligned with this, it can be argued that organizational action towards mitigating vulnerabilities shall be consistent with balancing the interest of stakeholders of the organization. For example, in order to combat the challenge of intensive price competition, organizations may reduce waste, introduce resource-efficient technology and increase efficiency of employees which will help to overcome competitive challenges as well as to safeguard the environment. Therefore, stakeholder theory directs us towards confirming the social, environmental and economic aspects of organizational resilient actions. The above discussion paves the way to deduce the fact that no single theory is enough; rather, integration of both theories is needed to enrich the knowledge base and to justify the concept of supply chain sustainability and resilience.

Although awareness about supply chain disruptions is increasing among practitioners, the concepts of supply chain vulnerability and its managerial counterpart, supply chain resilience (SCR), are still in their infancy (Juttner and Maklan 2011). To mitigate disruptions, it is imperative to identify the coherent dimensions of supply chain vulnerability and resiliency. Moreover, companies and their supply chains need to fix which, and to what extent, resilience capability is to be developed to mitigate the specific vulnerability (Pettit, Fiksel, and Croxton 2010). Failure to measure the vulnerability and the corresponding resilience capability causes the imbalanced resilience which may result in undesirable outcomes (Pettit, Croxton and Fiksel 2013). The impact of failure to identify and measure SCV and SCR is even worse if vulnerabilities have chain effect over the whole whole supply chain. Despite the emergence, previous studies have failed to address the coherent dimensions of supply chain vulnerability and resilience through empirical research. This gap in the literature is one of the

motivations for undertaking this study. Furthermore, there is a debate in the literature about the antecedents and the measurement constructs of supply chain resilience. Some consider antecedents as measurement constructs while others consider the measurement constructs as antecedents (Jüttner and Maklan 2011). Existence of such debate in the literature opens an opportunity to investigate the antecedent factors and measurement constructs of supply chain resilience.

A resilient supply chain is a prerequisite for sustainability of the supply chain because, due to the growing disruption and vulnerability of the global supply chain, there is demand for a resilient supply chain to remain sustainable (Christopher and Peck 2004). Along with the economic risks, supply chains are also facing risks arising from social and environmental issues (Foerstl et al. 2010). In today's world, there is increasing pressure from various stakeholder groups to include sustainability issues in organizations' supply chain management (Perez-Sanchez, Barton, and Bower 2003; Nawrocka 2008). With this backdrop, a resilient supply chain is essential to mitigate risks arising from different sources and to ensure sustainability in the supply chain (Christopher and Peck 2004; Ponomarov and Holcomb 2009). In the supply chain literature, the link between supply chain resilience and sustainability is yet to be investigated which is another important issue to address.

Overall, it can be inferred that there is a paucity of theoretically supported and empirically validated models for supply chain sustainability and resilience addressing the dimensions of supply chain vulnerability and resilience as well the relationships among supply chain vulnerability, resilience and supply chain sustainability.

1.3 RESEARCH FOCUS

There are limitations in practice, theory building and subsequent studies with regard to the pros and cons of supply chain vulnerabilities and the strategies to mitigate them. Therefore, this study has been conducted to increase the understanding and the knowledge base. More specifically, the study aimed at exploring and investigating supply chain vulnerability and resilience in a multidimensional frame. Relying on the resource-based view, stakeholder theory and existing literature on supply chain risk management it is apparent that supply chain resilience is essential to mitigate the vulnerabilities in the supply chain. Such resilience capability is also important for the sustainability of the apparel supply chain in Bangladesh, as it faces numerous disruptive events very frequently (Islam, Bagum, and Choudhury; Haider 2007). In the absence of a resilient approach, the sustainability of the apparel supply chain in Bangladesh is threatened as the industry loses millions of dollar per day. Moreover, a

good number of apparel manufacturers have already shut down their operations due to problems in supply chain functions caused by political instability (Asia News Network 2013). To the best of the researcher's knowledge, no empirical study has yet been initiated to identify and measure supply chain resilience and vulnerability as well as investigating the relationship between supply chain resilience, vulnerability and sustainability. Based on the above theoretical and practical underpinning, the primary focus of the study has endeavoured to investigate the following research questions through a wider study.

1.4 RESEARCH QUESTIONS

RQ1: What are the supply chain vulnerabilities and resilience in the context of the apparel industry of Bangladesh?

RQ2: How can sustainability in the supply chain be ensured through resilience in the context of the apparel supply chain of Bangladesh?

1.5 RESEARCH OBJECTIVES

This study assesses, in broad terms, the dimensions of supply chain resilience and vulnerability as well as the structural relationship between supply chain resilience, vulnerability and supply chain sustainability in the context of the apparel supply chain in Bangladesh. Relying on the research questions, the main research objective of the study is to construct a model of supply chain sustainability and resilience to overcome the disruptions and vulnerabilities of the apparel supply chain in Bangladesh. The specific objectives of this research are:

1. To identify and measure the dimensions of supply chain vulnerability (SCV) in the context of the apparel industry of Bangladesh.
2. To determine and measure the dimensions of supply chain resilience (SCR) corresponding to the vulnerabilities.
3. To investigate the relationship between SCR and SCV in the context of the apparel industry of Bangladesh.
4. To examine the role of antecedent factors of SCR.
5. To assess the association between SCR and sustainability in the context of the apparel industry of Bangladesh.

1.6 SIGNIFICANCE OF RESEARCH

1.6.1 Theoretical contribution

Supply chain resilience and supply chain vulnerability have been researched by a number of studies (Pettit, Fiksel, and Croxton 2010; Fiksel 2003; Ponomarov and

Holcomb 2009; Sheffi and Rice 2005; Christopher and Peck. 2004). But most are conceptual studies and fall short of empirically validating the dimensions of supply chain resilience and vulnerability. Therefore, this study identifies and measures the dimensions of supply chain resilience and vulnerability. Moreover, there is a paucity of research to identify and to test the relationship between supply chain resilience and its antecedent constructs and, hence, this was investigated in this research. Furthermore, there is conceptual agreement that supply chain resilience is a precondition for sustainability in the supply chain (Fiksel 2006; Ponomarov and Holcomb 2009); however, no empirical study has yet been conducted to establish the relationship between supply chain sustainability and resilience. This study, therefore, empirically tests and validates the relationship between supply chain sustainability and resilience components. Due to the existence of such voids in the literature, a comprehensive research model of supply chain sustainability and resilience has been developed in this research. Thus, the formulation of a supply chain sustainability and resilience framework is a unique contribution to the supply chain literature in general and to the apparel supply chain of Bangladesh in particular. Furthermore, this study combines the knowledge of the RBV and stakeholder theory to justify the concept of the supply chain sustainability and resilience model which opens a new dimension for the application of resource-based theory.

1.6.2 Practical contribution

There are a number of practical contributions made by this study. Firstly, this study highlights the sustainability and resilience of the apparel supply chain in Bangladesh as the apparel supply chain is facing different disruptions and challenges. It is expected that the proposed model will help the apparel supply chain managers to identify and measure supply chain vulnerabilities and the required resilience capabilities needed to overcome the disruptive events. Secondly, the proposed model will be a valuable input for supply chain managers to improve the facilitating factors, that is, the antecedent factors of supply chain resilience in the apparel industry. Thirdly, it will open the eyes of managers by addressing the resilient approaches needed to develop social, environmental and economic sustainability of the apparel supply chains. Overall, this study will help to ensure supply chain sustainability and resilience in the context of the apparel supply chain in Bangladesh.

1.7 SCOPE OF RESEARCH

The scope of this research corresponds with the development of a model for supply chain sustainability and resilience to overcome the disruptions existing in the apparel supply chain of Bangladesh. The existence of disruptive events has severe consequences on the whole supply chain which is threatening the sustainability of the apparel industry. Proactive organizational actions (i.e. a resilient approach) are urgent to mitigate these disruptions. Therefore, the primary motivation is to investigate the vulnerabilities of the apparel supply chain in Bangladesh and to develop resilience capabilities for reducing those vulnerabilities with the aim of achieving long-term sustainability of the industry.

1.8 DEFINITION OF TERMS

Supply chain: Christopher (2010) defined supply chain as the network of upstream and downstream entities which are involved in different processes and activities to produce value in the form of products and services in the hands of the ultimate consumer.

Supply chain resilience: This is defined as the ability of a supply chain to reduce the probability of disruptions, to reduce the consequences of those disruptions, and to reduce the time needed to recover normal performance (Falasca, Zoble, and Cook 2008).

Sustainable supply chain: A sustainable supply chain is one that "manage[s] material, information and capital flows and cooperate[s] among all entities in the chain with a view to achieve the economic, environmental and social goals deriving from customer and stakeholder requirements" (Seuring and Muller 2008, p. 1700).

Apparel supply chain: This consists of apparel manufacturers as the focal company; suppliers such as the fabrics suppliers; subcontractors (who work under the original apparel manufacturers); and accessories suppliers in the upstream supply chain and, finally, buyers, or buying agents in the downstream supply chain (Nuruzzaman 2009).

1.9 ORGANIZATION OF THE THESIS

This dissertation is organized and presented in eight chapters. The chapters are related to each other. Figure 1.1 exhibits the organization of this dissertation according to the chapters. The summary of each chapter is as follows:

Chapter 1- Introduction: This chapter is an outline of the study including an overview of the overall structure of the research, identifying problem statements and setting up

the context of the research with respect to supply chain sustainability and resilience. This is followed by statements of the research questions and research objectives, and finally, the proclamation of the potential contributions of the study is furnished.

Chapter 2- Literature Review: Chapter 2 presents an extensive literature review focusing on supply chain resilience, vulnerability and supply chain sustainability. Reviews of the two core theories: resource-based view (RBV) and stakeholder theory are presented in detail. This chapter also briefly illustrates the apparel industry of Bangladesh in terms of its supply chain characteristics, the existing vulnerabilities and the practices to mitigate these vulnerabilities. Finally, an initial research model has been developed based on the literature review.

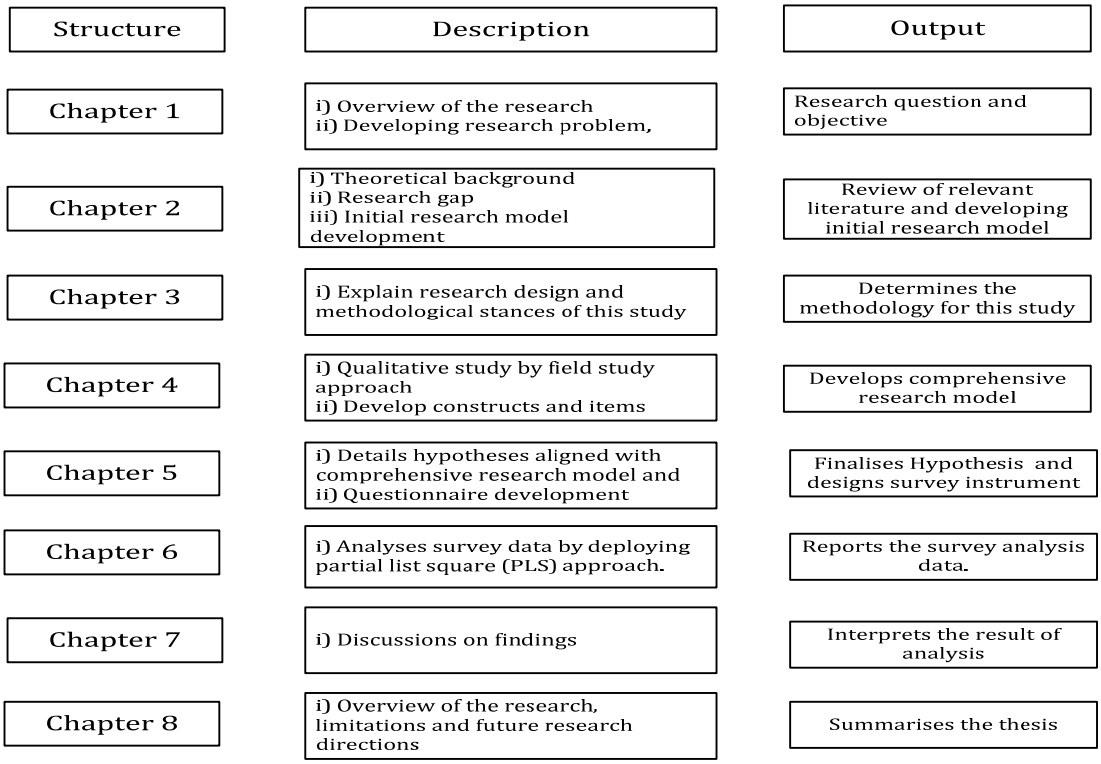


Figure 1.1: Summary of the research structure

Chapter 3- Research Methodology: This chapter primarily focuses upon determining the appropriate research approach employed to undertake this research and the discussion about the methodology adopted for this research. The justification of the method used in the study is explained. This chapter also describes the sample selection and data collection processes. Moreover, the underlying principles of data analysis have also been detailed in this chapter.

Chapter 4- Field Study: This chapter presents the process and outcome of a qualitative field study. The field study was conducted through semi-structured

interviews with fifteen (15) decision makers from apparel manufacturing companies and accessory-producing companies (suppliers) in Bangladesh. The content analysis technique was used to analyse the findings of the study. Based on the findings from the analyses of the qualitative data, the initial research model was modified to contextualise and to develop a comprehensive research model.

Chapter 5- Hypotheses and Questionnaire Development: The first section of this chapter describes the development of the hypotheses based on the comprehensive model developed in the previous chapter. This is then followed by a description of the instrument developed, and the sources of the measurement items in the light of previous literature are presented. Finally, the pre-test procedure is described.

Chapter 6- Analysis of Quantitative Data: This chapter presents the analysis of the quantitative data, using the structural equation modelling (SEM) approach. The initial section discusses the results of the pilot study followed by the results of the common method bias and non-response bias assessments. It then presents the findings of the quantitative data analysis in the light of partial least squares (PLS)-based structural equation modelling (SEM) to assess the measurement of the constructs as well as the hypothesized relationships among the constructs in the model.

Chapter 7- Discussion and Implications: This chapter discusses the findings of the PLS results corresponding to the research objectives. Specifically, the dimensions of SCR and SCV as well as the hypothesized relationships among the constructs in the model are discussed. Theoretical and practical implications from these results are also described in this chapter.

Chapter 8- Conclusion and Future Directions: The final chapter provides an overview of the study and presents its theoretical and practical contributions. The chapter also discusses the limitations and weaknesses of this study and concludes with a brief discussion of the possible future research directions in the subject area of this study.

1.10 SUMMARY

This chapter provided the outline of the current research and established the scope of this study. It presented an overview of the existing literature gap and outlined how the gap has been addressed by this research. It discussed the existing research in the area of supply chain resilience, vulnerability and supply chain sustainability. This chapter then defined the research questions and objectives and, finally, it presented a brief outline of the organization of this research dissertation.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The management of supply chain risk has garnered an increased focus from supply chain managers due to the detrimental impact that supply chain glitches or disruptions can have on supply chain performance (Blackhurst, Scheibe, and Johnson 2008). Apart from the risk management efforts, a new focus on managing and mitigating risk is required that extends beyond the four walls of a plant (Christopher and Peck 2004). According to Christopher and Lee (2004), the increased disruptions and vulnerabilities in the global supply chain generate the need for more resilient supply chains. Otherwise, the consequences will be discontinuity of supply chain operations which adversely affects both revenue and the cost of the whole chain (Ponomarov and Holcomb 2009). While the importance of supply chain resilience (SCR) is indispensable in the manifestation of vulnerability, studies pertaining to vulnerability measurement are very scarce. Although the studies of Blos et al. (2009); Pettit, Croxton and Fiksel (2013); Blackhurst, Craighead and Handfield (2005); Blackhurst, Scheibe and Johnson (2008); Colicchia, Dallaria and Melacini (2010) and others studied and presented a number of vulnerabilities, empirically validated measurement of vulnerability through survey research is yet to be carried out. Therefore, one of the goals of this study is to measure supply chain vulnerability.

In order to mitigate the disruptions efficiently and effectively, supply chains need to develop tangible and intangible capabilities (Christopher and Peck 2004; Pettit, Fiksel, and Croxton 2010). It is imperative to identify the resilience capability requirement in a supply chain based on the likelihood and severity of vulnerabilities to combat the challenges and disruptions in the supply chain (Sheffi and Rice 2005). Therefore, companies need to identify and measure their supply chain resilience. However, a supply chain resilience measurement model is yet to be introduced (Ponomarov and Holcomb 2009). Even empirical study in this regard is sparse. A review of the previous research reveals that there is no unanimously and commonly agreed measurement for SCR. Some of the researchers (Pettit, Fiksel, and Croxton 2010; Christopher and Peck 2004; Sheffi and Rice 2005; Erol, Sauser, and Mansouri 2010; and others) propose a number of dimensions such as supply chain vulnerability and supply chain capability to

measure SCR. In fact, most of the studies focus on a number of capabilities to measure resilience while Sheffi and Rice (2005) and Ponomarov and Holcomb (2009) emphasise the importance of response and recovery time to define resilience. In a recent paper, Wieland and Wallenburg (2013) attribute resilience as the proactive and reactive capabilities which more specifically emphasise proactive anticipation and preparation for changes if disruption occurs as well as the response and recovery effort for reaction to the disruptions. The review of the previous literature indicates that SCR is a multidimensional construct which can be measured not only in terms of capability and vulnerability but also from the aspects of supply chain response and recovery time, and that supply chain design should be considered (Craighead et al. 2007; Wieland and Wallenburg 2013; Falasca, Zoble, and Cook 2008). Development of such a multidimensional resilient measurement model is unique because existing studies fall short of developing a comprehensive model for resilience measurement (Ponomarov and Holcomb 2009). This study, therefore, seeks to address the existing gap in the literature of supply chain resilience.

Along with the measurement of SCR and vulnerability, the link between the two is discussed. In line with the proposed model: supply chain sustainability and resilience, this study also incorporates the role of supply chain resilience antecedents. In this regard, with reference to the previous studies, the antecedent factors of supply chain resilience such as supply chain orientation (SCO), learning and development, and supply chain risk management (SCRM) are discussed.

The importance of resilience for sustainability is often asserted by scholars in the literature. For example, in ecological science, Folke (2002) indicates that resilience is a precondition for sustainability. Similarly, Derissen, Quaas and Baumgärtner (2011) iterate the necessity of resilience for sustainability. Resilience is also necessary for the sustainability of the supply chain as the global supply chain is often exposed to numerous vulnerabilities (Fiksel 2006; Korhonen and Seager 2008; Leat and Revoredo-Giha 2013). Despite the importance of resilience for supply chain sustainability, the link between resilience and sustainability has not yet been tested by any empirical research. The scarcity of theoretical contributions on this concern has prompted calls for rigorous and empirical studies that examine the link between supply chain resilience and different components (social, environmental and economic) of sustainability.

In this study, the major theoretical views are carefully chosen from strategic management and supply chain management literature. Two widely used theories,

namely, the resource-based view (RBV) (Wernerfelt 1984; Barney 1991) and stakeholder theory (Freeman 1984; Donaldson and Preston 1995), and relevant literature on SCR and sustainability are used to justify different constructs and their relationships in the model. The resource-based view (RBV) has been widely used in supply chain management studies (Ponomarov and Holcomb 2009) to address SCR for mitigating vulnerabilities while stakeholder theory is also used in the supply chain literature as a cornerstone to illuminate the concept of supply chain sustainability (de Brito, Carbone, and Blanquart 2008). With reference to the previous studies and the nature of the research problem of this study, the above-mentioned theories have also been used to lay the foundation of this research.

This chapter consists of five main parts. The first section explicates the apparel industry and its supply chain in Bangladesh as well as the rationale for considering the apparel industry of Bangladesh as the study population. The second section illustrates a review of supply chain vulnerability (SCV) literature, SCV's relationship with supply chain resilience (SCR) and the measurement of SCV. The third section deliberates on the concept of SCR, its measurement and the antecedents. Different components of sustainability and the relationship with SCR are presented next in the fourth section. The underlying theories of the RBV and stakeholder theory are discussed in the fifth section of the chapter.

2.2 APPAREL INDUSTRY OF BANGLADESH

Bangladesh is one of the leading exporters of apparel in the world as it occupies more than 6% of the total global apparel market share (Tasin 2013). The apparel industry is an economic propeller of the country and accounts for 78.6% of total export earnings, 16% of the country's GDP and 81% of manufacturing export earnings (BGMEA 2012; Ahmed 2009a). As many as 5400 apparel factories are operating in the country employing over four million people directly in this industry while several million people are indirectly involved in the industry. Among the apparel workers, 90% are women, 90% of whom are basically migrants from rural areas who primarily come from the poorest rural households (Ahmed 2009; Razzaque 2005; Tasin 2013).

There are three different types of apparel manufacturing companies in Bangladesh: (1) integrated manufacturing, where factories import the cotton and do the remaining production processes (spinning, weaving, knitting, cutting and sewing) on their own; (2) factories that import yarn and then complete the rest of the manufacture; and (3) factories that import fabric and sew the fabric to make cloths, known as cut, make and

trim (CMT) factories (Ahmed 2009). Bangladeshi apparel manufacturers are mostly dependent on imported material because of low backward linkages (Ahmed 2009; Islam, Bagum, and Choudhury 2012). However, with the passage of time, backward linkages are developing and, as a result, some of the materials are produced by the company itself or sourced from local producers. The apparel supply chain is buyer-dominated and the process is of the make-to-order type. After getting the sales order from the buyers, the manufacturers collect raw material from the foreign or local suppliers. Sometimes the suppliers are specified by the buyers: as a result, the manufacturers need to buy materials from the specified (nominated) suppliers. Once the source of supply is confirmed, a sample production is produced. If the sample is approved by the buyer, full-fledged production is started. After finishing production, goods are packaged for shipment. Before shipment, a pre-shipment test needs to be performed by a third party inspection agency to ensure the export compliance of the particular buyer. The apparel producers of Bangladesh export their products mainly to the United States of America (USA) and the European Union (EU). These two markets account for more than a 90% share of the country's total earnings from apparel exports (Haider 2007). However, now Bangladesh is exporting to a number of countries such as Canada, Australia, Japan, Brazil, Middle East and others. The total supply chain process of the apparel industry of Bangladesh is depicted by Figure 2.1.

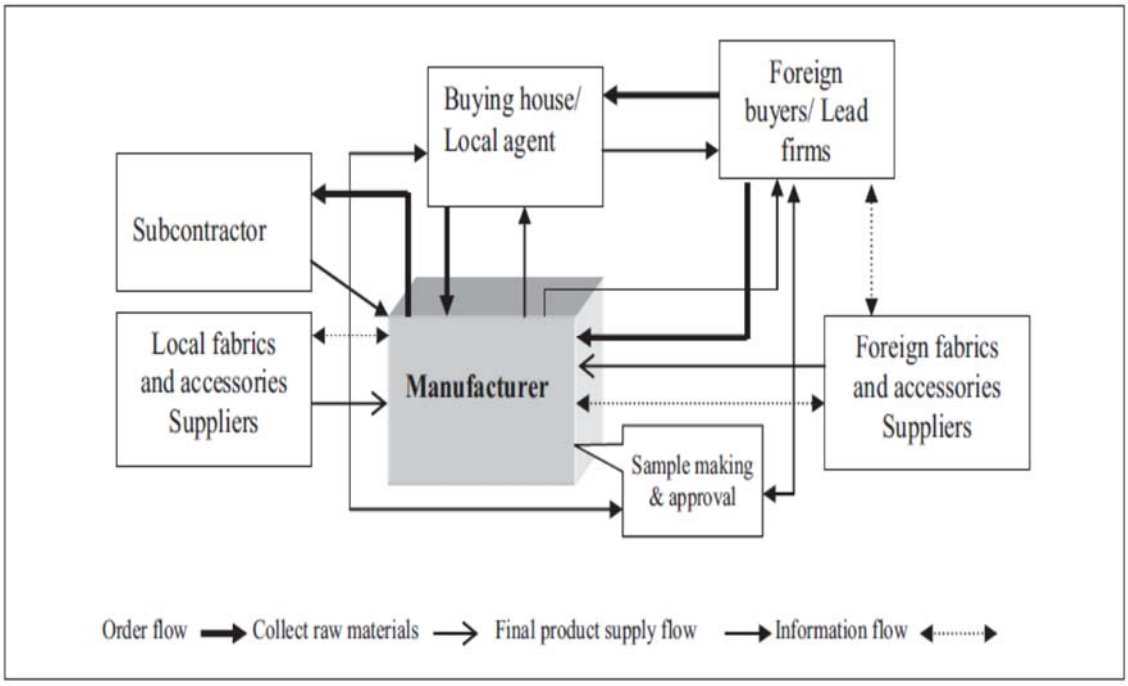


Figure 2.1: The apparel supply network of Bangladesh Source: Nuruzzaman (2007)

The apparel industry has grown by over 15% per year over the past decade. The export earnings from the apparel industry were barely US$1 million in 1978, whereas they rose to US$8 billion in 2006 and US$19.90 billion in 2011 which has marked the country as the second largest apparel exporter in the world (BGMEA 2012). Despite its huge growth in the last couple of decades, the apparel industry in Bangladesh is facing a crisis situation owing to myriads of challenges such as lacking backward linkages, possible trade diversion from various regional trade agreements, production of low value-adding products, non-compliance of social and environmental issues, infrastructure constraints, political instability, utility disruptions and other operational disruptions (Nuruzzaman 2009; Ahmed 2009; Islam, Bagum and Choudhury 2012). Ahmed (2009) further mentions that most of Bangladesh's apparel exports are made from imported textiles. The domestic textile industry cannot fulfil the growing need for the raw materials needed in the apparel industry. Moreover, the apparel exports from Bangladesh are highly concentrated on a few products as only nine categories constituted 60% of Bangladesh's apparel exports. In addition, a number of studies (Islam and Deegan 2008; Haider 2007; Nuruzzaman, Haque, and Rafiq 2010) discuss labour unrest for the violation of human rights, poor wages, hazardous working environment, environmental pollution, political instability, interruption in utility supply especially power shortages, inefficiency in customs and port management, exchange rate fluctuations, warehousing problems, disruption in supply of fabrics and other accessories, increased competition, inefficiency in operation, lack of backward linkages and other disruptions.

Islam, Bagum and Choudhury (2012), and Uddin and Jahed (2007) identify a number of operational disruptions in the apparel supply chain of Bangladesh which are: shortage of raw materials, defective raw materials, equipment failure, absenteeism, machine malfunction, unexpected work in process (WIP), defective products, quick changeover in production schedule, stalemate for labour strikes, production shutdown caused by political action and power supply problems.

With regard to infrastructural vulnerabilities, Rahman (2007), Nuruzzaman, Chowdhury, and Quaddus (2013) state that weak and inadequate infrastructures such as poor port facilities, port congestion, land transportation problems and inefficiency of customs documentation processes often create barriers in apparel supply chain functions. These vulnerabilities are the major causes of lead-time variability while lead time is a critical success factor in the fashion industry due to the shorter life cycle of fashion products. In this regard, shortening the lead time is the most crucial factor for

Bangladesh. The average lead time was 60-80 days for knit wear firms in Bangladesh whereas in China it is 40-60 days and in India it is 50-70 days (Haider 2007). Apart from the longer lead time, the existing disruptions are also creating a number of negative consequences such as increased cost of production, product quality problems and dissatisfaction of the buyers (Islam, Bagum, and Choudhury 2012; Rahman 2007).

Among other vulnerabilities, the violation of social and environmental codes is very sensitive. The violation of social and environment issues in apparel factories of Bangladesh is often the cause of concern to the buyers, non-governmental organizations (NGOs), government, media and other stakeholders. The recent incidents of the fire at the Tazreen Fashion factory killing over 112 workers and the Rana Plaza building collapse killing over 1100 people have caught the attention of international media (Fibre2fashion News Desk 2013). For example, *Washington Post* headlined the former incident as "THE TRAGEDY: A garment-factory blaze in Bangladesh this Saturday killed at least 112 people" (www.washingtonpost.com). The world's largest fashion site, Fibre2fashion, posted that more than 120 workers were killed in the Tazreen Fashion factory in the recent fire and that two years ago a transformer blast killed at least 117 people at a clothing factory in Dhaka. It also mentioned that over 500 people have lost their lives in fires at various apparel units across Bangladesh in the last 5-6 years (Fibre2fashion News Desk 2013). The international buyers (retail chains) are criticized by the media and consumer groups due to sourcing from non-compliant factories and compromising social and environmental quality to reduce cost. For example, Wal-Mart was criticized for sourcing from companies with a low safety standard after the death toll due to the building collapse and fire incidents. This is a huge loss of reputation for both Wal-Mart and the apparel industry of Bangladesh. Non-compliance of social and environmental issues is also one of the vital factors for operational disruption. For example, failure to pay minimum standard wages and provide benefits to workers often creates labour unrest in apparel factories of Bangladesh which ultimately hampers the production process. Such disruptions increase the lead time and ultimately affect the international buyers with regard to the time they have to market their products compared to their competitors.

From the above argument, it is apparent that the vulnerabilities in the apparel supply chain of Bangladesh are no longer confined to the national borders but rather affect the whole supply chain in the national and international arena. These disruptions need to be mitigated immediately because they are threatening the sustainability of the industry and the whole supply chain (Haider 2007). In this context, consistent with

Ponomarov and Holcomb (2009) it is urgent to develope resilience capability in order to mitigate the vulnerabilities and to achieve sustainability. In a similar fashion, a number of studies have discussed the mitigation capabilities needed to address the apparel supply chain vulnerabilities. For example, Haider (2007) mentions developing domestic backward linkages with the aim of reducing production and distribution time, improvements of social and environmental compliance, and focusing attention on the diversification of product and market composition. Similarly, Ahmed (2009); Nuruzzaman, Haque and Rafiq (2010) and others mention the need for forward and backward linkages; product differentiation; multiple sources of supply; channel rerouting to avoid late delivery; maintaining reserve capacity; quality control and reducing the defect rate; skill and efficiency development; product and process improvement; forecasting and predictive analysis to trace the uncertainties; responsiveness to the customer; and compliance of social and environmental issues. They also asserted other aspects such as internal and external integration; cooperation; communication and building relationships with buyers and suppliers; monitoring workers' rights in factories; locating and positioning in new markets; better infrastructure facilities; and more. Despite the substantial work in the literature on the vulnerability of the apparel industry and the strategies to overcome this vulnerability, empirical studies to validate these findings are absent. Therefore, there is an urgent need for research in this field to enhance the knowledge base and to ensure the sustainability and resilience of the industry. It is noteworthy that long-term sustainability in the apparel supply chain is very necessary owing to its enormous economic importance in the economy of Bangladesh. Therefore, identifying supply chain vulnerabilities and corresponding resilience capability development are emerging as approaches to make the supply chain resilient and sustainable.

2.3 SUPPLY CHAIN

The supply chain (SC) is a complex operational concept which is related to almost all functional business areas (Mentzer, Stank, and Esper 2008). Although many authors define the concept of supply chain management (SCM), still there remain ambiguities in clarifying different domains of the supply chain (Mentzer et al. 2001; Mentzer, Min, and Bobbitt 2004; Frankel et al. 2008). Lambert, García-Dastugue and Croxton (2008) define SCM as the integration of key business processes across the supply chain for the purpose of creating value for customers and stakeholders. A supply chain is "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a

source to a customer" (Mentzer et al. 2001, p. 4) Here, the term "upstream flows" refers to all the activities starting from raw material procurement planning to production and "downstream flows" refer to all the activities after production including distribution, transportation and customer service. In a similar vein, Pettit, Fiksel and Croxton (2010) define supply chain as the network of companies involved in the upstream and downstream flows of products, services, finances and information from the initial supplier to the ultimate customer.

Management of the supply chain is crucial especially in the event of continual turbulence and unpredictability. Therefore, supply chain management must consider the environmental uncertainties in decision making on every aspect of planning, sourcing and procurement, conversion and all logistics management activities. Risk management is now indispensable in the supply chain for accomplishing the value creation and delivery process in a highly disruptive business arena. Therefore, researchers such as Blos et al. (2009); Jüttner and Maklan (2011); and Pettit, Croxton and Fiksel (2013) posited the emergence of risk management and resilience in SCM.

2.4 SUPPLY CHAIN DISRUPTIONS AND VULNERABILITY

In the contemporary world, maintaining an effective supply chain has become challenging as supply chains are facing overwhelming complexities and unexpected disruptions. The frequent disruptions and the resultant complexities have triggered the importance of supply chain vulnerability (SCV) research. Despite the importance of research on vulnerability, the concept of supply chain vulnerability is still immature and has not been explored far (Svensson 2000; Wagner and Bode 2006). Therefore, it is important to unearth the issues related to supply chain vulnerability so as to facilitate the process of developing a resilient supply chain.

In supply chain management literature, the terms "disruption" and "vulnerability" are sometimes used interchangeably; however, there are some differences between them. While a supply chain disruption is the state of affairs that leads to the occurrence of risk, SCV is the consequence or final result. More specifically, disruption is the relevant source of the harmful consequences which lead to the concept of supply chain vulnerability (Wagner and Bode 2006). Supply chain vulnerability can be defined as the unexpected deviations from the norm and their negative consequences (Svensson 2002). Similarly, with reference to Blos et al. (2009) and Sheffi and Rice (2005), vulnerability can be regarded as a combination of the likelihood of an event and its potential severity. This conceptualization is also supported by authors such as Pettit,

Croxton and Fiksel (2013); Jüttner and Maklan (2011); Christopher and Peck (2004); and others. For example, Jüttner and Maklan (2011) emphasise the impact of disruptive events in order to address the term "vulnerability". In this research, the concept of supply chain vulnerability is used as the impact of any disruption on the supply chain if it occurs.

Vulnerability in the supply chain occurs due to the multiplicity of different risk drivers. A number of current business trends are responsible for the higher frequency and intensity of vulnerability in supply chains such as: more intense use of outsourcing of manufacturing and research and development (R&D) from distant suppliers; increased globalization of supply chains; consolidation of the supplier base; demand for more integrated processes between companies; reduced buffers with respect to inventory and lead time; increased demand for on-time deliveries and shorter lead times; shorter product life cycles and compressed time-to-market; and capacity limitation of key components (Norrman 2004; Trent and Monczka 2002; Blackhurst et al. 2005). Apart from these, other studies (Wagner and Bode 2006; Svensson 2004; Jüttner 2005; Peck 2005; Zsidisin, Melnyk, and Ragatz 2005) focus on customer dependence, supplier dependence, supplier concentration, single sourcing and global sourcing as the drivers of supply chain vulnerability. Although the literature on SCV discusses different drivers of supply chain disruptions and their impacts, empirical studies to assess the dimensions of SCV are scarce which is one of the motivations to conduct this study.

2.4.1 Supply chain vulnerability (SCV) dimensions and measurement

Supply chain vulnerability (SCV) is a multifaceted and multidimensional construct (Wagner and Bode 2006). Previous studies (Mitroff and Alpaslan 2003; Kleindorfer and Saad 2005; Blackhurst et al. 2005; Blos et al. 2009) contend that, among the many different types of vulnerabilities, some examples are delays during transportation, port stoppages, frequent occurrence of natural disasters, weak communication, supply shortages, demand volatility, quality problems, operational issues and terrorism. Pettit, Fiksel and Croxton (2010) consolidated 39 disruptive events to seven dimensions. In a similar fashion, Blos et al. (2009) refer to the dimensions of hazard, strategic, operational, financial and demand–supply vulnerability to exemplify the concept of SCV. On the other hand, Kleindorfer and Saad (2005) classified three dimensions of SCV: firstly, operational which includes equipment malfunctions and systemic failures, abrupt discontinuity of supply, bankruptcy, fraud or labour strikes; secondly, natural hazards which include earthquakes, hurricanes and storms; and thirdly, terrorism or political instability. Similarly, Peck (2005); Christopher and Peck (2004); Sheffi and

Rice (2005); and others discuss supply chain vulnerabilities which is presented in Table 2.1. It is apparent that there are a number of studies focusing on different dimensions of SCV; however, empirical evidence on the measurement of the multidimensional SCV construct is very rare. Although the study of Wagner and Bode (2006) embraces the measurement of the demand side, supply side and catastrophic vulnerabilities, several important dimensions of SCV such as financial, strategic, operational and infrastructural vulnerabilities and others have not been integrated in the study. Most of the studies (e.g. Blackhurst, Scheibe, and Johnson 2008; Peck 2005; Kleindorfer and Saad 2005; Stecke and Kumar 2009) use either conceptual or descriptive analysis of SCV dimensions without statistical validation of the dimensions. Empirically validated and integrated measurement for a multidimensional model of SCV is still scarce. Therefore, there is a demand for scholarly investigation on developing a valid multidimensional measurement of supply chain vulnerability.

Table 2.1: Dimensions and sub-dimensions of SCV

Dimensions	Sub-dimensions	References
HV	Natural disaster (flood, cyclone, endemics such as SARS, evian flu etc.)	Christopher and Peck (2004); Sheffi and Rice (2005); Kleindorfer and Saad (2005); Schoenherr, Rao Tummala and Harrison (2008); Wu, Blackhurst and Chidambaram (2006).
	Fire and other accidental damage	Blos et al. (2009); Stecke and Kumar (2009).
	Labour unrest, terrorism, industrial espionage, theft and other human actions	Peck (2005); Pettit, Fikesl and Croxton (2010); Pettit, Croxton and Fiksel (2013); Kleindorfer and Saad (2005); Wu, Blackhurst and Chidambaram (2006); Blos et al. (2009).
	Political instability	Peck (2005); Kleindorfer and Saad (2005); Blackhurst, Scheibe and Johnson (2008); Blos et al. (2009).
SV	Increased competition	Haider (2007); Schoenherr, Rao Tummala and Harrison (2008); Blos et al. (2009).
	Problem of relationship with buyer and supplier	Blos et al. (2009).
	Problem of integration and real-time information	Gaudenzi and Borghesi (2006).
FV	Currency fluctuation	Blos et al. (2009); Peck (2005); Manuj and Mentzer (2008).
	Economic recession	Blos et al. (2009); Xu (2008).
	Raw material price fluctuation	Blos et al. (2009); Xu (2008).
	High bank interest and funds shortage	Blos et al. (2009).
	Bankruptcy or credit default of any supply chain member	Blos et al. (2009); Blackhurst, Scheibe and Johnson (2008); Manuj and Mentzer (2008).
OV	Fault in production planning and inventory management	Wu, Blackhurst and Chidambaram (2006).
	Failure of IT system and machinery	Blos et al. (2009).
	Disruption in utility supply	Blos et al. (2009).

	Product quality defect	Blos et al. (2009).
IV	Delay in custom clearance	Colicchia, Dallaria and Melacini (2010).
	Delay from congestion and inefficiency in port	Colicchia, Dallaria and Melacini (2010); Blackhurst, Scheibe and Johnson (2008).
	Strike by port workers	Colicchia, Dallaria and Melacini (2010).
	Delay in transportation from poor infrastructure	Blackhurst, Scheibe and Johnson (2008).
DSV	Suppliers' delay and disruptions	Blackhurst, Scheibe and Johnson (2008); Ponomarov and Holcomb (2009).
	Lack of alternatives for critical items	Craighead et al. (2007).
	Defect/non-conformity of material	Blackhurst, Scheibe and Johnson (2008).
	Buyers' disruptions and opportunism	Ponomarov and Holcomb (2009); Pettit, Croxton and Fiksel (2013).
	Demand fluctuation	Wu, Blackhurst and Chidambaram (2006); Bansal et al. (2005).
	Suppliers' opportunism	Ponomarov and Holcomb (2009).

HV=Hazard vulnerability, SV=Strategic vulnerability, FV=Financial vulnerability, OV=Operational vulnerability, IV=Infrastructural vulnerability, DSV=Demand–supply vulnerability.

As depicted in Table 2.1, supply chain vulnerability is a multidimensional concept comprised of a number of dimensions such as hazard vulnerability, strategic vulnerability, and operational, financial and demand–supply vulnerability. Different dimensions of supply chain vulnerability are detailed in the following sub-sections.

2.4.1.1 Hazard vulnerability

Hazard vulnerability arises from both internal risk drivers such as malicious actions of human beings and external risk drivers such as natural disasters in the form of floods, cyclones, fires, etc. (Blos et al. 2009; Blackhurst, Scheibe, and Johnson 2008). Vulnerabilities that occur due to externalities and uncontrollable factors are difficult to predict and result in frequent changes of outcomes (Pettit, Fiksel, and Croxton 2010). On the other hand, vulnerabilities that occur due to human actions may often occur in the form of terrorism, theft, union action such as labour strikes, destruction of premises by workers, political instability, industrial espionage and product liability claims (Pettit, Fiksel, and Croxton 2010, Blackhurst, Scheibe, and Johnson 2008). Biological risk factors such as avian flu, SARS (severe acute respiratory syndrome), and foot and mouth disease are now an added factor in supply chain vulnerability especially when export–import through the port is restricted to protect against the spread of diseases (Pettit, Fiksel, and Croxton 2010). Outbreaks of foot and mouth disease in Europe and of SARS in Asian countries have led to such disruptions being experienced in the supply chain (Christopher and Lee 2004; Jüttner 2005). Hazard vulnerabilities are unavoidable but the intensity of these vulnerabilities can be reduced by taking actions that are proactive rather than reactive. For example, disruptions

arising from suppliers can be mitigated by maintaining alternative suppliers (Pettit, Croxton, and Fiksel 2013).

2.4.1.2 Strategic vulnerability

Strategic vulnerability results from the selection of wrong strategy or delay in strategic decision during crisis in supply chain. For example, delay in strategic decision of Ericsson's decision makers during fire on supplier's plant result in mutli-million dollar loss of the company (Norrman 2004). Strategic vulnerabilities may also arise from supply chain relationships, introduction of new methods and systems, supplier decisions, technology decisions, competition and any other strategic concern of the company (Blos et al. 2009). The production process is delayed and sometimes, in the worst case, the whole production lot is scrapped due to such vulnerabilities (Blos et al. 2009). These vulnerabilities need to be handled with care. Corrective actions and rework decisions can reduce the intensity of such vulnerabilities. Simons (1999) suggest for interactive control systems that drives managers to engage in conversations about strategic vulnerabilities – i.e. enforced cooperation, visibility and awareness. Cooperation with supply chain members, increased visibility and awareness help to select right strategy during disruptions in the supply chain and thus, reduce the strategic vulnerabilities.

2.4.1.3 Financial vulnerability

The cash flow in the supply chain is obstructed by different financial complexities and disruptions. Credit default or bankruptcy of supply chain members, raw material price fluctuation, exchange rate fluctuation, financial market instability, higher interest rate and economic recession are some of the significant drivers of financial vulnerability (Blos et al. 2009; Pettit, Croxton, and Fiksel 2013). Raw material price fluctuation in both domestic and international markets is a common phenomenon in international business and it has substantial influence on final product pricing. Similarly, exchange rate fluctuation also has an impact on raw material price and the final product price. Forecasting the ups and downs in material market price, back up system, collaborative relationships and information sharing with the supply chain partners are all important to mitigate these sorts of vulnerabilities (Kleindorfer and Saad 2005). For example, a good relationship with supply chain partners helps in sharing the risk of loss arising from raw material and exchange rate fluctuation.

2.4.1.4 Operational vulnerability

Operational vulnerability occurs in the form of operators' errors, shortage of raw material, loss of important employees, switching and absenteeism of employees, IT system failure, theft, non-conformity of quality, paucity of skilled workers, disruption in utility supply, etc. (Blos et al. 2009; Pettit, Fiksel, and Croxton 2010). Operational disruptions incur both cost and time. For example, acute power crises in Bangladesh interrupt the production processes in apparel manufacturing companies which results in a longer production lead time than estimated. Companies need to keep back-up generators to run production but this increases production cost (Ahmed 2009). Operational vulnerabilities may be the cause of a huge loss for a company and its supply chain if these are not handled properly and in the appropriate time. Failure to do so may result in significant supply chain delays magnifying the rate of stock-outs, customer dissatisfaction cost due to longer waiting time (Rice and Caniato 2003) and other consequences. The buyer may even deny receiving the product due to the quality issue or due to the delay in shipment (Blos et al. 2009). Research of Hendricks and Singhal (2003) reveals that the announcement of supply chain disruptions such as operational issues or delays in shipment cause significant decrease in shareholder value. Therefore, the significance of this issue certainly deserves attention from supply chain researchers. To mitigate the operational vulnerabilities, a number of strategies such as flexibility, quality control, skill development training, ensuring workers' satisfaction, back-up utility source and reserve capacity are useful (Pettit, Fiksel, and Croxton 2010; Duclos, Vokurka, and Lummus 2005;Suresh and Braunscheidel, 2009).

2.4.1.5 Infrastructural vulnerability

Infrastructural vulnerability arises from poor infrastructure facilities or from inefficient management of infrastructural facilities. It may be in the form of delays in the port, problems in the customs documentation process, poor land transportation network, etc. (Colicchia, Dallaria, and Melacini 2010; Nuruzzaman 2009). A number of studies such as Colicchia, Dallaria and Melacini (2010); Blackhurst, Scheibe and Johnson (2008); Nuruzzaman (2009, 2013); and others identify infrastructural problems as the drivers of supply chain vulnerability. Critical situations may also arise when problems occur during the transportation process, for example, a labour strike in the major port or a capacity bottleneck in the port that create congestion of containers and delays of product flow (Blackhurst et al. 2005). If there are no alternative transportation arrangements to avoid disruption on a particular mode of transportation, the suppliers fail to meet the lead time promised to the buyers. The

consequence of such delay may even lead to loss of the order and cancellation of the whole shipment (Islam, Bagum and Rahed 2012). Vulnerability due to lead-time volatility is quite common in the case of apparel supply from Bangladesh (Nuruzzaman 2009, 2013; Ahmed 2009). Aligned with this, they addressed the issue of poor infrastructure for its effect on supply chain delay and disruption.

2.4.1.6 Demand and supply vulnerability

Demand and supply disruptions are quite common and major sources of supply chain vulnerabilities (Christopher and Peck, 2004; Pettit, Fiksel, and Croxton 2010). These disruptions occur from both the suppliers' and customers' end. Supply disruptions refer to the unpredictable nature of the quantity supplied and the variation of timing in supply. They may occur due to the shortage of raw material, quality problems of the material supplied, suppliers' opportunism and delay (Wagner and Bode 2008; Pettit, Fiksel, and Croxton 2010). They may also occur due to manufacturing downtime, non-conformance of quality, production problems, forecasting error or logistical failure (Walker and Weber 1987). To Svensson (2000, 2002), inbound supply disruptions may occur due to the supplier's equipment failure, labour issues, weather conditions, etc. The need for on-time, in-full and defect-free supply is essential in the supply chain; otherwise, the production process is hampered which may affect the whole chain.

Supply chain managers should also pay attention to vulnerability arising from demand-side or customer-side disruption. Demand uncertainty arises due to the volatility of demand and forecasting errors (Bartezzaghi and Verganti 1995; Enns 2002). As customers' demand is stochastic and uncertain, supply chains often experience a bullwhip effect if information flow is not streamlined. Failure to cope with demand uncertainty either creates excess inventory or a bottleneck of stock and the resulting customer dissatisfaction (Verbeke, Farris, and Thurik 1998).

2.4.2 Vulnerability mitigation

Vulnerability mitigation is an issue of interest in the domain of supply chain risk management and resilience. Scholars suggest that mere risk management techniques are not enough; rather, supply chains need a proactive approach to develop adaptive capability which is an essential attribute of the resilience of a supply chain (Jüttner and Maklan 2011). Mitigation of supply chain vulnerability is challenging but necessary. Sometimes a minor issue may create a several million dollar loss to the supply chain partners.

For instance, the problem of diesel injection pumps supplied by Robert Bosch GmbH to some of the auto manufacturers (Audi, BMW and DaimlerChrysler) resulted in a product recall of several thousand cars. But, by digging deeper, the problem was found to be due to the Teflon coating on a 1.5 cm small socket (worth only a few Eurocents) in the pump. The socket was not produced by Bosch but by its US supplier Federal Mogul which in turn sourced the Teflon from DuPont (Wagner and Bode 2006). To mitigate vulnerabilities, it is important to identify the root causes and to measure the intensity of vulnerabilities. Authors suggest a number of resilient approaches to mitigate vulnerability in the supply chain. For example, firms need to have flexibility to adjust to the demand volatility and to mitigate demand-side disruptions (Pettit, Fiksel, and Croxton 2013). Collaboration with suppliers is also important to reduce demand disruptions (Austin and Reficco 2009). The studies of Pettit, Croxton and Fiksel (2013); Sheffi and Rice (2005); and Blos et al. (2009) are also notable with reference to the vulnerability mitigation approaches.

2.5 CONCEPT OF RESILIENCE FROM MULTIDISCIPLINARY PERESPECTIVES

Before discussing supply chain resilience, it is important to understand the origin and evolution of resilience. The concept of resilience has been used widely for many years in non-business disciplines such as ecology, psychology, engineering and economics. Eventually, it was adopted in the management literature in areas such as disaster management, supply chain risk management, etc. Therefore, the multidisciplinary aspects of resilience need to be discussed in the light of various streams of the literature such as ecology, psychology and engineering, and from the perspectives of new areas such as disaster management, from the organizational aspect and in the area of supply chain risk management.

2.5.1 Resilience in ecology

In ecology, Holling (1973) was one of the primary researchers to echo the concept of resilience as the ability of a system to absorb changes and to achieve a state of equilibrium. In line with this, Westman (1978) refers to resilience as the ability of an ecosystem to return to its original state after disturbance. Gunderson (2000) explains ecological resilience as the magnitude of disruption that a system can absorb before changing its structure. In the previous studies of ecological science, different terms such as elasticity, malleability, amplitude, hysteresis and damping are attributed to define resilience (Westman, 1986). Fiksel (2003) identifies four characteristics of resilience: diversity, efficiency, adaptability and cohesion, while Carpenter et al. (2001)

enumerate three important properties of resilience: i) the amount of change that a system can undergo without losing its functional ability; ii) the degree to which the system is capable of organizing itself without disorganization; and iii) the degree to which a system develops the capacity to learn and adapt after disruption. In fact, in most of the ecological science studies, the implicit concept of stability prevails when referring to resilience.

2.5.2 Resilience in psychology

There is a wide range of literature on the psychological perspective of resilience. In psychology, resilience was first echoed in the study of Garmezy and Masten (1986) in which resilience was explained as a quality of children to absorb stress against a hostile environment. Studies on psychology reveal that the most widely discussed area of resilience is developmental psychopathology which deals with an analysis of developmental differences in people's response to stress and adversity (Ponomarov and Holcomb 2009). In psychopathology, resilience is addressed as the capacity for successful adaptation, positive functioning or competence (Egeland, Carlson, and Sroufe 1993). The psychological principles of resilience: i) control, ii) coherence and iii) connectedness, developed by Reich (2006), are now widely used in other disciplines when referring to resilience. For example, considering the psychological principles of coherence, control and connectedness, resilience models are being developed in disaster management supply chain management (Ponomarov and Holcomb 2009).

2.5.3 Resilience in engineering

Engineering resilience suggests maximising the efficiency of the resilience effort of a system to return to the desired state (Erol, Sauser, and Mansouri 2010). In engineering, the very basic and widely used definition of resilience is "the tendency of a material to return to its original shape after the removal of a stress that has produced elastic strain" (Merriam-Webster 2007, P. 1340). Similarly, Gibbs (2009) indicates that resilience is the ability of the system to withstand disruption and to recover to maintain the same functionality. This definition also emphasises the popular concept of going back to the original state after the situation becomes normal. Gunderson and Pritchard (2002) describe engineering resilience as the speed of return to the stable condition after a perturbation. This implies the efficiency of a system.

2.5.4 Resilience from the organizational perspective

Resilience has gained popularity in just over a decade in relatively new fields of research such as disaster management, from the organizational aspect and in the supply chain risk management area (Ponomarov and Holcomb 2009). From the organizational aspect, resilience is mostly termed as the capacity to recover from disruptive events and to reduce the adverse effect on the organization. For example, Fiskel (2006) describes resilience as the capacity of an organization to survive, adapt and grow in the face of turbulence. A recent study by Lengnick-Hall, Beck and Lengnick-Hall (2011) refers to organizational resilience as the firm's ability to effectively absorb and develop situation-specific responses to disruptive events. According to Mitroff and Alpasan (2003), resilient organizations are proactive and recover better from adversity. Along with recovery, they emphasised having flexibility and adaptability to both the positive and negative influences of environmental uncertainty. In line with this, Hamel and Valikangas (2003) stress that resilience is not only concerned with recovery but also focuses on flexibility and readiness that corresponds to the disruptions. According to Ponomarov and Holcomb (2009), the emphasis in the organizational perspective of resilience is on some important attributes such as adaptability, flexibility, maintenance and recovery. Similarly, in explaining the characteristics of resilient enterprises, Erol, Sauser and Mansouri (2010) mention the capabilities of flexibility, redundancy, adaptability, connectivity and agility. The attributes of resilient organizations are similar to the resilient supply chains as resilient supply chains are based on the attributes of resilient organizations (Pettit, Fiksel, and Croxton 2010).

2.6 SUPPLY CHAIN RESILIENCE (SCR)

2.6.1 Concept and definition of SCR

Resilience in the supply chain is derived from supply chain risk management (SCRM) which has evolved from the intersection of supply chain management and risk management (Blos et al. 2009). Jüttner, Peck and Christopher (2003) define SCRM as the efforts toward identifying potential sources of risk and implementing appropriate strategies through coordinating the supply chain members, in order to reduce supply chain vulnerability. Supply chain resilience is derived from SCRM and is embedded in the efforts of risk management (Jüttner and Maklan 2011). The apparent ability of some supply chains to recover from uncertainties more effectively than others has triggered the urgency of supply chain resilience. While SCRM pays attention to the

identification and management of risks, SCR aims at developing the adaptive capability to prepare for unexpected events and to respond to and recover from disruptions (Jüttner and Maklan 2011; Ponomarov and Holcomb 2009).

In supply chain management, research on resilience is still in its infancy and unexplored (Ponis and Koronis 2012; Ponomarov and Holcomb 2009). In fact, impetus for the concept in the supply chain domain has only been over recent years (Falasca, Zoble, and Cook 2008). More specifically, research on supply chain resilience gathered pace after the incidents of transportation disruption in the United Kingdom (UK) during 2000 and the outbreak of foot and mouth disease at the beginning of 2001. After that, the studies of Christopher and Peck (2004), and Sheffi and Rice (2005) laid the foundation of supply chain resilience research. Recently, a number of studies such as those by Ponomarov and Holcomb (2009); Jüttner and Maklan (2011); and Pettit, Fiksel and Croxton (2010, 2013) have enriched the concept of supply chain resilience. Studies reveal that the attributes of supply chain resilience are adapted from multidisciplinary aspects as SCR is a multidisciplinary and multidimensional phenomenon (Ponomarov and Holcomb 2009). Although commonly accepted definitions of resilience can be found in other disciplines, the construct "resilience" lacks clarity in the tenets of supply chain management (Ponomarov and Holcomb 2009). In supply chain management, the first concise definition of resilience was proposed by Christopher and Peck (2004) as being the "capacity of a supply chain to cope with the consequences of vulnerabilities and to get back to its original state or an even more desirable state once it is disrupted". This definition was also supported by Pettit, Fiksel and Croxton (2010). In the period between Christopher and Peck's (2004) definition to now, a number of researchers have defined SCR from different aspects.

A comprehensive idea about SCR can be obtained from the definition of Ponomarov and Holcomb (2009, p. 131) stating that "Resilience is an adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function". Supply chain resilience (SCR) emphasises the system's adaptive capability to mitigate temporary disruptive events (Briano, Caballini, and Revetria 2009; Smith 2004). In the study of Sheffi and Rice (2005), resilience of the supply chain has been designed corresponding to the three distinct phases of disruptive events: "readiness", "responsiveness" and "recovery". Moreover, the system's response and recovery time has been used as the attribute of resilience in different studies (Hamel and Välikangas 2003; Mitroff and Alpaslan 2003).

It can also be argued that the concepts of response and recovery are interrelated and cannot be treated separately. For example, quick response is essential for quick recovery and efficiency. Craighead et al. (2007) and Falasca, Zoble and Cook (2008) refer to SCR with respect to it being a supply chain design property. Therefore, SCR can be comprehended by the following attributes: supply chain capability, supply chain design, and supply chain readiness, response and recovery. Based on the concept of SCR in previous studies, this study embraces SCR as "the attribute of a supply chain to exhibit certain capabilities such as flexibility, redundancy, integration, efficiency, market and financial strength as well as ensuring quick readiness, response and recovery from crisis through a well-controlled and connected supply chain design for achieving long-term sustainability in the supply chain".

2.6.2 Importance of supply chain resilience

Supply chains need to develop tangible and intangible capabilities to mitigate disruptions efficiently and effectively (Christopher and Peck 2004, Pettit, Fiksel, and Croxton 2010). Incidents such as the sudden volcanic eruption in Iceland have made companies aware of how little control they have over many of the risk events (Jüttner and Maklan 2011). Failure of companies and their supply chains to develop resilience in time has a devastating consequence on the whole chain. For example, in 1996, General Motors experienced an 18-day labour strike at a brake supplier factory that left workers idle at 26 assembly plants with an estimated reduction in quarterly earnings of $900 million (Blackhurst et al. 2005). Similarly, a late response during a fire in the supplier's plant of Ericsson in New Mexico accounted for a huge loss of $400 million (Norrman 2004). Failure to mitigate disruptions also has a tremendous impact on the stock market. For example, a study found that at the time a disruption is announced, the average shareholder return immediately drops 7.5% (Hendricks and Singhal 2003). Moreover, the implication of vulnerability on one supply chain entity and the consequence on other entities was vividly evidenced during the global financial crisis (Jüttner and Maklan 2011). Therefore, SCR is essential to offset the vulnerabilities in the supply chain.

2.7 ANTECEDENT AND MEASUREMENT CONSTRUCT OF SCR

Managing supply chain disruption is a critical success factor for supply chain managers. Organizations need a proactive and resilient approach to combat the challenges arising from turbulent changes and disruptions (Jüttner and Maklan 2011; Brandon-Jones et al. 2014) because resilience capability helps an organization to survive, adapt, and

grow during turbulent changes (Fiksel 2006). To plan possible courses of resilient actions, companies and their supply chains need to measure the magnitude of resilience inherent in the supply chain otherwise; imbalanced resilience may result in undesirable outcomes (Pettit, Fiksel and Croxton 2011). Therefore, measurement scale for SCR is essential. Despite the emergence, extant literature falls short of conceptualizing the measurement dimensions of SCR (Ponomarov and Holcomb 2009. Therefore, one of the goal of this study is to identify and measure the dimensions of SCR. To develop SCR capability it is also important to identify and improve the antecedent factors of SCR (Christopher and Peck 2004; Sheffi and Rice 2005). There are debates in the literature to properly identify the resilience measurement constructs and their antecedents (Pal, Torstensson, and Mattila 2014; Juttner and Maklan 2011). Sudies (e.g. Christopher and Peck 2004) consider supply chain risk management, agility, supply chain orientation supply chain collaboration etc. are the antecedents while others (Erol, Sauser, and Mansouri 2010; Pettit, Croxton, and Fiksel 2013) consider supply chain flexibility, redundancy, integration, readiness, responsiveness etc. as measurement constructs. However, empirical studies to differentiate and validate the measurement and antecedent factors are scarce. Therefore, in line with previous literature, paired with the validation of SCR dimensions, another goal of this study is to explore and investigate the antecedent factors of SCR and their interrelationships.

2.7.1 Measurement of supply chain resilience

Resilience is context-dependent (Carpenter et al. 2001), which infers that resilience capability requirements (what extent and what type of capability) depend on the nature of the vulnerability. Therefore, in order to develop a resilient system, it is important to assess the resilience of the system once the vulnerabilities are identified. However, an empirically validated model for SCR measurement has not yet been developed (Ponomarov and Holcomb 2009). Previous studies (Pettit, Fiksel, and Croxton 2013; Erol, Sauser, and Mansouri 2010; Jüttner and Maklan 2011; Christopher and Peck 2004; and others) argue that SCR is a multidimensional concept which can be assessed by a number of attributes such as capability, vulnerability, visibility, velocity, agility, flexibility, redundancy, collaboration, visibility, efficiency, responsiveness, supply chain design attributes, etc. However, there are debates in the literature in addressing the resilience attributes (Jüttner and Maklan 2011; Ponomarov and Holcomb 2009). Some studies consider the attributes as antecedents (Christopher and

Peck 2004) while others (Erol, Sauser, and Mansouri 2010; Pettit, Croxton, and Fiksel 2013) see them as measurement constructs.

Previous studies, for example, Craighead et al. (2007); Falasca, Zoble and Cook (2008); and Blackhurst et al. (2005) emphasize supply chain design for measuring supply chain vulnerability and resilience. It can be argued that supply chains need some important attributes during critical moments. Development of supply chain capabilities may not guarantee the resilience of a supply chain all the time but it should have the attribute of responding effectively and efficiently during a crisis. For example, despite having capabilities, a supply chain may collapse during a critical situation if it fails to respond and recover quickly. Therefore, the concept of the time taken to respond and recover is relevant and is an important aspect of resilience assessment. Based on the review of multidisciplinary literature on resilience, for example, Holling (1973) and Gunderson (2002) in ecology, and Bruneau et al. (2003) in disaster management, it is evident that recovery time is a salient component of resilience assessment. In SCR literature, the concepts of response and recovery have rightly been identified by Ponomarov and Holcomb (2009); Sheffi and Rice (2005); and Norrman (2004). Based on the above review of the literature, SCR can be ascribed as a multidimensional concept which can be measured by the dimensions of supply chain capability, supply chain design, and supply chain readiness, response and recovery. Table 2.2 provides a summary of the previous studies on supply chain resilience.

Table 2.2: Dimensions of SCR in previous studies

SCR studies	Resilience measurement factors	Study method	Research findings
Pettit, Croxton and Fiksel (2013)	Considers capability and vulnerability to measure SCR.	Mixed method	Linkage between the inherent vulnerability factors and controllable capability factors.
Pettit, Fiksel and Croxton (2010)	Considers capability and vulnerability as the dimensions of resilience.	Qualitative study	There is a positive link between supply chain capability and resilience, and a negative link between vulnerability and resilience.
Erol et al. (2010)	Considers vulnerability, and capability such as flexibility, agility and adaptability as the components of SCR.	Conceptual study	Describes the importance of integration of resources and alignment of information technology (IT) with business goals to develop a resilient system. They also consider the need for flexibility, agility and adaptability in this regard.
Ponomarov and Holcomb, (2009)	Logistical capabilities for supply chain readiness, response and recovery with necessary control, coherence and connectedness.	Conceptual study	Antecedents of SCR from logistical perspective, and their link with logistical capabilities, and the outcome of resilience as a source of competitive advantage.

Falasca et al. (2008)	Measures resilience based on supply chain design factors such as supply chain density, complexity and criticality.	Conceptual study	Relationship between supply chain disruptions and supply chain design principles.
Sheffi and Rice (2005)	Considers flexibility, redundancy and responsiveness as the components of SCR. They also show a disruption profile based on different stages of readiness, response and recovery.	Conceptual study	An organization's ability to recover from disruption depends on readiness, quick response, flexibility and redundancy.
Christopher and Peck, (2004)	Supply chain engineering, risk management and supply chain capabilities such as collaboration and agility and supply chain design as the antecedents of SCR.	Conceptual study	A resilient supply chain can be created by risk management, supply chain re-engineering, supply chain collaboration and agility.
Jüttner and Maklan (2011)	Flexibility, velocity, visibility and collaboration as the measurement components of SCR.	Case study	Relationship between supply chain vulnerability, risk management and supply chain resilience.

It appears from Table 2.2 that there is a lack of commonality and agreement on the conceptualization and the measurement of SCR attributes. The differences and debates with regard to resilience measurement and the lack of comprehensive empirical research on a SCR measurement model are likely to propel the issue of SCR measurement into the forefront of supply chain risk management literature. This study considers a number of resilience attributes from multidisciplinary aspects to develop a comprehensive concept of SCR which is reflected by the dimensions: supply chain capability, supply chain design, and supply chain readiness, response and recovery. In this research SCR is defined as "the attribute of a supply chain to exhibit certain capabilities such as flexibility, redundancy, integration, efficiency, market and financial strength as well as ensuring quick readiness, response and recovery from crisis through a well-controlled and connected supply chain design for achieving long-term sustainability in the supply chain." Here, the supply chain capabilities, that is, flexibility, redundancy, efficiency and integration, together with the planned design of the supply chain, can ensure the necessary control and connectedness in the system. For example, intra- and inter-organizational information integration and supply chain flexibility as well as risk-reducing supply chain design such as provision for alternative sourcing, production and distribution help to establish proper control and connectedness in the supply chain for smooth completion of scheduled supply chain functions. The definition also exerts the importance of the attributes of supply chain readiness, response and recovery during the disaster and at critical moments.

2.7.1.1 Supply chain capability

Supply chains need to have capabilities to create resilience against disruptions (Pettit, Fiksel, and Croxton 2010; Christopher and Peck 2004) as resilience is the capacity of a supply chain to get back to its original state after disruption (Christopher and Peck 2004). The term "capabilities" refers to the role of management to respond to the environmental factors by adapting, integrating and reconfiguring resources, organizational skills and functional competencies (Teece, Pisano, and Shuen 1997). According to Pettit (2008), capabilities are attributes that enable an enterprise to predict and overcome disruptions. Aligned with the spirit of the RBV, to overcome environmental uncertainties, organizations need to develop dynamic capabilities (Wernerfelt 1984). In uncertain conditions, dynamic capabilities are difficult to sustain and resilience is essential in such conditions to achieve sustainability (Eisenhardt and Martin 2000). Studies on the supply chain have emphasised different capabilities such as: flexibility, redundancy, adaptability, collaboration, visibility, market position, financial strength, diversity, efficiency and control to measure resilience (Pettit, Fiksel, and Croxton 2010; Sheffi and Rice 2005; Fiksel 2003; Ponomarov and Holcomb 2009). In addition, Jüttner and Maklan (2011) selected flexibility, velocity or speed of response, visibility and collaboration to characterize supply chain resilience. Table 2.3 shows the summary of the different capabilities mentioned by the previous studies.

Table 2.3: Supply chain capability dimensions

Dimensions	Variables	References
Flexibility	Flexibility in production (different volume of orders, flexible production schedule)	Duclos, Vokurka and Lummus (2005); Braunscheidel and Suresh (2009); Tomlin (2006).
	Ability to modify a wide variety of products as per buyer requirements (mix flexibility)	Braunscheidel and Suresh (2009); Handfield and Bechtel (2002).
	Flexibility in contract with SC partners (partial order and payment, partial shipment)	Duclos, Vokurka and Lummus (2005).
	Efficient and cost-effective logistics and supply chain functions (e.g. sourcing, producing, distribution)	Duclos, Vokurka and Lummus (2005); Gunasekaran, Lai and Cheng (2008).
	Ability to respond to additional orders or sudden demand	Jüttner and Maklan (2011).
	Ability to supply new and different products to different customer groups (mix flexibility)	Braunscheidel and Suresh (2009).
Redundancy/ Back-	Alternative and reserve capacity (logistical options)	Pettit, Croxton and Fiksel (2013); Pettit, Fiksel and Croxton (2010).
	Buffer stock	Pettit, Fiksel and Croxton (2013).
	Back-up energy source	Pettit, Fiksel and Croxton (2013).
Integration	Sharing information with supply chain partners	Braunscheidel and Suresh (2009); Peck (2005); Blackhurst et al. (2005).
	Communication and information flow with different departments (e.g. supply chain and other departments)	Braunscheidel and Suresh (2009).
	Joint or collaborative planning (e.g. product	Braunscheidel and Suresh (2009).

	development)	
	Communication with supply chain partners	Braunscheidel and Suresh (2009).
	ICT-supported planning and integration	Narasimhan and Kim (2001).
Efficiency	Waste elimination (efficient use of resources)	Pettit, Fiksel and Croxton (2010); Fiksel (2003); Sheffi and Rice (2005).
	Efficient and hard-working employees	Pettit, Croxton and Fiksel (2013)
	Quality control and less defects	Pettit, Fiksel and Croxton (2010); Kleindorfer and Saad (2005).
Financial strength	Funds availability	Pettit, Fiksel and Croxton (2010); Tang (2006).
	Profitability	Pettit, Fiksel and Croxton (2010).
	Insurance	Pettit, Fiksel and Croxton (2010); Tomlin (2006).

As shown on Table 2.3, it is evident that supply chain capability is a multidimensional construct which can be measured by the dimensions: flexibility, redundancy, integration, efficiency and financial strength. Although different scholars suggest different dimensions, some dimensions such as flexibility, responsiveness, redundancy, efficiency and integration are most commonly supported. While studies are available on supply chain capabilities to mitigate supply chain vulnerabilities, the main limitation of these studies can be identified as the dearth of empirical validation of the measures. Therefore, the present study fills this specific gap in the literature.

2.7.1.1.1 Flexibility

With the growth of globalization and increased outsourcing, flexibility in the supply chain has become a critical capability factor (Duclos, Vokurka, and Lummus 2005). Flexibility refers to the capability of an organization to respond to unforeseen changes in the environment that affect the production and distribution system of the organization (Candace, Ngai, and Moon 2011). Sánchez and Pérez (2005) referred to supply chain flexibility as encompassing the dimensions that influence a firm's customers through the adjustment of two or more supply chain functions either internal (marketing, manufacturing) or external (suppliers, channel members) to the firm. In supply chain management, the term "flexibility" is sometimes used interchangeably with the term "adaptability" as it helps to adapt the supply chain to the uncertain situation and to mitigate disruption (Stevenson and Spring 2009; Sheffi and Rice 2005). Adaptability is the ability to modify operations in response to challenges or opportunities by alternate technology development, lead-time reduction and learning from experience (Pettit, Croxton, and Fiksel 2013). According to Tang and Tomlin (2008), flexibility is an important attribute of SCR as flexibility in the supply chain helps to mitigate vulnerabilities. For example, the capability of having supply contract flexibility helps to reduce the risk of bottleneck or excess inventory in the supply chain.

A substantial number of research studies have been conducted on manufacturing flexibility and supply chain flexibility (Tang and Tomlin 2008; Chan and Chan 2009; Wadhwa, Saxena, and Chan 2008; Duclos, Vokurka, and Lummus 2005; Stevenson and Spring 2009). Slack (1983) describes five components of flexibility: new product; product mix; quality; volume; and delivery, while Vickery, Dröge and Germain (1999) mention five elements for supply chain flexibility, namely, product flexibility, volume flexibility, new product flexibility, distribution flexibility and responsiveness flexibility. Similarly, Duclos, Vokurka and Lummus (2005) identify six broader categories of supply chain flexibility: operations system flexibility, market flexibility, logistics flexibility, supply flexibility, organizational flexibility and information system flexibility. Table 2.3 mentions some of the important and widely used dimensions of supply chain flexibility.

2.7.1.1.2 Redundancy

Redundancy can be conceptualized as having the back-up capacity in the supply chain to cope with uncertain events. Reserve capacity or back-up capacity is a critical success factor during the time of disruption although it does incur costs (Pettit, Croxton, and Fiksel 2013; Tang and Tomlin 2008). Firms buy or produce a certain quantity of output on the basis of regular demands and maintain some extra capacity to meet variations in demand or to meet uncertainties in the supply process (Stock and Lambert 2001). Additional capacity of raw materials, components, tools, equipment, finished goods inventory and labour can be held as buffers (Croxton and Zinn 2005; Pettit, Croxton, and Fiksel 2013; Duclos, Vokurka, and Lummus 2005); however, reducing costs arising from an undesirable situation through maintaining buffer capacity is costly (Giunipero and Eltantawy 2004; Tang and Tomlin 2008). Such back-up capacity or buffers also increase responsiveness by providing timely and adequate response to short-term variations in demand and supply (Klibi, Martel, and Guitouni 2010). Furthermore, back-up capacity of utilities, and especially utilities such as electricity, water and communication, is crucial otherwise disruptions of utility factors affect operations (Rose 2007). Back-up capacity of utilities is even more important if the facility is located where crises occur in utility supply, for example, facility locations in underdeveloped countries.

2.7.1.1.3 Integration

The importance of integration itself lies in the definition of supply chain management (SCM) which, as defined by Cooper, Lambert and Pagh (1997), is the integration of

products, services and information flow from the original suppliers to the end-customers. According to Chen, Daugherty and Landry (2009), integration is the deliberate attempts of a supply chain to achieve its objectives through collaboration, commitment and coordination with another firm's functional areas and activities. Vickery et al. (2003) focus on closer customer relationships, supplier relationships and cross-functional teams as the different dimensions of supply chain integration. Similarly, Braunscheidel and Suresh (2009) place emphasis on internal integration among different departments of the organization as well as external integration with the key customers and suppliers as being the dimensions of supply chain integration. To enhance the strength of integration, the exchange of information both inside and outside the organization is important (Braunscheidel and Suresh 2009). Exchange of real-time information among supply chain members helps to forecast and manage inventory efficiently and to reduce the risk of disruption from demand volatility and stock-outs (Lau and Lee 2000; Chan and Chan 2009). However, for information exchange among the supply chain partners, collaboration and cooperation are essential. Collaboration enhances cooperation in the supply chain as it is the ability of the organization to work effectively with others in the network for the benefit of all (MacCormack and Forbath 2008). The exchange of information and adoption of technology also increase visibility in the supply chain which helps to reduce disruption (Pettit, Croxton, and Fiksel 2013) and, therefore, improves the resilience of the supply chain (Blackhurst et al. 2005).

2.7.1.1.4 Efficiency

Efficiency refers to the capability of a firm to produce more output by using less input. In the world of competition, efficiency plays a pivotal role in reducing the cost structure. Failure to achieve and maintain efficiency may lead to the threat of elimination from the market in the long run. Therefore, efficiency is essential for the supply chain to overcome the vulnerability arising from intensive competition (Pettit, Fiksel, and Croxton 2010; Pettit, Croxton, and Fiksel 2013). Efficiency can be obtained by improving the skill of labour, learning, production techniques, asset utilization, waste elimination, production variability reduction and failure prevention (Pettit, Croxton, and Fiksel 2013). Fiksel (2003) also asserted the necessity of efficiency for SCR. Companies can improve efficiency by reducing material and energy intensity and converting wastes into valuable secondary products. These attempts help to reduce cost as well as create value for shareholders and for society at large (Fiksel 2003). Though there is controversy between efficiency and redundancy, back-up capacity

should not be confused with efficiency. Efficiency should be achieved by cost-efficient means for the satisfaction of human needs (Fiksel 2003) while the capacity to cope with emergencies should not be compromised.

2.7.1.1.5 Financial strength

Financial strength is crucial for disaster recovery. Once a system is disrupted by uncertain events, financial back-up is needed to get the system back to the usual condition (Webb, Tierney, and Dahlhamer 2002). In a sociological network, it has also been proved that the financial health of an individual is a salient factor for disaster recovery by rebuilding housing, utilities and other essentials (Abramson et al. 2010). Moreover, financial support is needed when undertaking preparation against disruption as companies and their supply chains need to invest in capacity building. According to Pettit, Croxton and Fiksel (2013), financial strength refers to the capacity to absorb fluctuations in cash flow. Therefore, financial strength can be considered as a relevant dimension of supply chain resilience. Pettit, Croxton and Fiksel (2013) use the variables: insurance, portfolio diversification, financial reserves and price margin to measure financial strength. This means that if financial strength in terms of insurance protection, portfolio diversification, financial reserves and price margin, is high, resilience will be high and vice versa. In this research, financial strength reflects the ability of a supply chain to provide financial back-up for recovery from disruptions.

2.7.1.2 Supply chain design (SCD)

Supply chain design decisions can be illustrated as the decisions regarding supply chain node density, complexity and criticality (Craighead et al. 2007; Falasca, Zoble, and Cook 2008).

Node density is high in a supply chain when there are a large number of nodes in a limited area (Craighead et al. 2007; Falasca, Zoble, and Cook 2008). Supply chain nodes are clustered with high density when the sources of supply or the distribution market is concentrated on a particular area: on the other hand, nodes are widened when the sources of supply and the market are diversified (Kleindorfer and Saad 2005). The studies of Craighead et al. (2007) and Falasca, Zoble and Cook (2008) infer that increased density in the supply chain creates more vulnerability and reduces supply chain resilience.

Supply chain complexity is related to both the number of nodes in a supply chain and the interconnections between those nodes. A less complex supply chain would have

fewer nodes and/or fewer interconnections between nodes (Craighead et al. 2007; Falasca, Zoble, and Cook 2008). Increased complexity in the supply chain usually creates more vulnerability (Craighead et al. 2007; Falasca, Zoble, and Cook 2008). However, additional nodes that create buffers in the supply chain reduce vulnerability, for example, sourcing from multiple suppliers instead of a single supplier increases supply chain node complexity but reduces vulnerability through enhanced flexibility and resilience (Falasca, Zoble, and Cook 2008; Wagner and Bode 2006). Another way to reduce vulnerability is by using alternative suppliers which opens up an additional option during supply disruption (Jüttner 2005; Berger, Gerstenfeld, and Zeng 2004). Alternative supplier arrangements also allow the organization to reduce the risk of supply cost, that is, supply disruption for cost escalation (Tang and Tomlin, 2008).

Node criticality depends on the relative importance of a given node or set of nodes within a supply chain (Craighead et al. 2007). Existence of a node which is very important (e.g. an important distributor or supplier on whom others are highly dependent in the supply chain) makes a supply chain critical and vulnerable. Existence of a critical transportation hub during sourcing and distribution such as freight consolidation in Singapore also creates supply chain criticality. Alternative distribution channels are important when there is a critical transportation hub during sourcing and distribution or when disruption occurs in a network, for example, air cargo following the 9/11 attacks and volcanic ash in Europe in 2010 (Craighead et al. 2007; Falasca, Zoble, and Cook 2008; Pettit, Fiksel, and Croxton 2013). Colicchia, Dallaria and Melacini (2010) have also shown the effectiveness of using an alternative transportation mode in transportation risk reduction when outsourcing from a complex and distant location.

Based on the above discussion on node density, complexity and criticality, supply chain design issues are summarised in Table 2.4.

Table 2.4: Elements of supply chain design

Construct	Item	Reference
Supply chain design	Sourcing is from concentrated area vs. multi-sourcing Market is concentrated to specific area vs. diversified Production is concentrated to specific area vs. diversified Alternative transportation modes and Rerouting	Craighead et al. (2007); Falasca, Zoble, and Cook (2008); Kleindorfer and Saad (2005) Colicchia, Dallaria, and Melacini (2010); Tomlin (2006)

2.7.1.3 Supply chain response and recovery

Sheffi and Rice (2005) state that the ability to respond quickly to market needs and to disaster is an important determinant of supply chain resilience. Organizations can also achieve competitiveness by their quick response ability. A late response to disaster may cost companies and supply chains millions of dollars. For example, a late response and lack of readiness during a fire in the supplier's plant of Ericsson in New Mexico created a shortage of radio-frequency chip supply which later accounted for a loss of $400 million (Norrman 2004). On the other hand, owing to the quick response from Nokia after the occurrence of a fire in the same supplier's plant, Nokia was able to overcome the disruption of the supply shortage of the chips and to gain competitive advantage (Sheffi and Rice 2005). Therefore, the resilience of a supply chain is revealed by the ability of the supply chain to respond quickly during disruptions.

It can be argued that recovery from disruption is a critical and unique ability of organizations and supply chains. Some systems whether a business network, ecological system or a nation can quickly recover from the disaster which can be attributed to the resilience capability of such dynamic systems. In the literature, resilience is mostly measured in terms of recovery time. However, it is important to consider the effort and cost of recovery. Martin (2004) included cost as a parameter to measure resilience. Similarly, other researchers (e.g. Vugrin, Warren, and Ehlen 2011) emphasised the cost of resilience. A system may achieve recovery within less time (Wang, Gao, and Ip 2010) and with less effort and cost (Vugrin, Warren, and Ehlen 2011) due to the efficiency and unique ability of absorbing shock (Holling 1973) or by reducing the impact of disruption (Rose 2004) or by its inherent ability to return to its original position (Christopher and Peck 2004). Therefore, resilience can be measured by the extent of recovery time, cost and absorption of disruption to reduce the impact of loss. In other words, a resilient system can absorb huge disruption or can reduce the impact of loss compared to the estimation. It can be deduced that if a system is more resilient, the time and cost of recovery is low and vice versa.

2.7.2 Antecedents of supply chain resilience

2.7.2.1 Supply chain orientation

From the strategic perspective, supply chain orientation (SCO) can be referred to as "the implementation by an organization of the systemic, strategic implications of the tactical activities involved in the management of goods, services and information flow in a supply chain" (Min and Mentzer 2004, p. 63). From this definition, it is obvious that

strategic and top management involvement is crucial for facilitating the supply chain flows and for supply chain orientation of a firm. It is also true that top management support, that is, approval of disruption risk mitigation initiatives is vital to maintain the smooth flow of goods, services and information (Buehler and Pritsch 2003).

From the structural perspective, SCO can be cited as building and maintaining internal behavioural elements that facilitate relational exchange (Esper, Defee, and Mentzer 2010). In this regard, the authors shed light on the behavioural dimensions of trust, commitment, organizational compatibility, cooperative norms and top management support as elements of SCO. In a similar vein, Mello and Stank (2005) suggest that supply chain-oriented organizations should exhibit the attributes of trust, commitment, cooperation, compatibility with supply chain partners and top management support when making supply chain decisions. This type of inter-organizational trust, cooperation and commitment helps the supply chain members to reduce uncertainty in the network (Handfield and Bechtel 2002; Gao, Sirgy, and Bird 2005; Kleindorfer and Saad 2005). Therefore, supply chain orientation (SCO) is a precondition for disruption risk mitigation in the supply chain.

2.7.2.2 Learning and development

Learning from experience and increasing the range of knowledge from previous incidents are important aspects of resilience as organizations which take advantage of new opportunities can mitigate the vulnerabilities and allow the necessary learning and innovation to cope with such incidents (Berkes 2007). Folke, Colding and Berkes (2003) emphasised learning to live with change and uncertainties. Carpenter (2001) and Gunderson (2000) state that resilience is reflected by adaptive capacity which is dependent on the learning aspect of system behaviour in response to disturbance. Similarly, in a changing situation, adaptive capacity is closely related to learning (Carpenter 2001) as learning and adaptive management helps to mitigate uncertainties (Gunderson 2000). Korhonen and Seager (2008) state that learning and innovation help in the adaptive capacity and resilience of organizations. They also argue that learning helps to gain efficiency which is supportive in overcoming competitive pressure. In a similar fashion, Carroll, Rudolph and Hatakenaka (2002) identified the importance of individual and group learning in a high hazard organization to mitigate critical situations. Ritchie and Brindley (2007) focused especially on staff training and development programs, and on technical expertise development to mitigate risks as learning has a direct influence on improved flexibility and reduction of risk (Manuj and Mentzer 2008). Along with the ecological and organizational aspects, another stream of

research that has put substantial importance on the learning perspective of resilience is disaster management. Lindell, Prater and Perry (2006) suggest that a disaster-resilient community learns from previous experience, supports sustainable development policies, mobilizes the government, and demands the implementation of effective policies. Based on the above literature, it appears that learning and development enables an organization and its supply chain to improve resilience.

2.7.2.3 Supply chain risk management

Supply chain risk management (SCRM) is one of the important antecedents of supply chain resilience (SCR) (Christopher and Peck 2004) as it helps to identify risks and the likelihood of risks and to increase the capacity of the supply chain to mitigate them (Xu 2008; Wieland and Wallenburg 2013). In other words, one of the most important aspects of SCR is to create a SCRM culture as supply chain risk management is a process of risk-reducing effort (Blos, Wee, and Yang 2012). Jüttner, Peck and Christopher (2003, p. 201) defined SCRM as "the identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain risk members, to reduce supply chain vulnerability". Therefore, the primary focus of SCRM is the identification and management of risks for reducing supply chain vulnerability. Jüttner and Maklan (2011) address the functions of risk sharing attempts, risk reducing efforts and gathering knowledge about risk as important attributes of supply chain risk management. Research on SCRM is well explored. A number of studies can be referred to which investigate SCRM in terms of identifying risk drivers (Wagner and Bode 2006) or addressing risk-reduction efforts such as early supplier involvement (Zsidisin and Smith 2005), supplier development (Matook, Lasch, and Tamaschke 2009), etc. Although risk management is essential for risk mitigation, the major weakness of risk management is its inability to adequately address low-probability, high-consequence events (Kunreuther 2006; Pettit, Croxton, and Fiksel 2013). Therefore, supply chain resilience (SCR) is essential while SCRM is an enabler and antecedent of supply chain resilience (Jüttner and Maklan 2011).

2.8 SUSTAINABILITY

Climate change, depletion of resources, increased pollution, energy consumption, violation of social rights, and demand for transparency regarding social and environmental performance have brought the agenda of sustainability into every walk of life and within the broader facets of society (Carter and Easton 2011). Sustainability can be referred to as ‘‘creating long-term shareholder value by embracing

opportunities and managing risks deriving from economic, environmental and social developments'' (Dow Jones 2005, p. 7). In other words, it is termed as to "make the world a better place for future generations" and to "provide the processes and products which will give the people of the world shelter, clothing, food and drink, and which keep them in good health" (IChemE, 2005, p. 4). The most popular and most often quoted definition of sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their needs" (World Commission on Environment and Development (WCED) 1987, p. 8). In recent years, the domain of sustainability has extended beyond the organizational boundary to the whole supply chain (Gold, Seuring, and Beske 2010) because focal firms are not only responsible for their own operations but are also responsible for the environmental and social issues of their supply chain members (Koplin 2005).

2.9 SUPPLY CHAIN SUSTAINABILITY (SCS)

Supply chain sustainability has been of substantial interest to the academic and corporate sectors for just over a decade (Corbett and Klassen 2006; Seuring and Muller 2008). There are still fundamental issues that need to be addressed to assist business managers and supply chain professionals to achieve supply chain sustainability (Pagell and Wu 2009). Organizations need to manage material, information and capital flows and to cooperate with all entities in the chain to achieve the economic, environmental and social goals that are derived from customer and stakeholder requirements (Seuring and Muller 2008). To be responsible to stakeholders, the environmental and social burden arising from different stages of production, for example, the environmental and social performance of supply chain members, needs to be acknowledged (Koplin 2005). The branded companies come under pressure from stakeholders such as government, activists and non-governmental organizations (NGOs) if there is a problem with sustainability compliance in the supply chain (Seuring and Muller 2008). Likewise, the branded apparel chains such as Nike, Disney, Levi Strauss, Benetton, Adidas or C&A have been accused over problems in the upstream supply chain with respect to production of their clothing (Seuring and Muller 2008; Preuss 2001).

Despite the essential nature of supply chain sustainability (SCS), the literature on SCS is limited (Gold, Seuring, and Beske 2010). Studies mostly consider social, environmental and economic issues in a stand-alone fashion rather than in an integrated way. Studies on organizational sustainability and supply chain sustainability have focused mainly on

environmental aspects whereas there has been little concentration on social and economic aspects (Carter and Rogers 2008). The studies of Carter (2004); de Brito, Carbone and Blanquart (2008); Hutchins and Sutherland, (2008); are perhaps the few studies that consider both social and environmental sustainability in the supply chain. However, these studies also have some shortcomings; for example, the study of de Brito, Carbone and Blanquart (2008) analyses the social and environmental impacts only from the logistical point of view and lacks indications about the influence of the manufacturing operation on social and environmental aspects. Similarly, Hutchins and Sutherland (2008) studied supply chain sustainability mainly from the social perspective. Addressing this void, the current study considers an integrated aspect of sustainability (social, environmental and economic) in the supply chain. It also addresses the relationship between supply chain resilience and sustainability in terms of social, environmental, and economic sustainability in the supply chain.

2.10 MEASUREMENT OF THE DIMENSIONS OF SUPPLY CHAIN SUSTAINABILITY

Previous studies focus on different dimensions for achieving and improving sustainability but the most widely used dimensions can be found in the triple bottom line concept of John Elkington (1999). The United Nations Commission on Sustainable Development (2005) also describes the three pillars of sustainability: environmental sustainability, social sustainability and economic sustainability. It is now commonly agreed that a balance between social, environmental and economic factors is essential for the long-term success and sustainability of organizations which is also one of the principles inherent in stakeholder theory (Freeman 1984).

The “triple bottom line” has served as a common ground for numerous sustainability standards in business such as the Global Reporting Initiative (GRI), the Dow Jones Sustainability Index, International Organization for Standardization (ISO) 14001 standards, and the sustainability metrics of the Institution of Chemical Engineers (IChemE) (Delai and Takahashi 2011). Based on the multitude of products, services and operations, previous studies (Labuschagne, Brent, and van Erck 2005; Epstein and Wisner 2001; Vasileiou and Morris 2006; Hutchins and Sutherland 2008; Carter 2004) measure sustainability in different contexts. In the stream of supply chain management, sustainability is mainly discussed in terms of green supply chain management or sustainable supply chain management. A number of special issues on sustainability and sustainable SCM have been published of the *Journal of Supply Chain Management* (Pagell and Wu 2009); *Journal of Cleaner Production* (Seuring and Muller 2008); *Supply Chain Management: an International Journal* (Lindgreen et al. 2009);

Corporate Social Responsibility and Environmental Management (Gold et al. 2010); *International Journal of Physical Distribution & Logistics Management* (Carter and Easton 2011); and *International Journal of Production Economics* (Ageron et al. 2012). Despite this, there is still a paucity of sustainability measurement (Seuring and Muller, 2008; Ramos and Caeiro 2010) with considerable challenges faced such as the lack of an integrated focus for measuring economic, social and environmental aspects (Labuschagne, Brent, and van Erck 2005; Singh et al. 2009; Adams and Frost 2008). A few studies (e.g. Ageron, Gunasekaran, and Spalanzani 2012; de Brito, Carbone, and Blanquart 2008, Carter 2004) include some of the aspects of supply chain sustainability and its measurement. However, empirically tested measurement of supply chain sustainability in terms of social, environmental and economic issues is very rare. This current research incorporates the dimensions of supply chain sustainability in an attempt to explore the relationship between supply chain resilience and sustainability.

2.10.1 Social sustainability

Aligned with the definition of the Commission on Sustainable Development, the social dimension of sustainability emphasises how to achieve human well-being, how to meet people's needs and how to generate development opportunities for all (Disano 2002; Delai and Takahashi 2011). Addressing the social issues is intended to minimise any harm and maximise the long-run beneficial impact of the firm on society (Bloom and Gundlach 2000). From the organizational perspective, social sustainability focuses on the impact of organizational activity on stakeholders and, specifically, on employees, customers, suppliers, shareholders and government (Delai and Takahashi 2011). Social sustainability in the supply chain can be ensured by a number of responsible actions with regard to fair wages, health and safety factors, child labour, forced labour and some other indicators (GRI 2011; IChemE 2005; Dow Jones 2005; Carter 2004; de Brito, Carbone, and Blanquart 2008). Table 2.5 lists a number of factors related to social sustainability. In the contemporary world, social sustainability has received intensive focus owing to high profile corporate failures (Aaronson 2002) and supply chain members' failure to observe social issues (Kolk and Pinkse 2006). In relation to this concern, the poor working environment in apparel manufacturing companies of underdeveloped countries (Islam and Deegan 2008; Emmelhainz and Adams 1999) is worth mentioning. This type of violation of social and environmental issues is not uncommon in the corporations of many developing countries such as Bangladesh and Pakistan (Naeem and Welford 2009). Therefore, social sustainability issues in the supply chain need to be emphasised when outsourcing from low-cost countries to

ensure long-term sustainability and to reduce probable disruptions arising from the violation of social compliance issues.

2.10.2 Environmental sustainability

Environmental sustainability focuses on the maintenance of natural capital (Goodland 1995). Scholars argue that the depreciation of natural capital cannot go on endlessly (Lovins, Lovins, and Hawken 1999). From the organizational perspective, environmental sustainability concentrates on the production and consumption of resources by corporations in a responsible fashion (Seuring and Muller 2008). Responsible companies now keep track of the carbon footprint of their activities and open their records to the public. Consumers' concerns are increasing and environmental regulations are getting tougher regarding the impact of production and consumption: as a result, companies are shifting their production bases to areas where the regulations are relaxed and, specifically, to developing and underdeveloped countries. However, environmental factors should not be overlooked when outsourcing to low-cost countries (de Brito, Carbone, and Blanquart 2008). It is also a cause of concern that some production processes have high environmental impact; for example, due to the processes of dyeing, drying and finishing, the apparel industry makes intensive use of chemical products and natural resources (Caniato et al. 2012; de Brito, Carbone, and Blanquart 2008). Moreover, the production of fibres such as cotton, wool and synthetics, has a significant environmental impact (Caniato et al. 2012). In such situations, the environmental factors along with economic factors need to be considered throughout the supply chain for long-term sustainability. Previous studies (e.g. Hervani, Helms, and Sarkis 2005; Pagell and Wu 2009; de Brito, Carbone, and Blanquart 2008; GRI 2011) refer to a number of practices to ensure environmental sustainability in the supply chain such as pollution control, waste recycling, compliance of environmental issues, suppliers' environmental performance evaluation and monitoring, etc. (see Table 2.5). The environmental factors listed in Table 2.5 can be considered as the measures for environmental sustainability in the supply chain.

2.10.3 Economic sustainability

Economic sustainability evaluates short-term and long-term economic value, generated by the organizational activities and the corresponding relationship with shareholders (Delai and Takahashi 2011). It focuses on that segment of the natural resources base which provides physical inputs, both renewable and exhaustible, into the production process (Goodland 1995). For example, financial capital such as debt–equity, tangible

capital and intangible capital needs to be managed sustainably to produce maximum outputs. In other words, economic sustainability is concerned with the long-term economic health of the organization. It also accounts for share value, sales growth, profitability such as debt–equity and other important indicators while maintaining social and environmental responsibilities (Delai and Takahashi 2011). The economic indicators for sustainability are listed in Table 2.5.

Table 2.5: Sustainability measurement indicators

Indicators and sub-indicators	GRI	IChemE	Dow Jones
Social factors			
Health and safety	Y	Y	Y
Remuneration	Y	Y	N
Equal wage/no wage discrimination	Y	N	Y
Training and development	Y	Y	Y
Job creation	Y	Y	N
Freedom of association	Y	N	Y
Forced labour	Y	N	N
Child labour	Y	N	N
Employee turnover	Y	Y	Y
Impact on community	Y	Y	Y
Customer health and safety	Y	N	N
Employee satisfaction	N	N	Y
Performance appraisal	N	N	Y
Absenteeism	Y	Y	Y
Personal and organizational learning and development	N	N	Y
Customer satisfaction	N	N	Y
Compliance with regulation	N	Y	N
Assessment of supplier	N	N	N
Child labour in the chain	Y	N	N
Forced labour in the chain	Y	N	N
Compliance of health, safety and human rights by the suppliers	Y	N	N
Support for supplier development	N	N	N
Environmental factors			
Air pollution	Y	Y	Y
Human health effect	N	Y	N
Quantity of water consumption	Y	Y	Y
Disposing of pollutants (chemical waste, solid waste)	Y	Y	N
Waste recycled or reused	N	N	N
Material used that poses health, safety or environmental hazard	N	Y	N
Compliance of environmental legislation	Y	N	N
Performance of suppliers regarding environmental issues	Y	N	N
Environmental impact of products produced	Y	N	N
Environmental certification and auditing	Y	N	N
Economic factors			
Sales	Y	Y	N
Cost of goods	Y	Y	N
Value added	N	Y	N
Net income before tax	Y	Y	N
Return on average capital employed	N	Y	N

It is not enough to maintain profit and growth for the company itself; rather, the economic health of all supply chain members should be considered because

competition is no longer confined to firm versus firm but is instead extended to supply chain versus supply chain (Mentzer et al. 2001). Failure to keep the cost of production lower than competitors makes companies and their supply chains less profitable and incompetent in the highly competitive market. To keep the production cost lower, some companies shift their production location to areas where cheaper labour is available. For example, European clothing and textile factories could not sustain their production in Europe and, as a result, shifted production to the low-cost underdeveloped Asian and South American regions or became engaged in outsourcing which caused unemployment for thousands of people (de Brito, Carbone, and Blanquart 2008). Similarly, the companies that are operating in low-cost areas now need to consider the management capabilities and technological upgrades to remain economically sustainable in the long run. A number of factors need to be considered to ensure economic sustainability of the organizations and their supply chains. However, sales, cost, value addition, net income before tax and return on average capital employed are the most widely cited parameters to assess economic sustainability (Delai and Takahashi 2011; GRI 2011).

2.11 OVERALL RESEARCH GAP

Supply chain vulnerabilities often threaten the performance and existence of supply chains. Owing to the high frequency of disruptions and their severe consequences, supply chain vulnerability (SCV) research has received significant attention from academia. Despite the extensive studies on supply chain vulnerability, the hierarchical and multidimensional aspects of SCV (Wagner and Bode 2006) have not yet been validated empirically. A comprehensive measurement model of SCV is yet to be developed. However, to achieve the capability of mitigating vulnerabilities, organizations need to develop an increased understanding of vulnerabilities which generates the need for vulnerability measurement. Therefore, this research attempts to measure and to validate the multidimensional and hierarchical construct, SCV, in the context of the apparel industry of Bangladesh.

While vulnerabilities in the supply chain pose challenges to the sustainability of the supply chain, resilience is essential to supply chains to reduce the impact of vulnerabilities (Pettit, Croxton and Fiksel 2013; Christopher and Peck 2004). However, comprehensive measurement for supply chain resilience is yet to be developed (Ponomarov and Holcomb 2009). To the best of the researcher's knowledge, an empirically tested and validated measurement scale for the multidimensional and

higher-order construct, SCR, has not yet been developed. This research, therefore, attempts to fill the gap in the literature by developing a comprehensive multidimensional measurement model for SCR in the context of the apparel industry of Bangladesh.

Resilience of the apparel supply chain is essential because the apparel supply chain is facing numerous vulnerabilities which are threatening its existence. Given the critical condition of the apparel supply chain, there is a need for empirical investigation of vulnerabilities and resilience to overcome the existing challenges. Despite the importance of such studies in the context of the apparel supply chain of Bangladesh, to the best of the researcher's knowledge, no study has yet been conducted to measure supply chain vulnerability and resilience and to investigate the relationship between supply chain vulnerability and resilience in the context of the apparel industry of Bangladesh. This gap in the literature has been a significant motivation for this study.

While the susceptibility to vulnerability persists in a supply chain, the issues of resilience and sustainability are essential because resilience is a precondition for sustainability in the wake of vulnerabilities (Leat and Revoredo-Giha 2013; Fiksel 2006). Conceptually, it is established that SCR is essential for supply chain sustainability; however, there is a paucity of empirical investigation to test and validate this link. Therefore, this study addresses the relationship between SCR and sustainability.

This study also addresses the antecedents of SCR as there are debates in the literature about supply chain antecedents. Some studies consider the measurement constructs as antecedents while others ruminate on the antecedents as measurement constructs (Jüttner and Maklan 2011). Considering the existence of such discrepancies in the literature, this study attempts to explore the antecedents of supply chain resilience (SCR) and the associated relationships between resilience and its antecedents. Taking into consideration the gaps identified in the literature, an initial research model has been proposed which is shown in Figure 2.2.

2.12 INITIAL RESEARCH MODEL

Based on the gaps in the literature, this research is steered by the objective of developing a model: supply chain sustainability and resilience in the context of the apparel industry of Bangladesh. By synthesizing the previous literature on supply chain vulnerability, resilience and sustainability (as discussed in sections 2.4 to 2.12), this research proposes that in the wake of widespread vulnerability, supply chains need

resilience capability to mitigate the vulnerabilities and to achieve sustainability in the long term. Figure 2.2 provides a succinct picture of the research concept and depicts the initial research model for the current research. Aligned with Pettit, Croxton and Fiksel (2013), it can be argued that resilience capability is contextual and dependent on the nature and extent of vulnerabilities. As a result, it is important to identify and gather knowledge about vulnerabilities to develop vulnerability mitigation capabilities (Jüttner and Maklan 2011).

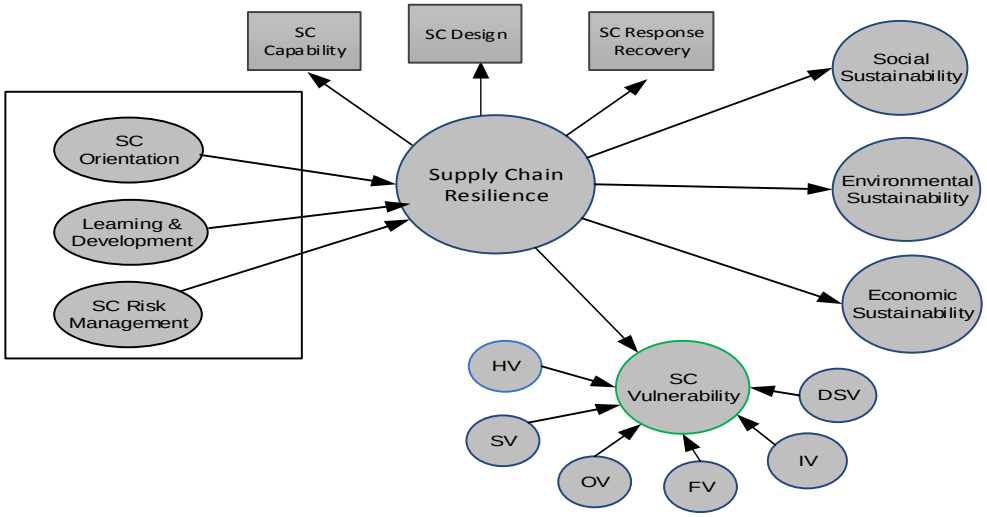


Figure 2.2: Initial research model

Based on previous studies, a number of vulnerability dimensions such as hazard vulnerability (HV), and strategic (SV), operational (OV), financial (FV), infrastructural (IV) and demand–supply vulnerability (DSV) have been identified which altogether constitute the concept of SCV in the model. The review of previous studies also identifies that supply chain resilience (SCR) is multidimensional and shows the attributes of supply chain capability, supply chain design, and supply chain response and recovery (Pettit, Croxton, and Fiksel 2013; Erol, Sauser, and Mansouri 2010). Therefore, SCR is modelled as multidimensional as it reflects the dimensions of supply chain capability, supply chain design, supply chain readiness, and supply chain response and recovery in the initial research model.

In addition, supply chain capability was also explored as a multidimensional concept which attributes the capabilities of flexibility and responsiveness, redundancy, integration and efficiency within the supply chain. Along with the multidimensional aspects of resilience and supply chain capability, it is observed that supply chain resilience (SCR) is facilitated by some antecedent factors such as supply chain orientation (SCO), and learning and development as well as supply chain risk

management (SCRM). Based on the literature review, it is further noticed from the initial model that supply chain resilience (SCR) leads to supply chain sustainability which is ultimately reflected by the social, environmental and economic sustainability in the supply chain. Therefore, based on the literature review, our initial research model, proposes the relationship between supply chain vulnerability, resilience and sustainability which is elaborated in sections 2.14 and 2.15.

2.13 RELATIONSHIP BETWEEN SCV AND SCR

Disruptions in the supply chain are sometimes beyond the direct control of supply chain managers. Some disruptions can be assessed in advance but some cannot. Based on the vulnerability map, Blos et al. (2009) reiterate the importance of SCRM and suggest some mitigating actions such as supply chain communication, business continuity management, training programs and creation of the position of chief risk officer. However, some researchers (e.g. Jüttner and Maklan 2011; Pettit, Croxton, and Fiksel 2013) suggest more proactive and resilient actions to mitigate highly uncertain events. Therefore, in order to cope with the changing environment and to initiate a proactive approach to supply chain vulnerability (SCV), supply chain resilience (SCR) is essential which is supported by a number of studies (Sheffi and Rice 2005; Pettit, Fiksel, and Croxton 2010; Christopher and Peck 2004; and others). The inherent limitations of SCRM necessitate the urgency of SCR to supplement the existing risk management initiatives (Jüttner and Maklan 2011). The proactive approach to tracing the disruptions in advance and to developing adaptive capacity for mitigating the vulnerabilities (Peck 2005) are essential for organizations and their supply chains in order to be resilient and to efficiently mitigate vulnerabilities. Therefore, SCV is reduced as SCR is improved which postulates a negative relationship between SCR and SCV.

2.14 RELATIONSHIP BETWEEN SCR AND SUSTAINABILITY

The contemporary business world has experienced numerous uncertainties arising from disruptions and turbulence. These disruptions and risks create impediments in discharging the functions of supply chains (Svensson 2000; Hendricks and Singhal 2003). In an environment of disruptions and uncertainty, developing a sustainable system has become challenging. In addressing this concern, a good alternative is to develop a system's resilience to resist and to overcome disruptions effectively (Fiksel 2003; Fiksel 2006; Gunderson 2002). Resilience is echoed when the issue of sustainability is discussed (Martin 2004). Folk et al. (2002) and Leat and Revoredo-

Giha (2013) mentioned that resilience enhances sustainability in a turbulent environment. Thus, existing literature supports the view that resilience is a precondition for sustainability. Bringing this concept to the supply chain, it can also be proposed that, in order to achieve sustainability in the supply chain, supply chain resilience (SCR) is indispensable. Thus, it appears that there is a positive relationship between supply chain resilience (SCR) and sustainability.

Based on the proposed relationships discussed in the above sections, the proposed model: supply chain sustainability and resilience is developed: this is justified by two major theories, namely, stakeholder theory and the resource-based view (RBV).

2.15 THEORETICAL JUSTIFICATION OF THE KEY CONSTRUCTS AND THEIR RELATIONSHIPS

While the authors present interesting and useful points to introduce and define the concept of resilience, there is criticism that unfortunately theoretical justification is presented for very few of these studies (Ponomarov and Holcomb 2009). Similarly, there is a lack of theoretical justification pertaining to these studies addressing the importance of resilience for the sustainability of organizations and their supply chains.

This study model is conceptualized based on the resource-based view (RBV) and stakeholder theory. In supply chain literature, some studies (e.g. Ponomarov and Holcomb 2009; Blackhurst, Dunn, and Craighead 2011) use the RBV for explaining supply chain resilience (SCR) while de Brito, Carbone and Blanquart (2008), Carter and Rogers (2008), Carter and Easton (2011) and others use stakeholder theory to explain supply chain sustainability. The logic behind using the RBV and stakeholder theory in this research is presented below.

The resource-based view (RBV) argues that firms achieve sustainable competitive advantages by deploying the bundle of resources and capabilities which are unique and internal to the firm (Wernerfelt 1984; Barney 1991; Grant 1991). Wernerfelt (1984) argues that “resource” means anything that can be considered as strength of the firm. It may be tangible such as financial reserves, plant and machinery, equipment, stocks of raw materials and other physical assets, or intangible such as brand names, in-house knowledge of technology, skilled and trained human resources, managerial capabilities, organizational culture, social relationships, reputation, trade contracts, and effective and efficient processes, etc. (Wernerfelt 1984; Grant 1991; Barney 1991).

Furthermore, in an environment of uncertainty and disruptions, organizations can be successful in competition by effectively overcoming threats and uncertainties

(Wernerfelt 1984). Studies have shown that effective capabilities vary with market dynamism and the business environment (Eisenhardt and Martin 2000; Brush and Artz 1999). Researchers of the RBV advocate for including the ability of mitigating disruption and contingency as organizational resources and capabilities (Barney 2001; Priem and Butler 2001). Aragón-Correa and Sharma (2003) in their "contingent resource-based view (C-RBV) of proactive corporate environmental strategy" argue that the organization's proactive environmental attempt to mitigate environmental uncertainties and complexities is a valuable dynamic capability of a firm. They also argue that firms need to invest in achieving tangible and intangible resources for developing capabilities during uncertain business environments. Integrating the natural resource-based view (N-RBV) and stakeholder theory, Markley and Davis (2007) advocate the need for a capability to reduce the environmental uncertainties in the supply chain in order to reduce the negative environmental and social impact and to retain higher stakeholder value. This study presumes that this type of dynamic capability is needed for developing supply chain resilience (SCR) and sustainability to overcome these vulnerabilities. Therefore, the spirit of the RBV justifies the relationship between supply chain vulnerability (SCV) and SCR.

Stakeholder theory holds the idea that managers should make decisions considering the interest of and impact on all stakeholders. According to Freeman (1984), stakeholders are those who have an interest in the firm (either benefiting from or harmed by corporation actions). The task of management is to maintain a balance among the conflicting interests and claims of stakeholders (see Figure 2.3).

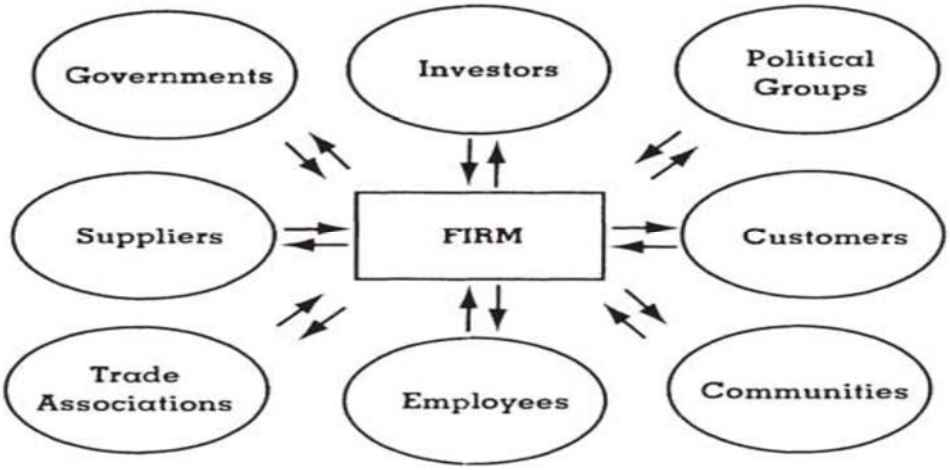


Figure 2.3: Contrasting interest of stakeholders Source: Donaldson and Preston (1995)

If a balance cannot be ensured, organizational sustainability will be questioned (Freeman 1984). Although there are conflicts of interest among the stakeholders with

the passage of time, the attention and interest of all stakeholders is converging towards the sustainability of the organization in terms of economic, social and environmental factors (Wheeler, Colbert, and Freeman 2003). Therefore, organizations try to maximize sustainability performance for a sustainable stakeholder relation (Perrini and Tencati, 2006). The stakeholders' demand for sustainability has now surpassed the organizational boundary as they are increasingly concerned about the sustainability of whole supply chain (Seuring and Muller, 2008). Therefore, in order to develop a sustainable supply chain, organizations need to ensure economic, social and environmental expectations (Carter and Rogers, 2008) of the stakeholders throughout the SC network. Starkley and Madan (2001) focus on the strategic need of involving the stakeholders in the decision making process to ensure the relevance of the strategies and to meet the future challenges. According to Freeman (1984), with the passage of time organizations are experiencing different types of internal and external changes and challenges from different stakeholders. In such a situation organizations need the capacity to change of concept, strategy to respond to the environment in an inactive or reactive, proactive or interactive way for managing the situation (Freeman, 1984). Consistant with this it can be argued that supply chains need resilient approach to meet the systainability challenges and to satisfy the requirements of the stakeholders.

Therefore, through the lenses of the resource-based view (RBV) and stakeholder theory, it can be deduced that organizations and their supply chains need resilience capability in the changing environment to achieve long-term sustainability.

2.16 SUMMARY

This chapter presented the relevant literature of this research. The literature related to supply chain vulnerability (SCV), supply chain resilience (SCR) and sustainability has been reviewed. The critical analysis in each section addressed the gaps in the existing literature. An initial research model that describes the dimensions of constructs as well as the relationship between the constructs related to SCV, SCR and sustainability has been developed. The selected constructs in the model have been justified based on the concepts from the resource-based view (RBV) and stakeholder theory. This analysis has shown that the resilience capability of a supply chain to mitigate vulnerabilities can be explained by the concept of the RBV. Sustainability, an outcome construct of SCR, can be explained by the stakeholder theory. Founded on the concepts of the RBV and stakeholder theory, the research model: supply chain sustainability and resilience extends the outcome perspective of the RBV which is a unique contribution of this research.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The previous chapter (Chapter 2) has formulated a preliminary research model of supply chain sustainability and resilience based on an extensive literature review. The aim of this chapter is to further elaborate on the nature of the research model identified in the previous chapter with epistemological views and to validate the conceptual propositions as discussed in section 2.13 and 2.14. An enquiry into the previous literature reveals that research in the area of supply chain resilience and risk management deploys quantitative methods (e.g. Braunscheidel and Suresh 2009; Colicchia, Dallaria, and Melacini 2010; Tomlin 2006) as well as qualitative methods (e.g. Jüttner and Maklan 2011; Blos et al., 2009; Blackhurst et al. 2005; Peck 2005; and others). Conceptual studies (e.g. Erol, Sauser, and Mansouri 2010; Ponomarov and Holcomb 2009; Christopher and Lee 2004; Christopher and Peck 2004; Sheffi and Rice 2005; Hamel and Välikangas 2003) and case study research (e.g. Norrman 2004; Oke and Gopalakrishnan 2009; Tuncel and Alpan 2010) are also prevalent in supply chain risk management (SCRM) literature. There is little mixed method research, a combination of qualitative and quantitative methods, available in supply chain literature. However, Pettit, Croxton and Fiksel (2013) conducted a mixed method research to measure supply chain resilience (SCR) and asserted the importance of qualitative study before undertaking the quantitative approach in the context of SCR to validate the study findings which was consistent with Greene, Caracelli and Graham (1989). Moreover, resilience is context-specific (Luthar and Cicchetti 2000) which generates the need for qualitative study to identify relevant capabilities corresponding to the context-specific vulnerabilities (Pettit, Croxton, and Fiksel 2013). In a similar spirit, qualitative field study is essential before undertaking quantitative survey research on supply chain sustainability and resilience in the context of the apparel industry of Bangladesh. Therefore, a combination of qualitative and quantitative methods research was used in this study to contextualise the preliminary research and to verify the causal relationships between different factors in the research model.

For its philosophical foundation, this study embraces a positivist research philosophy and adopts the survey research approach for data collection in the quantitative phase.

The overall research design for this study is elaborated in this chapter. In the first section, the research paradigm corresponding to this study is explained which addresses the explanation of the research methods adopted in this study and the justification of those methods. The next section illustrates the research process for the qualitative field study followed by the quantitative study. The final section presents a summary of the chapter.

3.2 RESEARCH PARADIGM

A paradigm provides basic guidelines and principles through which a research is structured. Willis (2007) defined "research paradigm" as a comprehensive framework which guides research and practice in a particular field. The author argues that there are a number of paradigms for the construction and development of knowledge, for example, Guba and Lincoln (1994) introduced four different paradigms, namely, positivism, post-positivism, critical theory and constructivism. In a similar fashion, Creswell (2003) stated the paradigmatic stances of knowledge as post-positivism, constructivism, pragmatic and participatory. Burrell and Morgan (1979) proposed a framework of functionalism, intrepretivism, radical humanism and radical structuralism where the functionalist paradigm is aligned with positivism and the remaining three paradigms are anti-positivist in nature. Although there are a number of paradigmatic stances of scientific research, from a broader aspect, Onwuegbuzie and Leech (2005) classified research into two views: positivist and interpretivist. However, based on Burrell and Morgan's (1979) framework, Burgess, Singh and Koroglu (2006) identified valuable findings from an enquiry into the paradigmatic stances of supply chain management knowledge and theory development. They found that 97% of the supply chain research follows the functionalist paradigm whereas only 3% of the studies use the anti-positivist paradigm which is under interpretivist and radical structuralist paradigms. Therefore, consistent with Onwuegbuzie and Leech's (2005) view of the paradigmatic stances of research, it can be deduced that most of the studies on supply chain management are in the positivistic tradition whereas a few are under the interpretivist tradition.

A positivist paradigm creates knowledge which is based on experience gathered from verifiable empirical evidence in support of theories and hypotheses (Denzin and Lincoln 2005). According to Orlikowski and Baroudi (1991), a research follows the positivist tradition if it is guided by a formal proposition, deals with quantification and measurement of variables, formulates and tests hypotheses, and draws inferences about a phenomenon from the sample of a particular population. Furthermore, the

positivist approach follows the assumption that a phenomenon has an objective reality which can be articulated in causal relationships and measured in a representative and accurate manner (Straub, Boudreau, and Gefen 2004). Positivist research also assumes that the data and the analysis are free from subjective interpretation and do not change, as reality is independent from the investigator (Krauss 2005; Johnson and Onwuegbuzie 2004). It can be added that a research investigation cannot be conducted without being objective; rather, it should be objective in order to explore, understand and draw inferences about the phenomenon (Johnson and Onwuegbuzie 2004). Further, it is worth mentioning that the positivist paradigm is related to the quantitative research method which attempts to develop and test hypotheses (Cresswell 2003, 2008).

In line with Onwuegbuzie and Leech (2005), the second research tradition from the paradigmatic aspect is the interpretivist paradigm. The interpretive research attempts to draw inferences through social interpretation of a reality (Neuman and Kreuger 2003) as the objective of interpretivist research is to understand any system in its social context concerning how they are embedded in it, how they impact on it and how they are impacted by this context. Unlike the positivist approach, the interpretivist approach rejects the separation of the researcher and participant because it relies on the subjective interpretation of the researcher and assumes that the researcher should interact and affect the issues being researched (Creswell 2003, 2008). In other words, qualitative research gives more emphasis to words, observations and meanings rather than facts and numbers (Creswell 2003). Table 3.1 presents a vivid picture of the differences between the positivist and interpretivist research paradigm.

Table 3.1: Interpretivist versus positivist paradigm

Assumption	**Interpretivist**	**Positivist**
Ontological: Nature or reality	Reality is subjective.	Reality is objective.
Epistemological: Relationship of the researcher and the issue being researched	Subjective involvement of researcher that affects the issue being researched.	Researcher is independent from what is being researched: that is why it is value-free.
Axiological: Roles of values	Scientific study is value-laden and biased.	Scientific study is value-free and unbiased.
Rhetorical: Language of research	Usually informal and qualitative terminologies are used.	Formal and quantitative terminologies are used.
Methodological: Process of research	Based on idealism, uses a number of methods to obtain different perceptions of the phenomenon.	Based on realism, focus is on objective and hypotheses formulation.

Source: adapted from Creswell (2003)

The research paradigm of this study was determined by the objective, nature and research context. The purpose of this research was to formulate a model of supply chain sustainability and resilience in the context of the apparel industry in Bangladesh. In this regard, this study aimed to ascertain the measurable and observable determinants of supply chain sustainability and resilience. This research thus develops hypotheses, has specific variables that are quantified and measured, tests hypotheses and draws inferences based on statistical analysis of data collected from samples. Therefore, the positivist research paradigm seemed to be appropriate for this research.

Apart from the positivist paradigm, this study also collected and analysed qualitative data to enrich the understanding of supply chain resilience (SCR) capability requirements in the context of the apparel supply chain in Bangladesh. The qualitative method indicates the tendency toward the constructivist interpretive paradigm due to the contextual factors and the participants' perspectives considered in the research (Willis 2007). Therefore, a blend of positivist and interpretivist approaches was used in this study as this study used both quantitative and qualitative tools. The use of both quantitative and qualitative tools in a single study is known as a mixed method research design (Tashakkori and Teddlie 2003; Teddlie and Tashakkori 2012).

The application of mixed methods research in this study can be supported with a number of arguments. For example, the study of supply chain resilience (SCR) is still in its infancy and the theories related to it have not yet been established (Pettit, Fiksel, and Croxton 2013). The factors and variables influencing SCR as well as factors influenced by resilience have not yet been explored. As a result, exploratory study is needed on SCR for developing concepts and theories. Moreover, resilience is context-dependent (Walker et al. 2002): as a result, the factors and variables discussed in supply chain risk management and resilience literature need to be verified by a group of representatives from the apparel industry to contextualise the research model. In addition, it is not unlikely that new factors related to SCR will be explored in the context of the apparel industry of Bangladesh. All of these factors justify the application of the qualitative method in this research. Similarly, the logic for the application of quantitative tools such as a survey is also very strong. The explored factors and variables relevant to SCR and the associated relationships among them need to be tested and verified statistically by collecting data through a quantitative survey which justifies the application of the quantitative method in this research.

3.3 RESEARCH METHOD

This study applied mixed methods research (Tashakkori and Teddlie 1998, 2003; Teddlie and Tashakkori 2012) which has become widespread in many disciplines including social science. It is also considered as the third research paradigm which helps to bridge the qualitative and quantitative methods at different phases of the research (Onwuegbuzie and Leech 2005). Mixed methods research offers a great opportunity to researchers who would like to use techniques that are used in practice (Johnson and Onwuegbuzie 2004). Due to being the most usable for research in practice, mixed methods research is becoming increasingly popular (Johnson, Onwuegbuzie, and Turner 2007; Teddlie and Tashakkori 2012). It uses qualitative and quantitative data collection and analysis techniques in either a parallel or sequential phase (Tashakkori and Teddlie 1998). In a similar spirit, Johnson, Onwuegbuzie and Turner (2007) state that mixed methods research is a synthesis that includes ideas from qualitative and quantitative research. They added that the objective of using mixed methods research is to minimise the weaknesses and draw from the strengths of each of the qualitative and quantitative methods rather than replacing either of these approaches (Johnson, Onwuegbuzie, and Turner 2007). Moreover, both research methods (qualitative and quantitative) facilitate each other when both are used in parallel and enhance the validity of the research (Creswell 2003). For example, the quantitative method documents the statistical proof and evidence on the factors and variables derived from the qualitative study. Therefore, a mixed methods study seems appropriate in this study.

With reference to Creswell (2003, 2007, 2008), mixed methods research can be segregated into four types: the triangulation design, the embedded design, the explanatory design and the exploratory design. Campbell and Fiske (1959) introduced the concept of triangulation, which they referred to as “multiple operationalism”, and referred to more than one method for the validation process. Creswell (2003) mentions that triangulation design guides researchers to collect and analyse data based on both qualitative and quantitative methods to validate or expand quantitative results with qualitative data. Like triangulation design, embedded design is a process that includes the collection of both qualitative and quantitative data but one of the data types works as an auxiliary role within the overall design (Creswell 2003). The explanatory design suggests the collection and analysis of quantitative data, and then that the collection and analysis of qualitative data is needed to support the quantitative findings. As

opposed to explanatory design, exploratory design starts with the qualitative phase of research at first which is then followed by the quantitative phase (Creswell 2003).

It is important to determine the appropriate type of mixed method for a particular research setting. To decide on an appropriate mixed method for this research, the objectives of this study needed to be evaluated and analysed. The main objective of this study is to develop a model of supply chain sustainability and resilience and to explore the relationship between supply chain vulnerability, resilience and sustainability. To operationalize the objectives of the research, a preliminary research model (Figure 2.2, page 49) was proposed on the basis of a wide literature review. As studies related to supply chain sustainability and resilience are still at the elementary stage and resilience is a contextual factor, qualitative study by adopting the field study method is considered important to ensure the applicability and validity of the model in a particular context. Therefore, a field study by conducting semi-structured interviews was performed and then a comprehensive model was developed based on the conceptual model and field study results. Following the field study, a quantitative survey was conducted to test the comprehensive model. Therefore, triangulation of the qualitative method followed by the quantitative method seemed appropriate in this research context.

3.4 RESEARCH PROCESS

In line with triangulation of both qualitative and quantitative methods, the qualitative method was deployed in the exploratory phase and the quantitative approach was executed in the confirmatory phase. The entire research process is shown in Figure 2.2.

Step-1: Literature Review

The first phase was initiated with a widespread review of the literature related to supply chain resilience (SCR), risk management and sustainability. In addition, as a foundation of the model, two relevant theories were also reviewed from the domain of strategic management literature, namely, the resourced-based view (RBV) and stakeholder theory. From the critical review, it was determined that the combination of the resource-based view (RBV) and stakeholder theory could justify the theoretical framework for the proposed model to be developed in this study. Thus, the key constructs and the association between the constructs of the proposed model were conceptualized and grounded on a strong theoretical foundation (see Chapter 2 for details).

Step-2: Development of Initial Research Model

Based on the review of the relevant literature, an initial research model of supply chain sustainability and resilience was developed which is diagrammatically presented by Figure 3.1. The constructs, sub-constructs and the links between constructs of the preliminary research model were rationalized and justified based on the review of the previous literature.

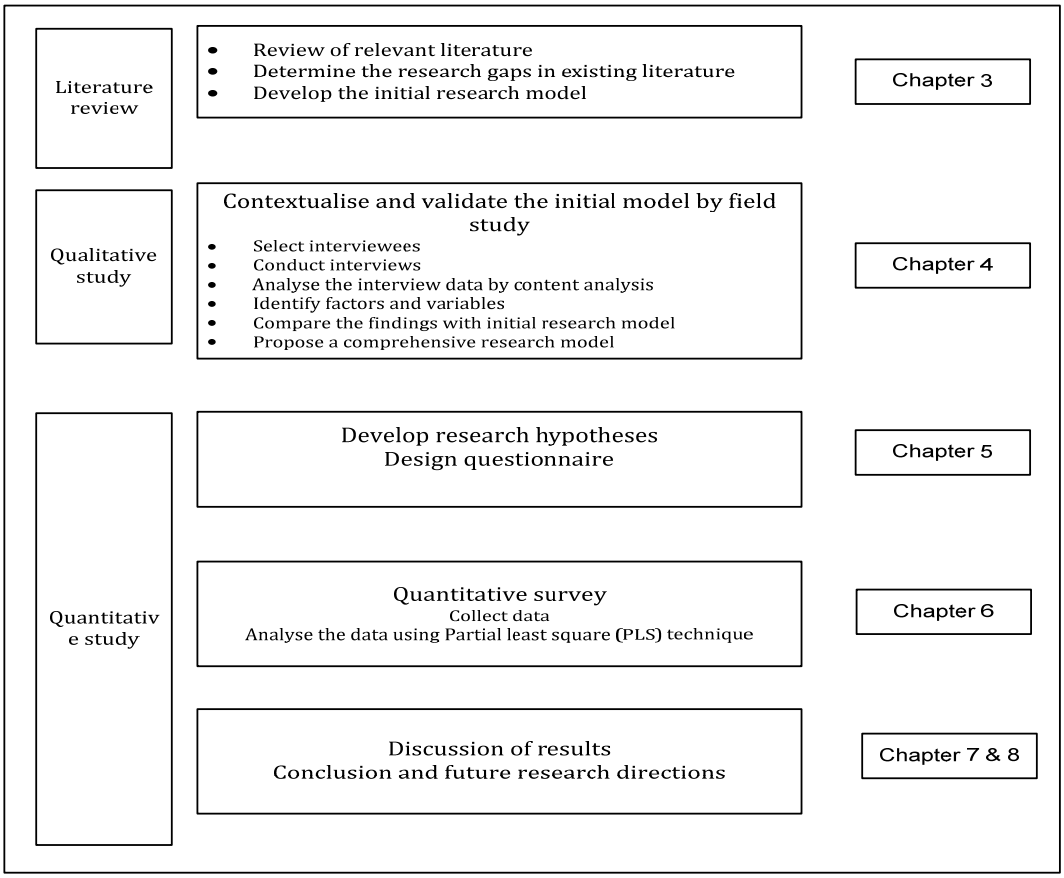


Figure 3.1: Research process

Step-3: Qualitative Field Study

Once the initial research model was developed, the field study through semi-structured interviews was then conducted to contextualize and validate the initial model developed from the literature review. Content analysis was used for data analysis. Based on content analysis, the factors and sub-factors were identified from the data from each interview. Then, cross-interview transcripts were compared and analysed to integrate all the individual factors and their associated relationships to generate a combined model. Details of the field study are highlighted in Chapter 4.

Step-4: Model Refinement

In this stage, to refine the initial research model, the findings from the qualitative data and the literature review were compared. Based on these findings, the necessary addition of items and constructs as well as the subtraction of redundant items and constructs were undertaken. Justifications based on previous theories and studies were analysed for each selected construct and dimension. Based on the refinement process, a final research model was proposed.

Step-5: Hypotheses Construction

From the careful review of the theories and application, each link between the constructs in the proposed model was justified to develop testable hypotheses. In this process, overall, 21 hypotheses were developed for quantitative verification of the links between the constructs. The detailed discussion of the hypotheses development is provided in Chapter 5.

Step-6: Questionnaire Design

An initial questionnaire was developed based on 26 constructs and 21 hypotheses. To ensure content validity, the measurement items for each construct were identified mostly from the previous literature. Some items were developed from the field study as those items were very relevant to the context. Thus, a tentative questionnaire was designed by using a six-point Likert scale. The details of the questionnaire design are provided in Chapter 5. This tentative questionnaire was then evaluated and refined through a pre-testing procedure to ensure reliability and validity of the measurement items.

Step-7: Pre-testing the Questionnaire

The initial questionnaire was pre-tested for refinement of the questions. The pre-testing procedure was conducted on 10 respondents. Based on the feedback from the pre-testing procedure, a refined questionnaire was developed.

Step-8: Pilot Study

A pilot study in the form of a survey was conducted next with the purpose of ensuring the applicability of the data. Supply chain managers were targeted for data collection. In total, 76 responses were collected from the pilot study (see chapter 6).

Step-9: Data Collection from the National Survey

National survey data were collected by a face-to-face questionnaire survey and mail survey on apparel manufacturing companies and accessory-supplying companies.

Supply chain decision makers in these companies were targeted for data collection. Respondents were selected by the convenience sampling method from the list of apparel manufacturers and accessory producers in the BGMEA directory.

Step-10: Data Analysis

Collected data were analysed by using SPSS and PLS-based structural equation modelling (SEM) (Chin 1998a; Ringle, Sarstedt, and Straub 2012; Barclay, Higgins, and Thompson 1995). SPSS was used for descriptive statistical analysis while PLS-based SEM was used for testing convergent validity, discriminant validity and testing the hypotheses.

Step-11: Discussion

The final step of the research process was discussion and interpretation of the results found from both qualitative and quantitative data analyses.

3.5 QUALITATIVE FIELD STUDY

A qualitative field study was deployed in the exploratory phase of the research to examine and to affirm the factors and variables (Creswell 2003) defined in the preliminary research model which is shown in Figure 2.2 (page 49). In conducting the field study, it was aimed to contextualise and validate the initial model developed from the literature review. It was also aimed at identifying factors and the association between the factors. A semi-structured interview approach was adopted which would help to gain a better understanding of the pros and cons of the research area. Moreover, the interview has been proven to be a very common and effective method in obtaining qualitative data (Malhotra 2004). Based on the qualitative field study outcome, the initial research model was fine-tuned.

3.5.1 Sample selection for qualitative field study

Like any other research method, field study also involves selecting samples from the population under study either through random or non-random methods (Xu and Quaddus 2005; Zikmund 2003). The sampling method used for this study is a convenience non-random type to which Malhotra (2004) referred as random and convenience sampling. The interview participants were selected based on three main criteria: (i) the employment position of the participants; (ii) the supply chain entity (apparel manufacturer or accessory producer); and (iii) the size of the company. Fifteen (15) decision makers who were either supply chain managers, general

managers, directors or the person responsible for supply chain decision making in the particular organization were chosen for interviews. The study focuses on sustainability and resilience of the apparel supply chain in Bangladesh: as a result, supply chain members within the manufacturing operation such as apparel manufacturers and accessory producers (suppliers) were selected for interviews. While buyers or buying agents are an important entity in the apparel supply chain, they were not interviewed because their involvement in the supply chain is mostly related to information flow and they are not involved in operational issues. Participants from firms of all sizes: small, medium and large were selected to get the real scenario about the whole industry. One participant from each company was selected for interview. A total of 15 interviews were collected consisting of 10 respondents from apparel manufacturing companies and five from suppliers/accessory-producing companies. No further interviews were needed because saturation level of the data was reached at this stage (Greg, Bunce, and Johnson 2006). The number of cases suggested by researchers differs. Some researchers recommend an open-ended number of cases while others suggest a restricted range. Between four and eight interviews are considered suitable for qualitative study (Eisenhardt 1989; Perry 1998); therefore, 15 interviews seemed enough for this study. The selection of all participants was based on personal contacts. Therefore, purposive sampling was employed in this regard (Corbin and Strauss 2008). Moreover, this technique provides the means to approach participants more conveniently (Cavana, Delahaye, and Sekaran 2001).

3.5.2 Data collection methods for qualitative field study

Once the selection of prospective sample companies was completed, the participants were approached by telephone to set their interview schedule. The response was encouraging as all of the prospective respondents agreed to participate in the interviews. All of the participants agreed to participate in a 1-1.5 hour interview and, therefore, a tentative schedule was fixed according to the convenience of the respondents. Once verbal consent was affirmed, the confirmation letter about the date and time of the interview and a brief outline about the interview were sent to them. It was ensured that interviewees' participation was fully voluntary and would be kept confidential. A semi-structured questionnaire was used to conduct the interviews. The interviews were recorded with the permission of the participants and notes were taken throughout the interviews. The interview duration was one hour and ten minutes on average. The data were transcribed immediately after the interview so that the essence

and tones of the interview were reflected properly. The interviews were conducted mostly in Bengali: as a result, during transcription, much attention was given to maintain the participants' original meaning. For further confirmation on this matter, participants were contacted for validation of the transcribed data.

3.5.3 Data analysis techniques for qualitative field study

For performing qualitative data analysis, content analysis is one of the useful techniques (Siltaoja 2006). Content analysis has also proven to be a good technique which has been widely applied in previous research. For example, Akter, D'Ambra and Ray (2013) and Xu and Quaddus (2005) employed it to examine the applicability of the conceptual model in a particular research setting. Since this research is more exploratory in nature than confirmatory, content analysis was used for analysis and examination of the collected data (Berg 2004). From the content analysis, factors and variables and their associated relationships were explored. The NVivo-9 software program was used to facilitate the data analysis process as it is a useful tool for searching, linking and exploring the pattern of data and ideas (Vickery, Dröge, and Germain 1999). According to Siltaoja (2006), the method of content analysis can be used in a number of ways. This study used the two-step process of inductive and deductive analysis (Berg 2004; Quaddus and Xu 2005) to scan and endorse the themes and sub-themes from the raw data to fulfil the objective of the exploratory study. Figure 4.1 (page 90) presents the sequential steps of the qualitative data analysis process in this study.

The first phase of the analysis was inductive. The inductive phase consisted of exploring themes, sub-themes, factors, sub-factors and variables. The interview contents were coded very carefully and a number of free nodes containing individual concepts were identified. Afterwards, tree nodes were developed from a set of relevant free nodes with a similar concept. Each tree node thus considered a prospective construct. The findings were frequently reviewed and checked time and again to ensure reliability. It also helped to double-check whether any theme or sub-theme was missed or even whether the classification was appropriately done. The findings from each interview were compared and afterwards, a comprehensive field study model was developed (Figure 4.2, page 116) by incorporating all constructs and dimensionality.

Once the inductive stage of content analysis was performed, the second phase, that is, the deductive analysis phase, began. This was a critical phase in which the model of the field study and the initial model (Figure 2.2, page 49) were reviewed. In this stage,

three steps were involved: first, the field model and the initial model were compared to assess the significance of the constructs and variables. Second, the findings from the field study were revisited and the constructs were selected based on commonality. Third, justification of the field study findings based on the literature review was carried out to finalise the constructs. Finally, based on the review of the field study model and initial model, a comprehensive refined model was developed which is shown by Figure 4.3 on page 126.

3.6 QUANTITATIVE STUDY

Once the refined model was finalised, the next step was the confirmation and validation of the factors, variables and the links among the factors by applying quantitative analysis. The quantitative phase or confirmatory phase of this research was comprised of developing the hypotheses and the questionnaire; pre-testing the questionnaire; conducting the pilot study; determining the sampling technique; collecting quantitative data; and analysing data through the partial least squares (PLS) method.

3.6.1 Hypotheses and questionnaire development

On the basis of the comprehensive research model, relevant hypotheses were developed. In total, 21 hypotheses were developed for testing different links among the constructs in the model. An initial questionnaire was also designed to measure different dimensions established by the refined model and to test the hypothesized relationships among the constructs. In order to design the survey instrument, this study deployed closed-ended questions. From the review of previous studies, it is evident that most of the SEM-based empirical studies deploy the Likert scale for measurement of the items in the survey instrument. This study adopted a six-point Likert scale to collect data based on the extent to which the respondents agreed or disagreed on each statement (1=strongly disagree and 6=strongly agree or 1=extremely low and 6=extremely high). The advantage of selecting a six-point scale is that it avoids a central tendency error because the pattern to choose the 'neutrality' answer is a common phenomenon during data collection in the context of Asian countries (Trompenaars and Hampden-Turner 1998). Blumberg, Cooper and Schindler (2008) also supported the view that the respondents' inclination to choose the middle response would lead to central tendency error. Therefore, the middle point for a seven-point Likert scale "neither agree nor disagree" was eliminated and finally a six-point

Likert scale was used for measurement. It can also be argued that the six-point Likert scale is easy to prepare and interpret, and also simple for respondents to answer (Zebal 2005; Zikmund, Carr, and Griffin 2012).

It is notable that one set of the questionnaire was used for both the manufacturers and suppliers because the operational aspects are almost same for the entities. Moreover, both supply chain members have similar types of vulnerabilities and face similar issues regarding sustainability. It is also noteworthy that the production process of each entity starts when the purchase order is placed by the buyers. Despite having an important role in the chain, buyers have not been included in the survey as their involvement in the chain is mostly with the flow of information rather than the physical operation (see Figure 2.1 on page 14 for more information).

3.6.2 Pre-testing the questionnaire

The initial questionnaire was pre-tested by sending the questionnaire to 10 respondents: four supply chain management academics, one BGMEA executive, three apparel supply chain decision makers and two accessory producers. The respondents were also asked for suggestions regarding the addition or deletion of particular questions and the clarity of the questions. All the respondents responded and sent their feedback. Overall, this procedure was conducted to reach a consensus on the understandability and viability of the selected dimensions. Based on the opinion of these experts, necessary modifications were done and the final version of the survey instrument was designed. Section 5.6 of Chapter 5 describes the details about the pre-testing process.

3.6.3 Pilot study

Based on the final version of the questionnaire, a pilot survey was conducted to test the applicability of the questionnaire and to identify any problems from the responses. Supply chain managers were the potential respondents. In some companies, the position of supply chain manager does not exist: as a result, the people who perform the supply chain functions were contacted in those organizations. Respondents were selected from the list of apparel manufacturers and accessory producers in the BGMEA directory by the convenience sampling method. The respondents were initially approached via telephone and they were informed about the objective of the research. Then, the managers who agreed to participate in the survey were selected for data collection. In all, 110 managers were contacted for the appointment and of them, 89 managers agreed to participate in the survey. Finally, 76 completed and usable

responses were collected from the respondents. Descriptive statistics of the pilot study data were analysed to check the viability of the questionnaire. Section 6.2 of Chapter 6 describes the details about the pilot study.

3.6.4 Study of population and sampling technique

The population in the research can be defined as the firms under the apparel industry of Bangladesh and, specifically, the apparel manufacturing companies and accessory-producing companies (suppliers). The aim of this research is to develop a model of supply chain sustainability and resilience in the context of the apparel industry of Bangladesh. Therefore, supply chain entities such as apparel producers and their suppliers are considered as the target population of this study. Firms of all sizes: small, medium and large were considered for the data collection process.

The broad-based survey data were collected by means of a face-to-face personal survey and mail survey of the apparel manufacturing and accessories companies situated in the Chittagong and Dhaka regions of Bangladesh. The name, address and contact details of the apparel manufacturers and accessory producers are available in the directory of the BGMEA. From the directory, 690 companies were contacted by telephone. The total targeted response from the survey was 350 which is enough for PLS-based SEM analysis. Purposive sampling was adopted for sample selection because the researcher needed to consider the location, size and type of the firms. The sampling procedure details are shown on Table 3.2.

Table 3.2: Sampling procedure for this study

Sampling process	Sampling strategy of the study	Comments
Target population	The apparel companies and accessory-producing (supplier) companies	To produce apparels, different accessories are needed which are either collected from local accessory producers or imported. The local accessory producers are targeted in this study.
Sampling frame	Two important business zones (Chittagong City and Dhaka City)	These two zones represent the sampling area of the target population.
Sampling unit	All apparel factories and accessory-producing factories in the two areas	These sample units contain the elements of the target population to be sampled.
Sampling elements	Supply chain managers or the person responsible for supply chain management functions	In some companies, the position of supply chain manager does not exist formally but the functions of supply chain management are performed by the general managers or the owner.
Sampling strategy	Convenience/purposive sampling	Three types of apparel and accessory producers: large, medium and small, are chosen.
Sample size	296 completed samples	76 for the pilot study and 220 for the main study.

3.6.5 Sample size determination

The number of observations is crucial for any statistical analysis to obtain the desired explanatory power of a model. This study adopts a partial least squares (PLS)-based structural equation modelling (SEM) approach to measure different dimensions and to test different hypotheses in the proposed model. Therefore, sample size should also be determined carefully in this research setting. With reference to Gefen, Straub and Boudreau (2000) and Chin, Marcolin and Newsted (1996), the minimum requirement of the sample size for a PLS study should be not less than 10 times the number of items within the most complex, formative construct of the model. On the basis of this rule of thumb, the minimum sample size requirement for this research is 70 responses (10 x 7) as the number of items in most complex formative construct: operations vulnerability is seven. The total usable response in this study is 296 which is more than the minimum sample size requirement of 70 aligned with the rule of thumb suggested by Gefen, Straub and Boudreau (2000) and Chin, Marcolin and Newsted (1996).

3.6.6 Quantitative data analysis by SEM

It was mentioned earlier that this study used partial least squares (PLS)-based SEM for quantitative data analysis. This is a second-generation data analysis technique that can handle a large number of variables and facilitate the researcher with the simultaneous running of several regression equations. The reasons for using SEM are discussed in the next section.

3.6.6.1 Why use SEM?

Structural equation modelling (SEM) offers a number of advantages such as: i) it has the flexibility of assessing the measurement properties of a construct under different theoretical settings in which they are entrenched; ii) it deals explicitly with measurement error; and iii) it facilitates the researchers with some other benefits which are not available with first-generation techniques such as multiple regressions, principal component analysis and cluster analysis (Barclay, Higgins, and Thompson 1995; Ullman and Bentler 2012). In addition, Barclay, Higgins and Thompson (1995) report that first-generation statistical analysis has some limitations that inhibit both creativity and the depth of analysis. However, the second-generation tool based on the

SEM method allows the researchers to answer a number of related research questions in a single, systematic and comprehensive analysis by simultaneously modelling the relationships among different independent and dependent constructs (Gefen, Straub, and Boudreau 2000). The research model in this study has a large number of

constructs and variables which cannot be analysed comprehensively by first-generation regression-based analysis. As a result, SEM, a second-generation data analysis technique which allows the simultaneous assessment of the measurement properties and the structural model, is suited for this study. It is also evident that SEM has been successfully applied in supply chain risk management models.

3.6.6.2 Justification for using PLS-based SEM for this study

Previous studies show that researchers use a number of SEM-based applications such as covariance-based SEM (CBSEM) (e.g. LISREL, AMOS) and partial least squares (PLS)-based SEM. Partial least squares (PLS)-based SEM is suggested for predictive research models focusing on theory development. Moreover, PLS-based SEM is suitable for exploratory research whereas covariance-based SEM is endorsed for confirmatory analysis and needs more solid observance of distributional assumptions (Hair, Ringle, and Sarstedt 2011; Ringle, Sarstedt, and Straub 2012; Rai, Patnayakuni, and Seth 2006; Chin 1995).

It can be argued that the focus of this study is quite new and very few empirical studies are available in this context. This research is also exploratory in nature as it attempts to explore the existing vulnerabilities and corresponding resilience capabilities in the context of the apparel supply chain in Bangladesh. It also explores the relationship between supply chain resilience, vulnerability and sustainability. To the best of the researcher's knowledge, there is no prior research that deals with predicting the interrelationship between supply chain vulnerability, resilience and sustainability in an integrated fashion.

Furthermore, the aim of this research is to develop theory rather than testing prior theory. Therefore, it is logical to use PLS-based SEM for this study. In addition, this study included both formative and reflective items. Therefore, PLS-based SEM which can handle both reflective and formative indicators unlike CBSEM-based applications (LISREL, AMOS), is suitable for this study (Barclay, Higgins, and Thompson 1995; Chin 1995; Rai, Patnayakuni, and Seth 2006; Ringle, Sarstedt, and Straub 2012). Another advantage of PLS-based SEM is the ability to handle complex model with a larger number of constructs (Chin 1995; Ringle, Sarstedt, and Straub 2012). The comprehensive model developed in this study included a larger number of constructs and the model is indeed complex. Therefore, based on the above argument, it can be deduced that PLS-based SEM is the ideal data analysis method applicable for this study.

3.6.7 Partial least squares (PLS) procedure

In the PLS-based SEM analysis, two procedures are involved: the assessment of the measurement model and the assessment of the structural model (Hair, Ringle, and Sarstedt 2011; Hair et al. 2012; Ringle, Sarstedt, and Straub 2012). In assessing the measurement model, specification of the causal relationship between manifest variables and the latent variable is very important (Jarvis, MacKenzie, and Podsakoff 2003). Based on the causal relationship between the latent variable and the indicators, two types of measurement models are available: reflective and formative models (Hair, Ringle, and Sarstedt 2011; Jarvis, MacKenzie, and Podsakoff 2003). The assessment of the measurement model is different for reflective and formative models. The proposed model in this study included both reflective and formative measurement; therefore, the assessment of the measurement model was conducted through examination of indicator reliability, internal consistency, average variance extracted (AVE), indicator weight, multi-collinearity and discriminant validity, aligned with the guidelines of Hair, Ringle and Sarstedt (2011). The structural model was evaluated by analysis of the explanatory power of endogenous constructs as well as examining the *t*-values of each path coefficient corresponding to the hypotheses. Table 3.3. depicts the systematic procedures for SEM analysis.

Table 3.3: Systematic procedures for SEM analysis

Stage	Type of Item	Type of Measurement	Decision Parameter
Stage 1 Assessment of Measurement Model	Reflective	Convergent validity	
		Item reliability	≥ 0.7, and *t*-value > 1.65
		Internal consistency	≥ 0.7
		Average variance extracted (AVE)	≥ 0.5
		Discriminant validity	
		AVE analysis	Square root of the AVE of a construct is larger than its correlation with other constructs
		Cross-loading matrix	Loading of an item within a construct is greater than its loading in any other construct
	Formative	Indicator weight	Review construct conceptualization and *t*-value = 1.65 (*p=0.1*)
		Multi-collinearity	VIF ≤ 10 or ≤ 5
Stage 2 Assessment of Structural Model	Reflective and Formative	Coefficient of determination	R2 ≥ 0.25
		Test of hypotheses	Significant *t*-value = 1.65

3.6.7.1 Specification of reflective or formative measurement

This research model includes both formative and reflective measurement constructs. As a result, specification of the measurement model, whether reflective or formative, is essential; otherwise, misspecification of measurement models often leads to biased results (Jarvis, MacKenzie, and Podsakoff 2003; Henseler, Ringle, and Sinkovics 2009). The following pages discuss the issues related to formative and reflective constructs. Based on these, the relevant constructs have been classified as either reflective or formative (see Chapter 5).

Based on the conceptualization, reflective items are deemed to be caused by the latent variable (see Figure 3.2). Due to the causal nature of the relationship between each item and the latent variable, any change in the construct would result in changes in the items. Moreover, the reflective model indicates that the measures are manifestations of constructs, that is, all the measures under a construct share a common theme (Jarvis, MacKenzie, and Podsakoff 2003; Polites, Roberts, and Thatcher 2011). Therefore, there are high correlations between items (Fornell and Bookstein 1982; Jarvis, MacKenzie, and Podsakoff 2003).

On the other hand, formative items show the opposite direction of the causal relationship (Diamantopoulos and Winklhofer 2001). Therefore, these items cause the latent variable (see Figure 3.3). The items are assumed to be not correlated and measure different underlying dimensions of the latent variable (Chin 1998a). Therefore, elimination of items is a serious concern as elimination of one item may change the meaning of the construct (Jarvis, MacKenzie, and Podsakoff 2003). The differing nature of the constructs in the conceptual model generated the need to use both formative and reflective items.

The selection of the measurement model (formative or reflective) for any construct needs theoretical deliberations (Coltman et al. 2008; Jarvis, MacKenzie, and Podsakoff 2003). In some cases, this choice is easier because the causal priority between the construct and the indicators is very clear. However, in some cases, choosing correctly between reflective versus formative measures can be difficult (Hulland 1999; Diamantopoulos and Siguaw 2006). In this regard, Jarvis, MacKenzie and Podsakoff (2003) developed a set of conceptual criteria that can be used as guidelines for determining the choice of either a reflective or formative measurement perspective. The decision rules are summarised in Table 3.4.

Table 3.4: Decision rules for formative or reflective measurements

	Formative model	**Reflective model**
1. Direction of causality between construct and measures	Direction of causality is from items to construct	Direction of causality is from construct to items
Whether the measurement items are defining characteristics or manifestations of the construct	Measurement items are defining characteristics of the construct	Measurement items are manifestations of the construct
Whether changes in the measurement items cause changes in the construct or not	Changes in the measurement items should cause changes in the construct	Changes in the measurement items should not cause changes in the construct
Whether changes in the construct cause changes in the measurement items	Changes in the construct do not cause changes in the measurement items	Changes in the construct do cause changes in the measurement items
2. Interchangeability of the measurement items	The measurement items need not be interchangeable	The measurement items should be interchangeable
Shall the measurement items have the same or similar content?	The measurement items need not have the same or similar content	The measurement items should have the same or similar content
Do the measurement items share a common theme?	The measurement items need not share a common theme	The measurement items should share a common theme
Whether dropping one of the domains of the construct items alters the conceptual domain of the construct	Dropping an item may alter the conceptual domain of the construct	Dropping an item should not alter the conceptual domain of the construct
3. Whether there is any covariation among the items	Not necessary for items to covary with each other	Items are expected to covary with each other
Whether a change in one of the indicators is associated with changes in the other indicators	Not necessarily	Yes
4. Nomological net of the construct indicators	Nomological net for the indicators may differ	Nomological net for the indicators should not differ
Whether the measurement items are expected to have the same antecedents and consequences	Items are not required to have the same antecedents and consequences	Items are required to have the same antecedents and consequences
Source: Jarvis, Mackenzie and Podsakoff (2003)		

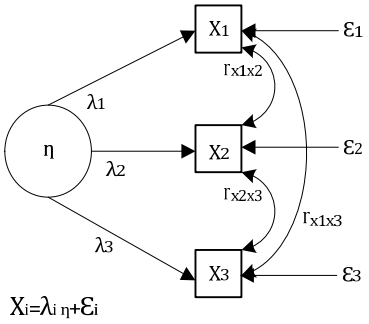


Figure 3.2: Reflective measurement model

η: latent variable; λ: loading; x: reflective indicator;
ε: measurement error on level of indicators;
r: correlation between indicators

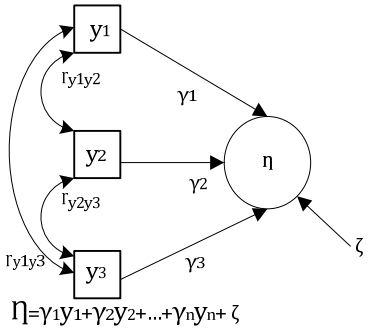


Figure 3.3: Formative measurement model

η: latent variable; γ: weight; y: formative indicator;
ζ: measurement error on level of the latent variable;
r: correlation between indicators

Figures 3.2 and 3.3 depict the relationship between the latent variable and its manifest variables in the case of both the reflective and formative measurement models. Based on the guidelines of Coltman et al. (2008), Jarvis, MacKenzie and Podsakoff (2003), Diamantopoulos and Siguaw 2006) and other studies, the constructs used in this study were modelled as either reflective or formative. With reference to the previous literature and the field study outcome, constructs relating to supply chain resilience (SCR), sustainability and antecedents of SCR were considered as reflective while supply chain vulnerability constructs were considered as formative in nature.

3.6.7.2 Assessment of reflective measurement model

It is important to assess the measurement model to evaluate the validity of a construct with reference to the manifest indicators (Santosa, Wei, and Chan 2005; Henseler, Ringle, and Sinkovics 2009). In the reflective measurement model, both convergent validity and discriminant validity are evaluated (Barclay, Higgins, and Thompson 1995; Santosa, Wei, and Chan 2005; Henseler, Ringle, and Sinkovics 2009). Convergent validity is assessed by calculating item reliability, internal consistency, and average variance extracted (AVE) whereas discriminant validity is ensured by examining item cross-loadings of the construct and comparing inter-construct correlations with the square root of AVE (Fornell and Larcker 1981; Hair, Ringle, and Sarstedt 2011). Unlike the reflective measurement model, the formative measurement model should be assessed based on the significance of the formative indicators' weights and the indicators' absolute importance or loading (Hair, Ringle, and Sarstedt 2011). Another way of assessing the formative measurement model is to determine redundancy by examining multi-collinearity in the formative indicators (Hair, Ringle, and Sarstedt 2011; Diamantopoulos and Siguaw 2006; Grewal, Cote, and Baumgartner 2004). The steps of the measurement model assessment are shown in Table 3.3.

Item reliability

Item reliability assesses the loading of each item with the constructs to examine how well each item relates to the respective construct. In other words, it measures the amount of variance in each individual item that occurs due to the construct (Barclay and Higgins 1995). Item loading also indicates the strength of the items to measure a particular construct. According to Nunnally (1978), low loading items indicate low correlation between the items in the construct whereas items with high loading indicate high correlation. In PLS, item reliability can be assessed by evaluating: (1) the item loading scores and their significance for the reflective measurement, or item level weights and their significance for the formative measurement (Hair, Ringle, and Sarstedt 2011; Ringle, Sarstedt, and Straub 2012). There are differences of opinion among researchers regarding the acceptable value of item loading. Hair, Ringle and Sarstedt (2011) opine that the item loading value should be higher than 0.7. In a similar fashion, Barclay, Higgins and Thompson (1995) suggest that the item loading threshold should be 0.707. They also suggest items with loadings less than 0.707 should be eliminated. However, some studies, for example, Chin (1998) and Hulland (1999) accept the item loading threshold as 0.5. Considering all the recommendations from the previous studies, and to maximise the convergent validity of the measurement model, in this research, the item loading threshold level was determined as 0.7.

Internal consistency

Construct reliability focuses on examining the composite reliability as a measure of internal consistency. It is used to establish the convergent validity to assure the unidimensionality and the correlation among the items in a construct (Hair, Ringle, and Sarstedt 2011; Fornell and Larcker 1981). In measuring reliability, it is a second-generation procedure developed by Fornell and Larcker (1981) which has overcome the weaknesses of the first-generation reliability measure using Cronbach's alpha. The review of past literature reveals that the minimum threshold for internal consistency is 0.7 (Hair, Ringle, and Sarstedt 2011; Fornell and Larcker 1981; Barclay, Higgins, and Thompson 1995; Hair et al. 2012). However, there are debates with regard to the cut-off point. For example, Bagozzi et al. (1998) and Henseler, Ringle and Sinkovics (2009) suggested 0.60 as the cut-off point value for internal consistency. The cut-off value for internal consistency considered in this study is 0.7.

Internal consistency can be calculated by using the following formula:

$$\text{Internal consistency} = \frac{(\Sigma\lambda i)^2}{(\Sigma\lambda i)^2+\Sigma \text{Var}\,(\varepsilon i)}$$

where λi = the factor loading which represents simple correlation between the item and its constructs, and Var (εi) = $1 - \lambda i^2$, the unique/error variance.

Average variance extracted (AVE)

To assess construct validity, the average variance extracted (AVE)of a construct by its corresponding items is useful (Fornell and Larcker 1981; Hair, Ringle, and Sarstedt 2011). It measures the variance explained by a particular construct with respect to its indicators (Fornell and Larcker 1981). The acceptable value for AVE suggested by Fornell and Larcker (1981) is 0.5 which is also supported by Hair, Ringle and Sarstedt (2011), Hair et al. (2012) and Henseler, Ringle and Sinkovics (2009). An AVE value of more than 0.5 refers to satisfactory convergent validity as the latent variable is able to explain more than half of the variance of its indicators on average (Henseler, Ringle, and Sinkovics 2009). The formula for calculating AVE is denoted by:

$$\text{Average variance extracted (AVE)} = \frac{\Sigma\lambda i^2}{\Sigma\lambda i^2+\Sigma \text{Var}\,(\varepsilon i)}$$

Where, λi factor loading denotes the simple correlation between the item and its constructs (item loading), and Var (εi) = $1 - \lambda\, i^2$ (the variance).

Discriminant validity

The next step for the evaluation of the measurement model is discriminant validity analysis. Discriminant validity for reflective measurement evaluates the degree to which constructs differ from each other. In other words, it tests statistically the degree of variance shared among the items and constructs in the model. Referring to Barclay, Higgins and Thompson (1995), Henseler, Ringle and Sinkovics (2009) and Hair, Ringle and Sarstedt (2011), there are two analytical procedures for this assessment: i) comparison between the square root of average variance extracted (AVE) of the constructs and the correlations among the constructs and ii) cross-loading matrix evaluation at the item level.

The requirement for fulfilling the conditions of discriminant validity is the off-diagonal elements (the correlation of latent variables) shall be less than or equal to the diagonal elements (square root of the AVE) in the corresponding rows and columns (Hair,

Ringle, and Sarstedt 2011; Barclay, Higgins, and Thompson 1995; Fornell and Larcker 1981; Henseler, Ringle, and Sinkovics 2009). Furthermore, in order to satisfy the criteria of discriminant validity through the cross-loading matrix**,** Hair, Ringle and Sarstedt (2011); Barclay, Higgins and Thompson (1995); Henseler, Ringle and Sinkovics (2009); and Chin (1998b) suggest that the loading of an item within a construct shall be greater than its loading with any other construct.

3.6.7.3 Assessment of formative measurement model

The literature suggests that for formative measurement models, the concepts of reliability and construct validity are not necessary (Bollen and Lennox 1991; Jarvis, MacKenzie, and Podsakoff 2003; Bagozzi and Heatherton 1994; Hair, Ringle, and Sarstedt 2011). The validity of formative indicators is established based on the theoretical rationale (Hair, Ringle, and Sarstedt 2011; Rossiter 2002). To assess a formative model at the indicator level, it is important to evaluate whether each indicator contributes to the formative index by referring to the intended meaning. In this regard, the details will be discussed in Chapter 5. With reference to Henseler, Ringle and Sinkovics (2009) and Hair, Ringle and Sarstedt (2011), the validity of the formative construct can also be assessed by statistical analyses at the construct and indicator levels. The significance of indicator weight and loading is useful for this assessment (Henseler, Ringle, and Sinkovics 2009; Hair, Ringle, and Sarstedt 2011). According to Cenfetelli and Bassellier (2009) and Hair, Ringle and Sarstedt (2011), a particular item shall not be included in the formative index if both weight and loading are insignificant. However, Fornell, Lorange and Roos (1990) and Santosa, Wei and Chan (2005) support the inclusion of all formative items even if the weight is very low or negative because, in the case of the formative construct, omitting an indicator is omitting a part of the construct (Bollen and Lennox 1991).

It is also important to determine the redundancy of the formative indicators (Hair et al. 2011; Hensler et al. 2009). In this regard, researchers should examine the variance influence factor (VIF) to test the degree of multi-collinearity for the formative indicators (Grewal, Cote, and Baumgartner 2004; Hair, Ringle, and Sarstedt 2011; Henseler, Ringle, and Sinkovics 2009). A VIF value of 5 or less is acceptable. If the VIF value is more than 5, it means that 80% of an indicator's variance is due to the remaining formative indicators related to the same construct (Hair, Ringle, and Sarstedt 2011; Henseler, Ringle, and Sinkovics 2009).

3.6.7.4 Assessment of hierarchical and multidimensional constructs

This research model includes hierarchical and multidimensional measurement constructs: as a result, juxtaposition of the hierarchical construct and its justification is required. The following sub-sections discuss the details of the hierarchical construct.

The hierarchical construct which is also referred to as the multidimensional construct can be defined as a construct that has more than one dimension (Wetzels, Odekerken-Schroder, and Van Oppen 2009; Jarvis, MacKenzie, and Podsakoff 2003). In a broader spectrum, Law, Wong and Mobley (1998) define a construct as multidimensional when it consists of a number of interrelated dimensions and exists in multidimensional domains. For operationalizing a particular construct as multidimensional, theoretical justification is very important. Theory should indicate the number of (sub)-dimensions and their relationship to the higher-order construct (Johnson et al. 2012; MacKenzie, Podsakoff, and Podsakoff 2011; Polites, Roberts, and Thatcher 2011). Failure to properly specify a multidimensional construct may lead to poor model fit (Polites, Roberts, and Thatcher 2011; Jarvis, MacKenzie, and Podsakoff 2003). Once the focal construct has been carefully defined, it is imperative to answer whether the construct has more than one conceptually distinguishable sub-dimension. If a construct is multidimensional, then it is important to define each of the sub-dimensions with due care (MacKenzie, Podsakoff, and Podsakoff 2011).

Levels and modes of hierarchical construct

Hierarchical and multidimensional concepts are characterized by: (i) the number of levels in the model (e.g. second-order or third-order level) and (ii) the relationships (formative vs. reflective) between the constructs in the model (Ringle, Sarstedt, and Straub 2012; Wetzels, Odekerken-Schroder, and Van Oppen 2009; Becker, Klein, and Wetzels 2012). A higher order construct is reflective (type I and III in Figure 3.4) if the higher-order concept is manifested by several specific dimensions that are unobserved, while a higher-order construct is formative (type II and IV in Figure 3.4) if it is a combination of several specific (latent) dimensions (Wetzels, Odekerken-Schroder, and Van Oppen 2009). A higher-order construct may be at different levels, for example, second order, third order or even fourth order; however, the second-order level is the most widely observed hierarchical model in the literature. A second-order hierarchical latent variable model can be classified into four types based on the relationship among: (i) the first-order latent variables and their manifest variables, and (ii) the second-

order latent variable and the first-order latent variables (Ringle, Sarstedt, and Straub 2012; Jarvis, MacKenzie, and Podsakoff 2003) which are shown by Figure 3.4.

The reflective-reflective type I model is most appropriate if the objective of the study is to find the common factor of several related, yet distinct reflective constructs. The formative-reflective type III model is useful if a higher-order construct represents the common part of several indices that are supposed to measure the same thing. In the reflective-formative type II model, the lower-order constructs are reflectively measured constructs which form a general concept. In the formative-formative type IV model, the lower-order constructs are measured by formative indicators and the formative indices eventually form a general concept at a higher-order level (Chin 1998b; Becker, Klein, and Wetzels 2012).

Higher-order reflective construct in the study model

At the second-order level, supply chain capability is measured by the first-order constructs: flexibility, redundancy, integration, efficiency, market position and financial strength (Pettit, Fiksel, and Croxton 2010, 2013; and others) as a reflective model. It can be contended that a highly capable and resilient supply chain exhibits more flexibility, redundancy, efficiency, integration, etc. than its less resilient counterpart (Pettit, Fiksel and Croxton 2013; Jüttner and Maklan 2011). It can also be argued that there is a high interdependence among the reflective first-order constructs. For example, flexibility is related to redundancy and integration (Stevenson and Spring 2009; Braunscheidel and Suresh 2009). Similarly, the construct, efficiency, is related with redundancy and integration (Christopher and Peck 2004). With this backdrop, aligned with the decision rule of Jarvis, MacKenzie and Podsakoff (2003), it is logical to model supply chain capability as a reflective higher-order construct.

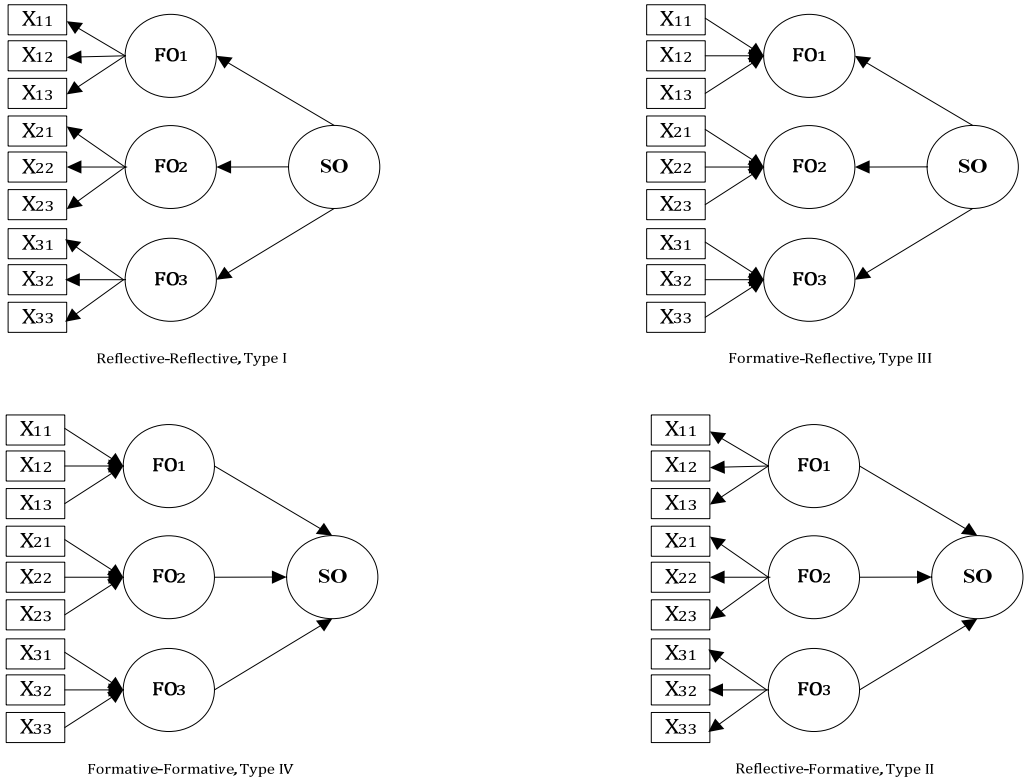


Figure 3.4: The four types of hierarchical latent variable models

Higher-order formative construct in the study model

In line with the previous literature (Blackhurst et al. 2005; Blos et al. 2009; Pettit, Croxton, and Fiksel 2013) and the field study outcome, it is apparent that the construct, supply chain vulnerability (SCV), is multidimensional and is operationalized as a formative construct both at the higher-order and lower-order levels. Supply chain vulnerability (SCV) consists of the first-order formative constructs such as hazard vulnerability, strategic vulnerability, and financial, operational, infrastructural and demand–supply vulnerabilities and these constructs are defining characteristics of the higher-order construct, SCV (Jarvis, MacKenzie, and Podsakoff 2003). Moreover, the first-order vulnerability constructs are independent and uncorrelated, for example, hazard vulnerability, strategic vulnerability and financial vulnerability may occur randomly and are not supposed to be related to each other.

Approaches to measure hierarchical construct

Measurement of a hierarchical latent variable can be performed by using three approaches: (ii) the repeated indicator approach (Lohmöller 1989); (ii) the two-stage approach (Ringle et al. 2012; Wetzels et al. 2009); and (iii) the hybrid approach

(Wilson and Henseler 2007). In the repeated indicator approach, a higher-order latent variable can be constructed by specifying a latent variable that represents all the manifest variables of the underlying lower-order latent variables (Lohmöller 1989; Becker, Klein, and Wetzels 2012). The two-stage approach estimates the construct scores of the first-order constructs in a first-stage model and subsequently uses these first-stage construct scores as indicators for the higher-order latent variable in a separate second-stage analysis (Wetzels, Odekerken-Schroder, and Van Oppen 2009; Wilson and Henseler 2007). The linear composites from the items used to measure each first-order construct are operationalized as the proxies of the first-order constructs to measure second-order constructs (Rai, Patnayakuni, and Seth 2006). Latent variable scores, factor scores or multivariate means can be used to compute linear composites (Hair, Ringle, and Sarstedt 2011; Rai, Patnayakuni, and Seth 2006). In this study, latent variable scores were used as the proxies of the first-order constructs as they maximise the R^2 value estimation of the endogenous latent constructs (Lohmoller 1989). The hybrid approach splits the indicators of each first-order construct and uses one half to estimate the first-order construct and the other half to estimate the second-order construct (Wilson and Henseler 2007).

The two-stage approach has the advantage that it estimates a complex higher-order model in a more parsimonious way without needing the lower-order constructs (Becker, Klein, and Wetzels 2012). Moreover, to operationalize a hierarchical model with formative first-order and formative second-order constructs, the two-stage approach generates less measurement bias (Becker, Klein, and Wetzels 2012). Therefore, to operationalize the complex hierarchical model of this study, the two-stage approach has been used.

3.6.7.5 Assessment of structural model

Once the evaluation of the measurement model is completed and it is proved to be reliable and valid, the next step is to assess the structural model (Henseler, Ringle, and Sinkovics 2009; Hair, Ringle, and Sarstedt 2011; Fornell and Larcker 1981). Barclay, Higgins and Thompson (1995); Santosa, Wei and Chan (2005); and Hair, Ringle and Sarstedt (2011), state that the structural model assessment examines the statistical significance of the hypothesized relationships between constructs by examining the path loadings and path coefficients among the latent constructs.

An advantage of using PLS-based SEM is that the technique is effective for prediction and estimation of the coefficient of determination (R^2) values which are usually used to

characterize the ability of the model to explain and predict the endogenous latent variables (Ringle, Sarstedt, and Straub 2012; Hair, Ringle, and Sarstedt 2011). In line with the guidance of Hair, Ringle and Sarstedt (2011), the structural model of this research has been assessed by examining the explanatory power of the proposed model. The explanatory power of the proposed model with respect to each construct can be assessed by the R^2 values for each construct (Hair, Ringle, and Sarstedt 2011). The R^2 values can be obtained from the bootstrapping result of the PLS run. There are differences of opinion regarding the acceptable values of R^2. According to Hair et al. (2011), R^2 values of 0.75, 0.50 and 0.25 for endogenous latent variables can be considered as substantial, moderate or weak, respectively. However, a substantial number of studies (e.g. Santosa, Wei, and Chan 2005) support an even lower value for the acceptable value of R^2.

Along with R^2 values, the path coefficients and *t*-values of the hypothesized relationships were calculated to assess the significance of the relationships among constructs in the model following the guidelines of Hair, Ringle and Sarstedt (2011). Studies in line with PLS-based SEM suggest two non-parametric approaches to test the relationship between constructs, namely, the jackknife and bootstrap techniques (Santosa, Wei, and Chan 2005; Gefen, Straub, and Boudreau 2000). A review of the previous literature also endorses that both methods have advantages and disadvantages (Chin 1998a). However, for the data analysis in this research, the bootstrapping method is chosen as it is considered to be a more advanced approach than the jackknife method (Chin 1998a).

Nomological validity

Nomological validity is evaluated to examine whether the indicators of the focal construct are related to the measures of other constructs specified in the construct's theoretical network (MacKenzie, Podsakoff, and Podsakoff 2011). The statistical significance of the path coefficients for endogenous to exogenous constructs provides the key test of nomological validity of the focal construct's indicators (MacKenzie, Podsakoff, and Podsakoff 2011; Akter, D'Ambra, and Ray 2013). If these path coefficients are significant, it implies that the focal construct relates to the constructs specified in the nomological network and, therefore, increases confidence in the validity of the indicators (MacKenzie, Podsakoff, and Podsakoff 2011; Akter, D'Ambra, and Ray 2013).

Nomological validity of a construct can also be examined by further evaluating the adequacy of the multidimensional structure of the focal construct (Edwards, Ward, and Bytheway 1995). In the case of an endogenous multidimensional focal construct with reflective indicators (Figure 3.5), this can be conducted by evaluating the direct effect of the antecedent construct on the sub-dimensions of the focal construct and the indirect effect that this antecedent construct has on the sub-dimensions through the focal construct itself (Edwards 2001; MacKenzie, Podsakoff, and Podsakoff 2011). If the indirect effects of the antecedent on the sub-dimensions of the focal construct are substantially larger than the direct effects of the antecedent on the sub-dimensions, it can be inferred that the dimensions of the multidimensional construct are valid (MacKenzie, Podsakoff, and Podsakoff 2011).

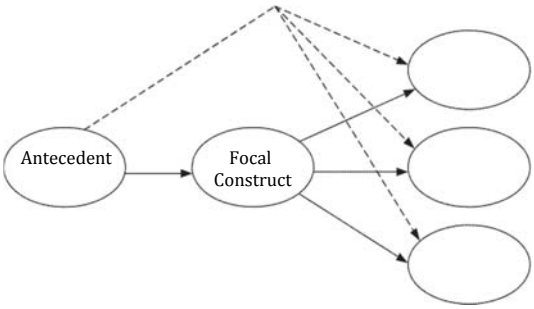


Figure 3.5: Nomological net for reflective construct

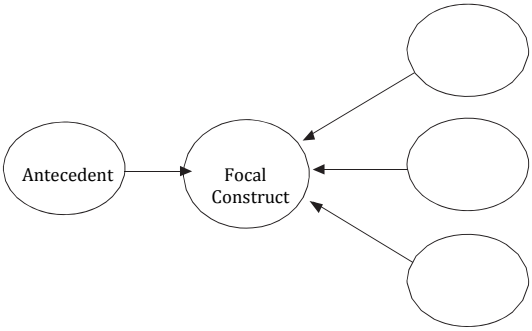


Figure 3.6: Nomological net for formative construct

In the case of an endogenous multidimensional focal construct with formative indicators (Figure 3.6), the testing of the multidimensional structure cannot be done as suggested above. According to Edwards (2001), the R^2 value for the effect of the antecedent on the focal construct shall be equivalent to the multivariate R^2 value for the focal construct's sub-dimensions to support the dimensions of a multidimensional construct. However, it can also be tested by evaluating whether the direct effects of the antecedent on each sub-dimension (without the focal construct in the model) are equal (MacKenzie, Podsakoff, and Podsakoff 2011).

Predictive validity

Predictive validity examines whether the scores from a measurement procedure make accurate predictions about the construct they represent (Newsome 2000). In order to ensure predictive validity, the predictive sample reuse technique (Q^2 value) (Chin 2010; Fornell and Cha 1994) can be used. Based on the blindfolding procedure, the Q^2

value evaluates the predictive relevance of a large complex model using PLS. The predictive relevance for a particular construct can be measured based on the following parameters:

$$\text{Predictive relevance } (Q^2) = 1 - \frac{\sum_D E_D}{\sum_D O_D}$$

where E = the sum of squares of prediction error; O = the sum of squares error using the mean for prediction and D = the omission distance.

The Q^2 value can be estimated by using two different types of prediction techniques: cross-validated communality and cross-validated redundancy. For a larger and complex model, Chin (2010) suggest using cross validated redundancy technique. Therefore, this study estimates the cross-validated redundancy to estimate the predictive relevance of the hierarchical supply chain resilience construct and other endogenous constructs in the model. The Q^2 value is generally calculated using an omission distance of 5-10 under existing PLS software packages. The rule of thumb specifies that a cross-validated redundancy of $Q^2 > 0.5$ is regarded as a predictive model (Chin 2010; Akter, D'Ambra, and Ray 2013).

Effect size

Along with evaluating the size of the R^2 values of all endogenous constructs, one can also calculate the $\mathbf{f^2}$ effect size**.** The $\mathbf{f^2}$ effect size estimates the role of a specific exogenous latent construct in predicting the endogenous constructs. The rule of thumb to evaluate f^2 values is 0.02, 0.15 and 0.35 for small, medium and large effect sizes, respectively (Cohen 1988). Effect size is calculated by applying the following formula:

$$f^2 = \frac{R^2_{\text{included}} - R^2_{\text{excluded}}}{1 - R^2_{\text{included}}}$$

where f^2 = effect size; R^2 included = value of R^2 after including control variables; R^2 excluded = value of R^2 without including control variables.

Goodness-of-Fit (GoF)

Goodness-of-Fit (GoF) is used to determine the overall prediction power and to evaluate the overall performance of both measurement and structural parameters of a large complex model.

Although the overall fitness index is suitable for assessing reflective indicators, it can also be applied for formative indicators (Akter, D'Ambra, and Ray 2011; Chin 2010). As such the GoF index is suggested by Tenenhaus et al. (2005) for assessing the global validity of PLS-based complex models. GoF index is measured by the geometric mean of the average communality and average R^2 values for the endogenous constructs (Wetzels, Odekerken-Schroder, and Van Oppen 2009; Tenenhaus et al. 2005). It is notable that in the PLS algorithm, output communality equals average variance expected (AVE).

Therefore, GoF can be calculated as $GoF = \sqrt{AVE \times R^2}$

Based on the calculation of GoF, Tenenhaus et al. (2005) indicated that GoF should be less than 1 and more than 0. More specifically, Wetzels, Odekerken-Schroder and Van Oppen (2009) considered the GoF value to be 0.1, 0.25 and 0.36 for small, medium and large, respectively.

It is worth noting that there are competing views on using GoF in PLS SEM for example, Henseler and Sarstedt (2013) challenged the use of GoF in PLS SEM.

Power analysis

Power analysis represents the probability of obtaining a statistically significant result (H1) or successfully rejecting the H0 (Cohen 1988). It is also important to validate the implications of sample sizes in developing and validating a complex model using PLS path modelling (Chin and Newsted 1999; Akter, D'Ambra, and Ray 2011). The power analysis depends on three parameters: the significance level (α), the sample size (N) of the study and the effect size (Cohen 1988). Cohen (1988) suggested that the power of a statistical test should be more than 0.80. This confers adequate confidence in the hypothesized relationships in a model having power > 0.80 (Akter, D'Ambra, and Ray 2011).

3.7 SUMMARY

This chapter has elucidated the research design for this study. In the early section, the research paradigm and the issues related to the quantitative and qualitative methods were discussed. The rationale for choosing the mixed method (a combination of

qualitative and quantitative methods) was then discussed. The next section entailed the description of the data collection and analysis processes in both the qualitative (field study) and quantitative phases (pilot study and survey). The details about the qualitative and quantitative phases are described in Chapters 4, 5 and 6. The final section of this chapter presented the summary of the research design.

Chapter 4

FIELD STUDY ANALYSIS

4.1 INTRODUCTION

This chapter describes the analysis of the data derived from the field study. The field study was conducted by semi-structured interviews with 15 decision makers (concerned with supply chain decision making) from apparel manufacturing companies and their suppliers in Bangladesh.

The focus of this phase is to cross-examine the factors and variables defined in the preliminary research model as shown in Figure 2.2 (page 49). This research has been conducted on the apparel supply chain of Bangladesh but the initial research model was compiled from the literature review which is based on different contexts. Therefore, the field study is necessary to ensure that the model is valid and applicable in this particular research context. In addition, the field study aims to dig deeper with a view to explore the pervasiveness of the constructs in the model.

This chapter starts with the overview of the field study followed by the findings of the content analysis including both inductive and deductive stages. From the analysis of field study data, a field study model was developed and then it was compared with the initial model. Finally, a comprehensive and refined research model of supply chain sustainability and resilience was established.

4.2 OVERVIEW OF THE FIELD STUDY

4.2.1 Qualitative research paradigm

As was mentioned earlier, this study uses the mixed method approach with the field study being conducted in the qualitative phase of this research (Akter, D'Ambra, and Ray 2013; Quaddus and Xu 2005; Zikmund 2003). The field study was conducted by semi-structured interviews with 15 supply chain decision makers of apparel manufacturing companies and their suppliers in Bangladesh. The review of the relevant literature has provided the framework for the initial development of the interview questions. The literature also helped in refining the interview questions so that they would better fit the actual situation. Once the method of collecting data is selected, the next step is selection of the samples. The sampling method used for this study is a convenience non-random type.

The significance of the field study was to develop a refined model of supply chain sustainability and resilience. Based on this refined model, a quantitative study was conducted by undertaking a questionnaire survey on the apparel industry of Bangladesh. This type of research, a qualitative approach followed by a quantitative approach, is usually known as mixed method research (Johnson, Onwuegbuzie, and Turner 2007) which is a popular and widely used approach in the present research stream (Curry, Nembhard, and Bradley 2009; Johnson, Onwuegbuzie, and Turner 2007; Creswell and Clark 2007; McEachern and Warnaby 2005). The details of the field study process are presented in the following sections.

4.2.2 Interview questionnaire development

To integrate the main aspects of the model: supply chain vulnerability, resilience and sustainability, overall, nine questions were designed in the field study. Table 4.1 presents the topics with the relevant questions.

The first topic explores the general idea of the apparel supply chain in terms of firms/entities involved in the chain as well as the flows of goods, services and information among them. Question 1 has been designed in this regard. The respondents were asked about the supply chain members of their organization and how those supply chain members are related to the organization in terms of the flow of goods and services.

The second topic identifies the vulnerabilities in the supply chain and the role of resilience to overcome those vulnerabilities. Questions 2, 3, 4 and 5 have been designed corresponding to this topic. More specifically, question 2 investigates whether the organizations and their supply chains are disrupted by different uncertain events and vulnerabilities. Likewise, question 3 is designed to identify the specific vulnerabilities in the supply chain. Similarly, question 4 explores the resilience in the supply chain and question 5 reveals whether resilience is important for the organizations and their supply chains.

Questions 6 and 7 have been planned to gain an insight about supply chain resilience measurement. Therefore, question 6 is about the measurement of resilience of organizations corresponding to supply chain disruptions. In a similar fashion, question 7 enquires about the ways and means of improving supply chain resilience (SCR). It basically explores the enablers/antecedents of SCR.

Finally, the last topic concentrates on supply chain sustainability and its relationship with SCR. In line with this, question 8 explores the understanding of supply chain

members about sustainability of their organizations and supply chains. Question 9, last but not least, investigates the relationship between resilience and sustainability in the sense of whether resilience is important for sustainability. It also asks why resilience is important or why not.

Table 4.1: Issues and related questions in the field study

Topic	Questions	Descriptions of the questions
To explore the supply chain and related flows	1	The different supply chain members of the organization and the functional relationship with them
To explore the vulnerabilities in the supply chain, resilience and resilience measurement	2	Existence of vulnerabilities in the supply chain
	3	Identification of vulnerabilities
	4	Understanding about supply chain resilience
	5	Importance of supply chain resilience
	6	The way of measuring supply chain resilience
	7	The means of improving supply chain resilience
To understand the view of supply chain members about sustainability and to investigate the relationship between supply chain resilience and sustainability	8	Idea about different aspects of sustainability of the organizations and their supply chains
	9	The relationship between resilience and sustainability with respect to determining the importance of resilience for supply chain sustainability

Based on the answers and feedback from field study respondents, an in-depth idea about the factors and variables related to supply chain vulnerabilities, resilience and sustainability was obtained. In addition, the relationships among the factors were comprehended which is discussed in subsequent sections. A complete set of questions for the field study is provided in Appendix A. It is worth mentioning that these questions were approved by Curtin University's ethical requirements.

Before conducting the first interview, a pilot study was performed to test the understandability and applicability of the questions in the interview guide. The pilot study was also useful to discover any other issue related to the questions. Three participants consisting of one apparel manufacturer, one supplier and one researcher (a PhD research fellow on apparel supply chain barriers of Bangladesh), took part in the pilot study. The pilot study respondents from the apparel manufacturer and supplier were interviewed over the telephone while the other respondent who is pursuing PhD research at Curtin University on the apparel supply chain was interviewed face to face. All the questions seemed relevant; however, some modifications were performed according to the feedback of pilot study respondents. For example, before modification, question 8 stated: what is your understanding about sustainability? Following feedback, however, the question was extended to: what is your understanding about sustainability and how is it applied to the supply chain of

your organization? Thus, the interview questions were finalised for the field study interviews. The interviews were conducted with 15 supply chain decision makers (supply chain managers, general managers and directors) of different apparel manufacturing companies and their suppliers.

4.2.3 Sample selection

Fifteen (15) decision makers were chosen for interviews. The selection of all interviewees was based on personal contacts and convenience: as a result, purposive sampling or non-random sampling was employed in this research (Corbin and Strauss 2008; Malhotra 2004). The selected decision makers were highly knowledgeable on supply chain functions as a result collected data were consistent and reliable. A copy of the interview questions with a detailed information sheet about the study objectives was provided to assist the understanding of the participants. The participants took part in this study voluntarily. The demographic information of the interview participants is presented on Table 4.2.

4.2.4 Data collection

Once the sample selection was accomplished, the interviewees were approached by telephone to set their interview schedule. The response was encouraging as 15 managers out of 18 agreed to participate in an interview. The interview duration was one hour and fifteen minutes on average. Interview data were recorded with the permission of the participants and notes were taken throughout the interview. The data were transcribed immediately after the interview so that the essence and tones of the interview would be properly reflected.

4.2.5 Data analysis

Content analysis was used because this research is more exploratory than confirmatory in nature (Berg 2004; Berg 2008). From the content analysis, the relationships between the different constructs were explored. The NVivo-9 software program was used to facilitate the data analysis process as it is a useful tool for searching, linking and exploring the pattern of data and ideas (Richards 1999). This study uses the two-step process of inductive and deductive analysis (Berg 2004; Quaddus and Xu 2005) to scan and endorse the themes and sub-themes from the raw data to fulfil the objective of the exploratory study.

The themes, sub-themes, factors, sub-factors and variables were identified in the inductive phase. A number of free nodes were identified and afterward tree nodes were developed from a set of relevant free nodes with similar concepts. Each tree node was thus considered as a prospective construct. The constructs developed from each

interview were compared and, finally, a field study model (shown in Figure 4.2, page 116) was developed based on all the significant constructs and dimensionalities. The first phase of the qualitative data analysis was finalised at that point.

The second phase is deductive analysis. In this phase, the field study model and the initial model were compared and reviewed to assess the significance of the constructs and variables and to justify the field study findings based on the literature review. Ultimately, a comprehensive and final research model for this study was developed. The steps followed for the qualitative phase of this research are shown by Figure 4.1.

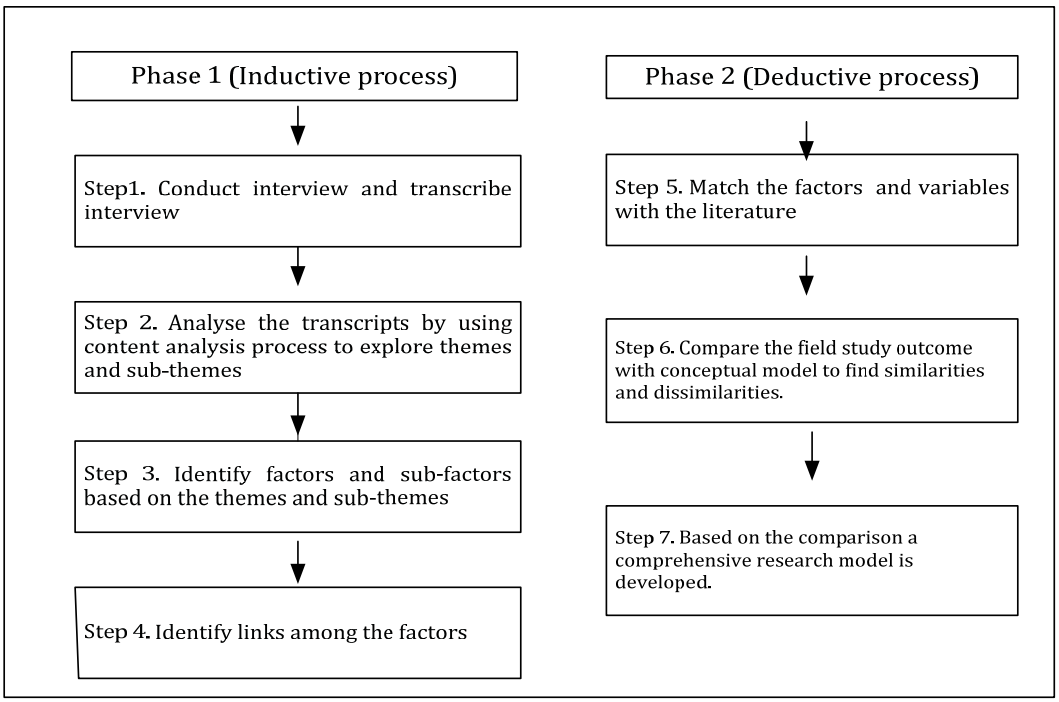


Figure 4.1: Data analysis process of the field study

4.2.6 Participants' description

Fifteen (15) participants, comprised of 10 decision makers from apparel manufacturing companies and five from accessory-producing companies (suppliers), were chosen for data collection. Convenience sampling was adopted in this regard. Careful attention was given to select apparel manufacturers and suppliers of different sizes (large, medium and small). Table 4.2 presents the profile of the participants in this study. Supply chain decision makers of each organization were interviewed.

Table 4.2 shows that the participants were selected from large, medium and small firms. For example, among the sample manufacturers, D4, D6, D8, D9 and D11 are from large firms; D1, D3 and D7 are from medium firms, and D2, D5, D10, D12, D13, D14 and D15 are from small firms.

Table 4.2: Participants' description

Partici-pants	Position	Company type	Company size (no of employees)	Age of company
D1	Manager merchandising	Apparel manufacturer	2000-3000	10-15
D2	Supply chain manager	Supplier	Less than 1000	5-10
D3	Manager merchandising	Apparel manufacturer	1000-2000	0-5
D4	General manager	Apparel manufacturer	More than 4000	5-10
D5	Managing director	Apparel manufacturer	1000-2000	5-10
D6	Supply chain manager	Apparel manufacturer	More than 4000	20-25
D7	General manager	Apparel manufacturer	2000-3000	20-25
D8	Supply chain manager	Apparel manufacturer	More than 10000	20-25
D9	Manager merchandising	Apparel manufacturer	3000-4000	5-10
D10	Supply chain manager	Supplier	Less than 1000	5-10
D11	Deputy general manager	Apparel manufacturer	More than 20000	25-30
D12	General manager	Supplier	Less than 1000	0-5
D13	Deputy general manager	Supplier	Less than 1000	10-15
D14	Deputy general manager	Supplier	Less than 1000	15-20
D15	Manager merchandising	Apparel manufacturer	Less than 1000	10-15

4.3 FINDINGS OF THE FIELD STUDY (1st stage: inductive analysis)

This section describes the findings of the field study based on the first stage of content analysis. The findings are provided in the following five sub-sections: firstly, findings related to supply chain vulnerability and, secondly, findings related to resilience and their measurements are discussed. Findings related to the antecedents of resilience are presented in the third section and findings in line with the sustainability factors (social, environmental and economic) and operational issues are presented in the fourth section. Finally, findings with respect to the relationships among different factors and sub-factors are included.

4.3.1 Supply chain vulnerability

Supply chains are often vulnerable to numerous disruptions (Pettit, Fiksel, and Croxton 2013). The apparel supply chain of Bangladesh is also exposed to a number of vulnerabilities such as labour unrest, political instability, interruption in utility supply, disruption in timely supply of material, increased competition, etc. (Hossan, Sarker, and Afroze 2012; Islam, Bagum and Choudhury 2012). The participants in the field study also focused on the existence of a number of vulnerabilities which affect the targeted time, cost and revenue. From the content analysis, it was revealed that vulnerabilities are different in nature. Some are very uncertain and uncontrollable which can be termed as hazard vulnerabilities, while a number of vulnerabilities are strategic in nature. In addition, some of the vulnerabilities are related to financial

aspects and some are associated with operational disruptions and can be labelled as operational vulnerabilities. Similarly, a number of vulnerabilities occur due to infrastructural problems: on the other hand, some are linked with demand and supply disruptions. Details of the field study findings on supply chain vulnerability are discussed in the following sub-sections.

Hazard vulnerability

Field study data reveal that the apparel supply chain of Bangladesh is frequently disrupted by a number of hazards such as natural disaster (N=12), fire and other accidents (N=4), labour unrest (N=6) and political instability (N=13). These hazards are unpredictable in nature and, as a result, precautions are critical. Occurrences of such vulnerabilities create obstacles to the process of material procurement, and production and distribution of goods. For example, participant 1 stated that *"... Last year, [the] flood in China delayed the procurement of material ..."* On the other hand, participant 2 stated that *"... couple of months before, our production was off for 15 days due to labour unrest".* These disruptions not only affect the functions of the focal firm but also the whole supply chain. For example, a delay in production may increase the time to market a product which results in loss of a competitive position in the market.

Strategic vulnerabilities

Some vulnerabilities are strategic in nature and have a long-term impact. A number of such vulnerabilities have been reported by the participants, for example, competition (N=8), non-compliance of social and environmental factors (N=7), problem with relationships with buyers and suppliers (N=6), problem of integration (N=5) and plant location problem (N=4) (see Table 4.3). Concerning the vulnerability arising from the relationships with buyers and suppliers, participant 15 illustrated that *"... Our factory is not located in [an] industrial zone {.....} We cannot do loading and unloading during day time which cause[s] a delay in [the] procurement and shipment process."* The field study participants also reported that competition is increasing both from the domestic and international market. China, Vietnam, India and Sri Lanka are close competitors of Bangladeshi apparel producers. Buyers choose the best offer from among the competitors. Participant 9, for instance, stated that *"... 5 years back, there were only 4-5 apparel [factories] that used to produce shirts. But now many companies produce and export shirts. We need to collect the order by beating these companies ..."*

Financial vulnerabilities

Financial vulnerabilities have an impact on the financial condition of the organizations. This may happen due to different financial occurrences. In the apparel industry of Bangladesh, financial issues often affect supply chain performances. Participants reported issues such as currency fluctuation (N=10), economic recession (N=13), ups and downs of raw material price (N=13), high bank interest rates (N=5) and bankruptcy of supply chain members (N=3). For example, regarding currency fluctuation, participant 6 indicated that *"Our accessories suppliers are dependent on foreign raw material: as a result, currency fluctuation is responsible for fluctuation of material price."* Aligned with this, participant 8 added that *"Raw material price hike is a problem because I have a commitment with my buyer at a specific price … I cannot charge a high price from the buyer if price is increased."* Most of the participants reported the problem of economic recession. Corresponding to this, participant 3 explained that "*We have an Italian buyer and we used to export 2 million dollars each month to that buyer. But a couple of months before, their order is reduced due to recession in Europe."* Some of the participants reported about the existence of high interest rates. This increases the overall cost of their products; for example, participant 5 indicated that *"… Sometimes bank interest is even more than 18% …"*

Operational vulnerability

Operational vulnerability occurs due to disruptions during the processing of products. Different types of operational vulnerabilities may affect the apparel supply chain functions. Shortage of skilled labour (N=12), switching and absenteeism of workers (N=13) and disruptions in utility supply (N=15) are a few among many operational disturbances (see Table 4.3) as reported by the participants. For example, participant 4 stated that *"… We give salary on 5th day of [the] month and then on 6th day find that 200 workers left their job …"* In addition, the issue of utility supply was raised as being of high importance during the interviews. Utility supply is not steady which creates disruptions during production and increases the production lead time. As an example, participant 4 stated that *"… Electricity is failing frequently nowadays. It hampers our production because production process is stopped as electricity goes off. It takes some time to set up the processes again …"*

Infrastructural vulnerability

Infrastructural vulnerability occurs due to disruptions arising from poor infrastructure. Different types of disruptions may occur from infrastructural inefficiencies. The field

study participants reported examples such as delay in custom clearance (N=5), inefficiency of port operations (N=8) and delay due to poor land transportation facilities (N=8) (see Table 4.3). Corresponding to poor land transportation, participant 8 explained that *"sometimes it takes more than two days to transport a container from Dhaka to Chittagong but it should not take more than 6 hours ..."* This type of delay hampers the production process if there is no safety stock of material remaining.

Demand and supply vulnerability

Some of the vulnerabilities occur from the demand and supply side. Vulnerabilities such as suppliers' delay and disruption (N=8), dependence on imported material (N=14), non-conformity of material (6), buyers' disruptions (N=5) and demand fluctuation (N=5) were reported by the participants. Among the vulnerabilities, dependence on imported material and non-conformity of the material sourced were supported by the majority of the participants (see Table 4.3 for details). On the other hand, the least-reported issue was buyers' disruptions (N=5). Regarding demand and supply disruptions, participant 1, for example, indicated that: *"Sometimes suppliers make delay[s] in procuring material and cannot supply us on time ..."*

Dependence on imported material is an important problem for the apparel manufacturers of Bangladesh. It creates delays in sourcing and increases the production lead time. A number of participants reported this vulnerability. For example, participant 2 stated that *"We are dependent on foreign raw material: as a result, we need more lead-time ..."*

Sometimes suppliers send the wrong material or may supply material that falls short of the required quality. If non-conformity of material supply occurs due to the fault of domestic suppliers, it is possible to rectify in a reasonable time but if such problems occur in the case of foreign suppliers, it will be a significant problem. As lead time is limited, rectification of the imported product is challenging.

Vulnerability in the supply chain may also occur due to buyers' problems or opportunism. Sometimes some buyers try to take extra benefits. However, most participants agreed that it does not occur frequently and does not occur among good buyers. The accessory suppliers to the apparel manufacturers also reported that, in some cases, apparel manufacturers try to take benefits in the form of a discount by raising a false claim. In line with this, participant 10, for example, added that *"... Sometimes buyers [say] that out of 10000 pieces, 1000 pieces have been rejected and try*

to take 1000 pieces extra ...". It was also revealed from the field study that, in some cases, some buyers delayed making payments which delays the apparel manufacturers in paying their suppliers. Another major problem that occurs from the buyers' side is a sudden change in specifications. If an order is already placed and a sample is approved, the apparel manufacturer starts procurement and production. If, suddenly, during the work in process, the buyers change any specification, it is very difficult to adjust because some products are already produced, procured material is already in the pipeline or some material has already been supplied. This creates problems for the entire supply chain. This is explained by participant 4 as:

"... our buyer approved a sample with 11 snap buttons on a shirt. I booked material as per the specification approved by the buyer. We started production for 2-3 days and by this time, the buyer sent a message that there will be a change in the buttons."

From the above quotations and content analysis, a consolidated picture of supply chain vulnerabilities can be obtained as shown on Table 4.3.

Table 4.3: Supply chain vulnerability factors

Factors	Variable	Enterprises														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
HV	Natural disaster (flood, cyclone, earthquake)	y	y	y	y		y	y	y	y	y			y	y	y
	Fire and other accidental damage			y						y				y	y	
	Labour unrest		y	y				y			y		y	y		
	Political instability	y	y		y	y	y	y		y	y	y	y	y	y	y
SV	Increased competition	y		y		y		y	y	y					y	y
	Non-compliance of social and environmental factors				y		y		y				y	y	y	y
	Problem of relationship with buyer and suppliers			y	y			y		y	y					y
	Problem of integration and real-time information			y							y	y			y	y
	Plant location problem (far from port or lack of infrastructural facilities)	y				y		y								y
FV	Currency fluctuation	y	y	y		y		y	y		y		y	y	y	
	Economic recession		y	y	y	y	y	y	-	y	y	y	y	y	y	y
	Raw material price fluctuation		y	y	y	y	y	y	y	y	y		y	y	y	y
	High bank interest and fund shortage			y		y							y		y	y
	Bankruptcy of any supply chain member									y	y				y	
OV	Shortage of skilled workers	y		y		y	y	y	y	y	y	y	y	y		y
	Switching and absenteeism of workers	y	y	y	y	y	y	y		y	y	y	y	y		y
	Fault in production planning	y									y	y				y
	IT system failure									y		y				y
	Disruption in utility supply	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y

	Product quality defects	y	y		y	y			y	y	y				y	y
	Illiteracy of workers and supervisors				y				y		y	y	y	y	y	y
IV	Delay in custom clearance				y		y		y				y	y		
	Inefficiency in port	y			y		y		y		y		y	y		y
	Delay in transportation					y			y	y	y	y	y	y	y	
DSV	Suppliers' disruptions	y		y		y		y	y	y	y					y
	Dependence on imported material	y	y	y	y		y	y	y	y	y	y	y	y	y	y
	Non-conformity of material	y			y		y		y			y		y		
	Buyers' disruptions				y					y	y		y		y	
	Demand fluctuation/uncertainty		y								y		y	y		y

HV=Hazard vulnerability, SV=Strategic vulnerability, FV=Financial vulnerability, OV=Operational vulnerability, IV=Infrastructural vulnerability, DSV=Demand–supply vulnerability.

Table 4.3 clearly shows that the field study participants confirmed the existence of numerous vulnerabilities in the apparel supply chain of Bangladesh. In this situation, the apparel manufacturers and their suppliers need capabilities to overcome those vulnerabilities and to sustain their organizations in this business.

The field study participants talked about a number of capabilities to mitigate the existing vulnerabilities. For example, the participants emphasised flexibility, responsiveness, efficiency, proper supply chain network structure, etc. Participant 1, for instance, stated that *"we always keep alternative suppliers so that if one supplier fails to supply us we can get it from another."*

The participants also focused on the importance of readiness, response and recovery to mitigate the vulnerabilities. According to them, quick response is very important in the apparel business. Participant 11, for example, stated that *"sometimes buyers request some extra quantity from us because of over-demand. In that situation, we need to respond quickly …"*

Some participants focused on the recovery factor. They indicated that quick recovery in the apparel business is vital; otherwise, buyers will not wait for them and may switch to other producers.

From the above analysis, it was revealed that supply chain members need to exhibit a number of resilient attributes during critical times to overcome vulnerabilities. In an attempt to delve deeper about the factors, more information was extracted. The following section explains the factors of supply chain resilience in detail.

4.3.2 Findings regarding supply chain resilience

Resilience is the capacity of a system to achieve recovery to the previous position or to an even better position if the system is interrupted (Christopher and Peck 2004).

Supply chain resilience (SCR) is needed to mitigate the disruption which is posing a threat to the supply chain (Pettit, Croxton, and Fiksel 2013; Jüttner and Maklan 2011). From the content analysis, it was revealed that the apparel supply chain of Bangladesh requires resilience capabilities to overcome vulnerabilities as the supply chain is often jeopardised by numerous disruptions. For instance, participant 13 stated that *"a few months before we had an occurrence of fire in one of the production floors but we met the production target from alternative production capacities ..."* This statement demonstrates the requirement for alternative and back-up capacity. Similarly, the field study participants expressed their concern about different types of capabilities (see Table 4.4 for details). When probed deeper about supply chain capabilities, some participants commented about flexibility, a few mentioned reserve capacity, a number emphasised integration, while others spoke about efficiency, market position and financial strength.

Supply chain flexibility

Supply chains need flexibility to cope with the changes and the uncertainties (Pettit, Fiksel, and Croxton 2013). As the apparel supply chain of Bangladesh is exposed to different disruptions, supply chain flexibility is important to mitigate those disruptions. From the content analysis, a number of capabilities related to supply chain flexibility were explored such as flexibility in production (N=10), product customization (N=11), multi-skilled workforce (N=8), contract flexibility (N=10), cost effectiveness (N=7), responsiveness (N=12) and introducing a new product (N=5).

The participants agreed that to meet the delivery deadline, they increase the production hours and pay their employees for overtime working hours. It was also known that sometimes the workers work during holidays to meet the production target. The statement of participant 6: *"If we have [a] shortage of time, we meet [the] target by overtime work"* can be cited with reference to flexibility in the production capacity and schedule.

The field study participants emphasised their responsiveness to customers' requirements, for example, the ability to meet flexible order sizes for the convenience of different buyers. In relation to this, participant 9 mentioned that *"we take orders of 50 units to even 5 million."* Participant 2 also emphasised the responsiveness to customers' requirements and indicated that *"We allow partial orders or even additional orders to customers ..."*

Some participants emphasised flexibility in the contract in terms of payment. This

provides flexibility to the manufacturers and suppliers for funds management. As an example, participant 7 reported that *"we have partial payment arrangements with our suppliers ..."*

Redundancy

Some capacities are needed as back-up or alternatives which can be termed as redundancy. Redundant capacity is effective for overcoming supply chain vulnerabilities (Pettit, Croxton, and Fiksel 2013). Capabilities such as reserve capacity/alternative logistical options (N=9), buffer stock (N=7) and a back-up utility source (N=11) were mentioned by the participants to overcome volatility of demand, supply shortage and other uncertain events.

With respect to alternative logistical capability, two-thirds of the participants focused on the necessity of meeting the uncertainties. To them, if there is alternative logistical capability, they can run supply chain functions smoothly even in the case of a crisis. For example, participant 11 stated that *"we always keep alternatives ... last month, one of our boilers failed but we had one alternative and we used it to continue production."*

Most participants stressed the importance of a back-up utility source because utility supply is not reliable in Bangladesh and it is one of the major causes of disruption in production. This statement of participant 8 supports the necessity of a back-up utility source: *"We have our own power generation which is very important because we do not have uninterrupted power supply from PDB (Power Development Board) ..."*

Integration

Integration in the supply chain can help the supply chain members to overcome disruptions (Pettit, Fiksel, and Croxton 2013). Sharing information with supply chain partners (N=11), internal integration (N=12), collaboration and communication with supply chain partners (N=7) and ICT adoption (N=5) were supported by the participants with the details presented in Table 4.4. It is evident that information sharing with supply chain partners was suggested by almost two-thirds of the participants. On the other hand, one-third of the participants agreed on the issue of ICT adoption. Regarding collaboration and information sharing, participant 3, for example, reported that *"We have good relations with supply chain members and we inform everything to the buyers and suppliers. We try to minimise loss and disruption by mutual understanding. If we do not have [a] good understanding with our supplier we cannot give good service to our buyers ..."* In line with ICT-supported planning, participant 2 stated that *"Our whole production planning and processing is based on [an] (enterprise*

resource planning) ERP system: as a result we have less faults and problems regarding planning."

Efficiency

It is evident from the field study analysis (see Table 4.4) that a number of participants focused on the capability of efficiency for mitigating vulnerability and for achieving resilience. This finding also was in agreement with the studies of Pettit, Fiksel and Croxton (2013) and Fiksel (2003). Factors relevant to efficiency such as waste reduction, workers' efficiency and quality control were revealed by the participants. Participants expressed their perceptions about the necessity of efficiency in a number of ways. For example, corresponding to worker efficiency, participant 6 justified that *"We improve the efficiency of employees. Earlier it was 30% but now it is 70%. We have a two-year plan to train the people with different skills."* Similarly they mentioned other issues related to efficiency. For example, waste elimination was supported by nine out of 15 participants. Worker efficiency was mentioned by 10 participants and finally, nine participants indicated their support for quality control.

Market strength

The field study participants mentioned some capabilities such as buyer–supplier satisfaction (N=10), preferred brand (N=5) and buyer–supplier relationship (N=8) which were explored in the interviews. These factors help to increase the strength of an organization in the market over its competitors. In this research, these factors are labelled as "market strength" which helps to mitigate supply chain vulnerability through establishing a value-based relationship with supply chain partners. Pettit, Fiksel and Croxton (2013, 2011) also stated the importance of market strength for supply chain resilience (SCR). According to the field study participants, a good relationship with all supply chain members, through mutual understanding, helps them to reduce the risk of loss. Consistent with this, the statement of participant 8 can be quoted as *"we have good understanding with our buyers: as a result, if we take one or two weeks more than the targeted shipment time due to any trouble, they understand the situation*" Regarding buyers' preferred brand, participant 10, for example, stated that "*… we are [the] preferred brand to the buyers and they nominate the apparel manufacturers to buy from us."*

Financial strength

The field study participants emphasised financial strength to mitigate supply chain vulnerability. Some of them mentioned that their financial strength helped them to be

more resilient. In response to further probing about financial strength, a number of factors were explored such as funds availability (N=9), consistency of profit (N=8) and insurance for assets (N=9). With respect to funds availability, participant 13, for example, stated that, *"... even if we face loss in a particular consignment, we do not have a problem to pay workers because we have enough funds ..."*

From the above statements and content analysis, a summary of capability factors has been compiled which is shown in Table 4.4.

Table 4.4: Supply chain capability factors

Capability	Variable	Enterprises														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flexibility	Flexible production schedule	y	y				y	y	y	y		y		y	y	y
	Product customization		y		y	Y	y	y		y	y		y	y	y	y
	Multi-skilled workforce		y		y		y	y		y	y		y		y	
	Contract flexibility	y	y	y	y	Y	y		y	y	y			y		
	Cost effectiveness			y	y	Y		y	y			y	y			
	Responsiveness	y	y	y	y	Y	y		y	y	y			y	y	y
	Introducing new product	y		y				y				y	y			
Redundancy	Reserve capacity	y	y	y	y		y		y		y	y		y		
	Buffer stock		y						y		y	y	y	y	y	
	Back-up energy/utility source	y	y		y		y	y	y		y	y		y	y	y
Integration	Information sharing	y	y	y	y	y		y		y	y		y		y	y
	Internal integration		y	y	y	y	y	y	y	y	y		y		y	y
	Collaboration		y	y			y	y	y	y		y				
	ICT adoption		y		y		y				y			y		
Efficiency	Waste reduction	y	y	y	y		y		y	y	y					y
	Efficiency of employees		y	y		y	y	y	y	y		y		y	y	
	Quality control	y	y	y	-	y	y	y	-	y		y	y			
Market Strength	Buyer and supplier satisfaction	y			y		y		y	y	y	y	y	y	y	
	Preferred brand (having buyer's nomination)		y				y		y		y		y			
	Buyer–supplier relationship	y			y	y	y		y		y			y		y
Financial strength	Funds availability	y	y			y	y		y		y	y		y	y	
	Consistent profit		y		y	y	y		y		y	y			y	
	Insurance	y	y	y		y		y		y	y			y		Y

As shown on Table 4.4, the supply chains exhibit the capabilities of flexibility, redundancy, integration, efficiency, market strength and financial strength to overcome vulnerabilities. If a supply chain fails to show these attributes during a critical time, its sustainability will be challenged in the long run.

Supply chain design

Along with the capability factors, for resilience, some other issues such as multiple sourcing arrangements, alternative distribution, alternative market, alternative production and backward linkage facilities were echoed by the voices of participants.

These factors seem to relate to the supply chain network structure and are effective in mitigating some of the important vulnerabilities. It is evident that 13 of the 15 participants agreed about the existence of alternative suppliers while alternative distribution arrangements were supported by 10 participants. In addition, 12, five and seven participants expressed their support for a diversified market, differential production location and backward linkage facilities, respectively. Participants perceived the importance of supply chain resilience (SCR) capabilities in different ways. For example, participant 3 stated that *"We try to cover different markets rather than depending on only US or EU market. {....} when there was recession in US, we tried to take more orders from Europe ...."*

Furthermore, concerning alternative distribution and transportation modes, participant 3 stated that *"... If we fail [with a] vessel, we may arrange air shipment up to Singapore then from Singapore to final destination, goods are shipped through sea ... it saves our cost and time."* The response of the field study participants about the supply chain design issues are shown by Table 4.5.

Table 4.5: Supply chain design factors

Factors	Variables	Participants														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SC Design	Alternative sourcing	y		y	y	y		y	y	y	y	y	y	y	y	y
	Alternative distribution	y	y	y	y		y	y	y	y	y	y				
	Alternative market	y	y	y	y	y	y	y	y	y	y	y				y
	Alternative production	y	y						y		y	y				
	Backward linkage facilities	y	y	y			y				y	y	y			

Table 4.5 reveals that supply chain design factors such as alternative sourcing, distribution, market options, production facilities and required backward linkage facilities are important for mitigating supply chain vulnerabilities.

Readiness

From the content analysis, it was revealed that a substantial number of participants talked about the issues related to training and preparation such as preparedness training (N=10), resources (N=5), early warning signals (N=5), forecasting (N=7) and a security system (N=11) for reducing the chances of risk and risk consequences. As these factors are relevant to the supply chain preparation for disaster response, they are labelled as supply chain readiness. Previous studies (e.g. Pettit, Croxton and Fiksel 2013; Sheffi and Rice 2005) also support the importance of readiness to minimise the impact of disruptions. Readiness is important in the sense that one may have resources

but may not have the required readiness to use the resources during a crisis effectively and efficiently (Rousaki and Alcott 2006). Prior information and forecasting about disruptions help so that alternative preparation can be made in advance. Forecasting is very important for apparel suppliers. They need to forecast in advance because their demand is derived from the demand of apparel manufacturers. Participant 2 stated that *"... we need to forecast at least two-three months in advance ..."* The lead time of apparel manufacturers is short: as a result, the suppliers need to respond to apparel manufacturers' demand very quickly. To supply within the limited time and to respond to sudden demand of the apparel manufacturers, good forecasting is very important; otherwise, demand cannot be met in time. Participants also emphasised readiness training. In this regard, participant 8 illustrated that "*In every month, we have fire drilling and fire equipment checking operation ..."* Similarly, the field study participants expressed their opinions about the importance of supply chain readiness issues.

Response and recovery

Quick response is crucial during a critical situation. Being a little late in response may account for a multimillion dollar loss. The financial loss of Ericsson after the fire in a supplier's plant (Norrman 2004) can be mentioned as an example of such an event. The participants also expressed their opinions regarding the importance of quick response. Eight of the 15 participants supported the capability of quick response. Corresponding to this, participant 11 mentioned that *"if there is a sudden declaration of a strike during shipment time, we finish everything overnight to send the products to the port before the strike."*

Both recovery time and cost are considered important determinants for resilience as per the opinions of participants. Ten (10) of the 15 participants confirmed the importance of quick recovery. On the other hand, only three participants supported the importance of recovery cost. Regarding recovery time, participant 13, for example, reported that *"we can recover very quickly because of our financial ability."* Corresponding to quick recovery ability, participant 8 mentioned that *"a couple of months before, during industry-wide labour unrest, some outside labourers attacked our factory and damaged some of our delivery trucks but we managed alternative transportation from a 3rd party very quickly."*

With regard to recovery cost, participant 3 stated that *"We can recover from vulnerability at less cost due to our skilled people and preparedness."*

From the above quotations and content analysis, an overview of readiness, response and recovery can be obtained from Table 4.6.

Table 4.6 reveals that a supply chain needs to exhibit a number of attributes to have better readiness, response and recovery. Such attributes help to offset the vulnerabilities in the supply chain.

Table 4.6: Supply chain readiness, and response and recovery factors

Factors	Variables	Participants														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SC Readiness	Readiness training		y		y	y	y		y	y	Y	y		y	y	
	Readiness resources		y		Y		y		y		Y					
	Early warning signals		y		y		y		y	y						
	Forecasting		y					y	y		y		y	y		y
	Security	y	y	y	y	y	y		y	y	y		y		Y	
SC Response and Recovery	Quick response		y		y		y		y	y	y	y		y		
	Quick recovery	y		y	y		y		y	y	y	y	y	y		
	Loss absorption		y				y				y			y		
	Reduction of impact	y		y	y	y	y	y	y	y	y	y	y	y	y	y
	Recovery cost			y					y	y						

4.3.3 Antecedents of supply chain resilience

The field study participants also expressed their opinions about the requirement for some factors that help them to improve resilience. The participants voted for supply chain orientation, supportive environmental factors, learning and development, and supply chain risk management. According to them, these factors facilitate them to improve resilience. Details about supply chain resilience (SCR) antecedent factors are described below.

Supply chain orientation

The participants expressed their views on the importance of some factors such as trust (N= 14), commitment (N= 12), cooperation (N=10) and top management support (N=5) in order to perform supply chain functions smoothly and to mitigate disruptions. In the literature, these factors are considered as supply chain orientation (Mentzer et al. 2001). This statement of participant 3 is similar to the perception of field study participants: *"We always try to create trust. … we inform everything to the buyers which helps us to ease the situation if there is any problem."* In addition, participant 8 expressed his company's commitment towards supply chain members as he stated that *"we are always committed to deliver on time."*

Supportive factors

The field study participants placed emphasis on the role of government support, institutional support and other facilitating factors to enhance and improve resilience capability. As the interviews delved deeper, it was observed that different participants posited the importance of different supportive environmental factors. Among them, eight participants commented about government support in the form of tax incentives and infrastructural development. Ten (10) participants focused on the existence of cheaper labour, while nine participants talked about a favourable international trade environment and trade body support. In this research, these facilitating services and factors are termed as supportive environmental factors. To explain what was meant by a supportive international trade environment, participant 1, for example, stated that "*the GSP [Generalized System of Preferences] facility in Europe is helping us a lot to compete."* Participant 3 added that "*We want a duty-free access facility. We are enjoying it in some countries which keep our price lower than competitors."* Similarly, participant 10 stated that *"if government improves port, customs management and transportation structure we can accomplish the supply chain functions quicker and better."* Therefore, it was understood that supportive environmental factors can facilitate organizations and their supply chains to improve their resilience towards competitive pressure.

Learning and development

Learning from past experience influences the adaptability and resilience capabilities (Giunipero and Eltantawy 2004; Pettit, Fiksel and Croxton 2010). Furthermore, continuous learning and development effort helps organizations to perform better and to be competitive. Field study participants also shared similar experiences. For example, while discussing the facilitating factors of supply chain resilience (SCR), some participants talked about training and counselling (N=7), research and development (R&D) (N=5), development opportunity (N=5) and learning from experience (N=8). They indicated that to improve resilience, they need to learn and create an environment for development. Therefore, altogether, these factors are similar to the learning and development of an organization and, therefore, they are labelled as learning and development. Participants' opinions about learning and development can be cited as *"when an employee joins, we train and counsel him/her to develop skills"* (participant 13). Furthermore, *"we provide opportunity to employees if they show good performance"* (participant 4).

Supply chain risk management

Supply chains need risk management efforts in an attempt to facilitate resilience capabilities (Jüttner and Maklan 2011). The field study participants also mentioned risk sharing (N=9), effort to reduce disruptions (N=13), effort to know about risk (N=5) and risk consideration in decision making (N=10), when delving deeper into facilitating factors of supply chain resilience (SCR). These factors seem to have relevance to supply chain risk management (SCRM) and, therefore, are termed as SCRM. Concerning these issues, participant 8, for example, mentioned that "*we always think about risk when we take a decision on selecting a supplier."* Moreover, participant 9 mentioned that *"we discuss with our supply chain members to reduce any problem and risk."*

A summarised picture of supply chain resilience (SCR) antecedents can be deduced from Table 4.7.

Table 4.7: Antecedent factors of supply chain resilience

Factor	Variable	Participants														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SCO	Trust	y	y	y	y	-	y	y	y	y	y	y	y	y	y	y
	Commitment	y		y		y	y	y	y		y	y	y	y	y	y
	Cooperation and collaboration	y	y	y		y	y	y		y	y	y	y			
	Top management support		y		y		y		y			y				
SF	Government support	y		y	y		y		y	y	y					y
	Factor endowment (raw material, labour and others)	y		y	y		y	y	y	y				y	y	y
	Favourable international trade environment	y		y	y	y	y	y	y	y		y				
	Trade body and institutional support	y		y	y		y	y	y	y		y				y
LD	Training and counselling	y	y	y			y		y	y				y		
	R&D and technology improvement		y		y		y		y		y					
	Development opportunity		y	y	y				y			y				
	Learning from experience	y	y					y	y	y		y		y	y	
SCRM	Risk sharing activities	y		y	y	y	y	y		y		y	y			
	Effort to reduce disruption	y	y	y		y	y	y	y	y	y	y	y		y	y
	Effort to know about risk		y						y	y	y	y				
	Risk consideration in decision making	y	y		y		y	y	y		y		y		y	y

SCO=Supply chain orientation, SF=Supportive environmental factor, LD=Learning and development, SCRM=Supply chain risk management.

4.3.4 Findings on sustainability factors

Organizations and their supply chains should have the capability to maintain a balance among social, environmental and economic factors in order to be sustained in the long run (Freeman 1984). Referring to Freeman (1984), for the sustainability of the apparel supply chain, a balance of social, environmental and economic factors is also important. It was revealed that sustainability in the apparel supply chain is dominantly perceived

as the buyers' requirements. The apparel manufacturers of Bangladesh are almost all export-oriented and largely dependent on buyers such as Wal-Mart, Kmart, Nike, H&M, GAAP and other retail chains. These retailers are under pressure from consumers, activists and government to ensure social and environmental quality from the supply side (de Brito, Carbone, and Blanquart 2008). As a result, foreign buyers impose some social and environmental compliance issues on apparel manufacturers and their suppliers. According to the participants, for the sustainability of the apparel supply chain, compliance with the buyers' requirements is a prerequisite. For example, all the participants (N=15) as per Table 4.8 agreed that they need to ensure that they address the social factors of their workers. They further confirmed that social compliance issues are very important for the sustainability of the supply chain. In line with social compliance, for instance, participant 6 stated that:

"Today if you do not have a social code, you cannot do business. If you have a quality problem, you can recover and still do business. But if you lose your reputation for social issues, your business will be ended."

Along with social sustainability issues, apparel supply chain members need to ensure that their production processes do not have a detrimental impact on environmental quality and that their products are free from hazardous components. Referring to environmental compliance with buyers' requirements, participant 4, for example, indicated that:

"... All suppliers and manufacturers need to show test reports to ensure that goods are lead-free, Azo-free and free from other hazardous chemicals. ..."

Apart from the literature, some new issues of sustainability were revealed from the interviews. Participants frequently talked about quality, reliability, time and other issues for the sustainability of apparel exports. These issues were considered as operational sustainability factors as they were related to the operations of the firms. It was realized that the apparel supply chain members must be vigilant to the requirements of buyers regarding quality, reliability, time and other operational factors. All the participants focused on compliance of operational factors to be sustained in the market. For example, participant 4 explicated that:

"... we need to ensure quality and on-time delivery to satisfy the buyers and to continue business ..."

In addition, all participants (N=15) stressed economic sustainability. According to them, without considering economic factors, they cannot compete and survive in the

market. They need to quote a competitive price to buyers while maintaining quality standards. As a result, they need to save costs. Moreover, they need enough sales orders to make profit and to cover costs. For example, the opinion of participant 5 regarding economic sustainability was:

"We need more orders {....}. Last year by this time we had a lot of orders but this year orders are very poor because of the world economic situation. If this economic crisis lasts longer, we cannot pay our workers and we need to shut down."

From the above quotations and content analysis, it was ascertained that sustainability in the apparel supply chain can be achieved through adherence to social compliance, environmental compliance, operational compliance and economic efficiency. The existing literature shed light mostly on social, environmental and economic factors. From the field study, operational compliance emerged as a new dimension of sustainability in the context of the apparel supply chain of Bangladesh. The essence of operational compliance in achieving sustainability was justified by most of the participants in the field study. The relevant literature also supports the importance of quality, lead time and conformance with specifications for competitiveness and the sustainability of business (Bicheno 1998; Bateman and David 2002; Epstein and Wisner 2001). The following sections include more in-depth analysis on each sustainability dimension.

4.3.4.1 Social sustainability

The apparel industry of Bangladesh is under intense international scrutiny for the violation of social sustainability issues (Islam and Deegan 2008). Digging deeper about social sustainability, it was revealed that the apparel buyers are concerned about a number of social sustainability factors such as wages and benefits of workers, hazard and safety issues, health and sanitation factors, and human rights issues. Therefore, the apparel manufacturers and their suppliers need to ensure fair wages and benefits, a hazard-free safe working environment and other social factors. For example, corresponding to wages and benefits, the apparel supply chain members need to ensure the minimum wage standard, overtime payment, leave benefit, medical benefit, child care facility and others. Buyers are very strict on the social compliance issues to avoid the risk of an image crisis from negative media exposure and customer boycott. Participant 6, for example, revealed that *"buyers show zero tolerance to child labour".*

It is often claimed in the media that the apparel workers are very poorly paid. However, consciousness is growing about the wages and benefits, and the related

issues of the workers. An idea about this can be obtained from the opinion of participant 4:

"… we need to pay a minimum wage of 3000 taka per month for 8 hours' working day as per labour law and we need to show the pay register to the auditor …"

Referring to health and safety issues, participant 9 indicated that "*… We are concerned about [the] working environment, [and] health and safety standards. We have two cleaners for each floor; have at least one toilet for every 25 workers …"*

Along with the apparel manufacturers, the suppliers (accessory producers) also need to maintain social compliance issues. When buyers place orders with the apparel manufacturers, they govern the whole chain. In many cases, they nominate specific suppliers for material procurement. It was revealed from the interviews that the nominated suppliers comply with the social and environmental requirements of the buyers and they are certified by the buyers. Buyers monitor their plants from time to time to inspect for compliance issues. Sometimes buyers do not specify any supplier. In that case, the well-known and large apparel manufacturers try to ensure compliance issues are addressed in their suppliers' plants to avoid the risk of reputation loss. The statement of participant 10 reports on the concern about monitoring of the supply chain: *"… We are a buyer-nominated supplier. our buyers come and visit our factory to monitor compliance issues …"*

Based on the above quotations and content analysis, Table 4.8 is presented to illustrate the social compliance issues for apparel supply chain sustainability.

Table 4.8: Social sustainability issues for apparel supply chain sustainability

Variable	Participants														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Wages and overtime payments	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Benefits and facilities to the employees	y	y	y	y	-	y	-	y	y	y	y	-	y	-	
Hazard and safety of the employees.	y	y	-	y	y	y	-	y	y	y	y	y	y	y	y
Health and sanitation of the employees	y	y	y	y	y	y	-	y	y	y	-	-	-	-	
Controlling child labour	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Controlling forced labour and harassment	y	y	y	y	y	y	-	y	y	y	y	y	-	y	y
Monitoring social compliance factors of suppliers	-	y	-	y	-	y	-	y	-	y	y	-	-	-	-
Employee satisfaction	y	y	y	y	-	y	-	y	y	-	y	y	-	-	y

Table 4.8 shows that most of the social compliance issues were supported by the majority of participants. It was identified from the interviews that, regarding the issues of child labour and forced labour, all apparel supply chain members are highly concerned because buyers show zero tolerance on these issues. It was also ascertained

that, in comparison to the apparel manufacturers, the apparel suppliers are relaxed on some issues such as evaluation and monitoring of suppliers as well as health and sanitation issues. In this context, supply chain governance is important to ensure social sustainability in low-performing supply chain entities.

4.3.4.2 Environmental sustainability

The environmental impact of the apparel industry is high (Caniato et al. 2012) because the processes of dyeing, drying and finishing make intensive use of chemical products and natural resources (de Brito, Carbone, and Blanquart 2008). Therefore, environmental sustainability is considered an important factor for the textile and clothing supply chain. This was also reflected in the content analysis, as most of the participants talked about stakeholders' concerns about environmental issues. Concerning environmental compliance issues, 11 participants focused on controlling water pollution, nine participants mentioned about controlling air pollution, 11 participants commented on controlling soil pollution while 12 participants talked about recycling or selling wastes. The interviews revealed that a portion of the apparel supply chain members treated pollutants through the use of an effluent treatment plant (ETP) and obeyed the environmental legislation set by the Ministry of Environment in Bangladesh.

The initiatives of the apparel supply chain members about environmental factors can be seen from the opinion of participant 11: *"… We have an effluent treatment plant (ETP) in our entire factory to reduce chemical and water pollution …"* He added that *"We have two types of clothing wastes. Big wastes are sold to the small local apparel producers and small clothing wastes are sold to the recyclers …"* The initiatives for environmental compliance were also justified by participant 9: according to him "*We are ISO 14000 certified. The inspectors measure noise level, dust and emission. They also check [the] cleanliness of water tank, sewerage system …."*

In addition, the apparel supply chain members expressed their concern about the use of hazardous ingredients (N=15), environmental certification (N=12), compliance of environmental legislation (N=8) and monitoring environmental performance of suppliers (N=7). The field study participants stated that buyers' highest priority issue is controlling hazardous material in the products. To test for the non-existence of banned chemicals, there are some mandatory laboratory tests. The apparel supply chain members need to test their products by buyers' nominated testing laboratories before the shipment of merchandise. If any ingredients hazardous to the environment

and/or health are found in the test report, the whole production lot is rejected. In line with this, participant 4 reported that *"... The nominated as well as non-nominated suppliers need to show test reports of materials to ensure that supplied goods are lead-free, Azo-free and free from other environmental hazards ..."*

Based on the above quotations and the content analysis results, Table 4.9 is presented to illustrate the environmental compliance issues for apparel supply chain sustainability.

Table 4.9: Environmental sustainability issues

Variable	Participants														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Controlling water pollution (ETP)	y	y	y	y	-	y	y	y	y	y	y	-	-	y	-
Controlling air pollution	y	y	-	y	-	y	y	y	y	y	y	-	-	-	-
No soil pollution or careful disposal of waste	y	y	y	y	-	y	y	y	y	y	y	-	-	-	y
Recycling wastes or selling to recyclers	y	y	y	y	y	y	y	y	y	y	y	-	-	-	y
Controlling the use of hazardous material	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Environmental certification and audit	y	y	y	y	-	y	-	y	y	y	y	y	y	y	-
Complying with environmental legislation	-	y	-	y	-	y	y	-	y	y	y	-	y	-	-
Monitoring the environmental performance of suppliers	-	y	y	y	-	y	-	y	y	-	y	-	-	-	-

4.3.4.3 Operational sustainability

Based on the content analysis, it was evident that participants placed emphasis on some operational aspects such as conformance of the quality of products (N=15), meeting delivery lead time (N=15), maintaining reliability on specifications (N=15) and efficient updated machinery (N=9) for the sustainability of the apparel supply chain. The apparel products are sensitive to design, colour and the use of accessories. The apparel manufacturers need to submit samples for buyers' approval before producing in a bulk quantity. If the size, colour, design and other specifications are approved by the buyers, the operation is started. Sometimes, buyers reject some batches of products because of non-conformity of the sample with the final bulk production. This is a huge economic loss and reputation loss for the apparel manufacturers. Moreover, buyers set a fixed lead time and within this time the manufacturers need to procure, produce and deliver the finished products. If there is any deviation, buyers are dissatisfied and even reject the shipment. Owing to the short life cycle of fashion products, the supply chain members are very concerned about time. For example, regarding this concern, participant 6 stated that "*In [the] apparel business, you must respect the time. Otherwise, you need to quit from [the] business.*" In a sense, it is to be noted that apparel supply

chain members are serious about meeting the operational compliance issues; otherwise, their companies will be difficult to sustain. Corresponding to operational compliance, participant 1, for example, reported that:

"... we need to prove that our quality is good. We test quality when we buy material from suppliers and we show the sample to the buyer. If buyers approve the sample then we buy material from them ..." The importance of operational compliance issues was also reflected by the statement of participant 6: to him *"Buyers place orders to those who can meet their requirements ...."* Some of the participants stated that if they use good machinery, output quality will be good. For example, participant 8 stated that "*We use a Japanese Zuki machine for production because buyers like it*".

Based on the above quotations and the content analysis results, Table 4.10 is presented to illustrate the operational sustainability issues for the apparel supply chain.

Table 4.10: Operational sustainability issues

Variable	Participants														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Delivery lead time	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Quality	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Reliability regarding quality, design and other specifications	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Efficient and updated machinery and technology	y	y	y	-	-	y	-	y	y	y	y	-	y	-	-

Table 4.10 shows that most of the participants expressed their concern about delivery lead time, quality, specifications, design and the use of updated machinery. Therefore, operational compliance seems an important component for apparel supply chain sustainability.

4.3.4.4 Economic sustainability

For the survival of an organization and its supply chain, economic sustainability is important (Carter and Rogers 2008). If an organization cannot show economic sustainability, it cannot compete in the market. Content analysis also showed evidence in favour of economic aspects such as cost, profit, sales volume and sales growth. According to the participants, the apparel supply chain members need enough sales orders so that they can make a profit and be able to pay the workers properly. Sometimes, if sales orders are not enough, the apparel supply chain members cannot run the production floor and cannot bear the costs. Moreover, participants indicated that the market is competitive and that cost is very important. Some participants stated that they are facing competition both from domestic and international markets. It was

also identified that if the apparel manufacturers do not quote a competitive price, they cannot compete. However, the cost of production is increasing day by day due to increases in utility cost, labour cost, material cost and all other costs. In relation to this, participant 4, for example, commented that: *"... we calculate the cost of [the] product in advance. When we take an order, we calculate the cost and profit ..."*

The need for economic efficiency was also supported by other participants in terms of the importance of sales volume. Participants pronounced that the continuance of their operation depends on sales. It was also revealed that the sales and profit of the accessory suppliers depend on the sales volume of apparel manufacturers. One interviewee (participant 11) for example, stated that "*... demand for our product depends on demand for apparels. Our apparel export is increasing. In this situation we can make good profit after meeting all costs. I think we will sustain if this trend goes on."*

Based on the above quotations and the content analysis results, Table 4.11 is presented to illustrate the economic efficiency issues for apparel supply chain sustainability.

Table 4.11: Economic sustainability issues

Variable	Participants														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sales and business volume	Y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Cost	Y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Profit	Y	y	y	y	y	y	y	y	y	y	y	y		y	y
Sales growth	-	y	-	y	-	y	-	y	y	y	y	-	y	-	-

Table 4.11 shows that all 15 participants supported the importance of sales volume, cost and profit, whereas eight of the 15 participants focused on sales growth for economic sustainability.

4.3.5 Relationships among the factors

Table 4.12, which shows the relationships among the factors, is a precise illustration of the explored relationships among the factors extracted from the qualitative analyses. In addition to the literature, the relationships thus extracted from the field study lay the foundation for developing hypothesized relationships among the constructs. The interesting and important information about the relationships among the factors of the model were explored from the qualitative analyses which are discussed in this section.

Table 4.12: Relationships among the factors

Relationship	Participants														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SCR → SCV	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
SCO → SCR		y	y			y		y		y	y				
Learning & Development → SCR		y		y		y	y	y					y		
Supportive factor→ SCR	y		y	y	y		y		y		y	y		y	y
SCRM → SCR	y	y		y		y		y		y			y		
SCO → SCR		y		y		y		y		y					
SCRM → SCV	y	y	y	y		y		y	y	y		y			
SCR → Social sustainability		y				y	y	y	y	y		y		y	
SCR → Environmental sustainability		y				y		y		y	y				
SCR → Economic sustainability	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
SCR → Operational sustainability		y	y	y		y	y	y	y		y		y	y	
Economic sustainability→ Social sustainability	y	y	y	y		y	y	y	y	y	y	y	y	y	y
Economic → Environmental sustainability	y	y		y		y				y	y	y	y	y	
Economic → Operational sustainability	y		y					y	y						y
Social → operational sustainability	y				y	y		y	y						y

Table 4.12 has been developed from the findings of the field study data, as presented in the previous sections. The table establishes the relationships between factors extracted from the field study findings. For example, the notion (SCR→SCV) presents the relationship between SCR and SCV. All participants directly or indirectly indicated the importance of SCR to mitigate SCV. Participant 8, for example, indicated that *"… We have enough capabilities: as a result, we are not much affected by disruptions and vulnerabilities."* This was similarly expressed by participant 3: *"We always try to create trust in [the] supply chain to ease the situation …"* indicating the relationship between SCO and SCR. Furthermore, the statement: "*GSP facility in Europe is helping us a lot to compete"* (participant 1) reveals the relationship between SF and SCR.

From the content analysis, the extraction of the relationship between SCR and sustainability components is worth mentioning. It is very significant that all field study participants affirmed the relationship between supply chain resilience (SCR) and supply sustainability directly or indirectly. Their perception is if apparel supply chains cannot mitigate the vulnerabilities, it is not possible to be sustained in the market. For example, participant 6 stated that "*… You need to have capabilities to mitigate disruptions in time. Otherwise you cannot survive in the long run."* He added that: *"Buyers place orders to those who can meet their requirements …"* It can be objectively deduced that the capacity to respond to buyers' requirements helps the apparel manufacturers to achieve economic sustainability. Similarly, to extract the relationship between SCR

and social sustainability, environmental sustainability and operational sustainability, objective judgements have been used. For example, the capacity of efficiency and strong quality control leads to achieving both economic and operational sustainability. However, where it was not possible to draw a relationship from direct comments, detailed data analysis was performed.

From Table 4.12, it is observed that a number of important relationships among the sustainability components are explored by the content analysis. For example, the relationships between economic and social, social and operational, economic and environmental sustainability as well as operational issues are explored in this study. In line with the relationship between economic sustainability and social and environmental sustainability, participant 7 indicated that *"Buyers press us for social and environmental compliance but do not pay a good price for improving social and environmental issues …"* The opinion of participant 15 that: *"we cannot provide benefit to the workers if we face loss ..."* can be mentioned in this regard. These statements justify the view that if the apparel manufacturers and suppliers do not receive a good price from the buyers, it is difficult to implement social and environmental compliance. The statement of participant 13 *"We are trying to install [an] ETP in our plant but it's very costly for us"* also illustrates the relationship between economic and environmental sustainability.

Another valuable finding of the field study is the relationship between social sustainability and operational sustainability (N=6) as well as between economic sustainability and operational sustainability (N=5). It is revealed that apart from buyers' requirements, to satisfy the employees, some of the larger and financially stable apparel manufacturers provide some additional benefits to the workers such as transportation (e.g. companies 3, 4, 6, 8 and 9); food and breaks (e.g. companies 1, 2, 8 and 9); and insurance (e.g. companies 1, 2, 3, 6, 8, 9 and 11). These proactive companies have come to realize that compliance with social factors helps them to achieve operational and economic benefits. As a result, they are not only complying with buyers' requirements but also are motivated to ensure workers' satisfaction through providing additional benefits.

In line with this, participant 6 clarified that: *"… If you develop a good community relationship, you will get good and responsible workers and they will stay with you rather than switching. It will help to reduce production disruption ..."* From this quotation, it can be deduced that addressing social issues helps to reduce operational disruption

(worker switching, quality problems) which helps with the smooth processing of products.

The relationship between economic sustainability and operational sustainability can be justified from the statement of participant 1: *"In [the] apparel business you need to prove that your quality is good. { ....} It needs latest and efficient machineries to ensure quality but we cannot replace all old machines due to [the] fund crisis."*

4.4 THEE FIELD STUDY MODEL

Following the step by step process as shown in Figure (4.1, Page…) a field study model has been developed in the inductive phase of field study data analysis process. In this process at the first step, interview was conducted on fifteen respondents and the interview data were transcribed immediately. At the second step, themes and sub-themes were extracted by analysing the transcripts using content analysis technique. At the third step, through matching the themes and sub-themes a number of factors and sub-factors were identified. Total thirteen factors were been identified in the field study. Among these, four factors are related to antecedent factors of SCR which are supportive factors, learning and development, SC orientation and SC risk management. Another four factors (capability, SC design, SC readiness and SC response & recovery) are related to measurement of SCR and the remaining five factors are related to consequences of SCR which are SC vulnerability, social sustainability, environmental sustainability, economic sustainability and operational sustainability. At the fourth step, based on the content analysis, the interrelationship among the factors was identified and then, by using the identified factors and their interrelationships, a field study model has been developed (see Figure 4.2). In the field study model, a number of new factors can be construed with reference to supply chain sustainability and resilience. This model indicates that the qualitative data provide a unique contribution by introducing some new variables and factors related to supply chain resilience and sustainability.

Apart from the factors that have been conceptualized in the initial model, as shown in Figure 2.2 on page 49, three other factors: supply chain readiness, supportive environmental factors and operational sustainability and one sub-factor: market strength have been explored from the field study analysis. The findings also proposed a complex relationship and interrelationships among the antecedent factors of supply chain resilience (SCO, SF, LD and SCRM) and among the outcome constructs (social,

environmental, economic and operational sustainability) of supply chain resilience (SCR).

As a whole, the model depicts a comprehensive structural relationship among different factors of supply chain resilience (SCR) and sustainability. In addition, it has established the dimensionalities of the constructs in the model that are valid and reliable from theoretical and contextual stands. The outcome of the field study model indicates the complete analysis of the inductive stage. Therefore, the next phase addresses the deductive phase of qualitative analysis.

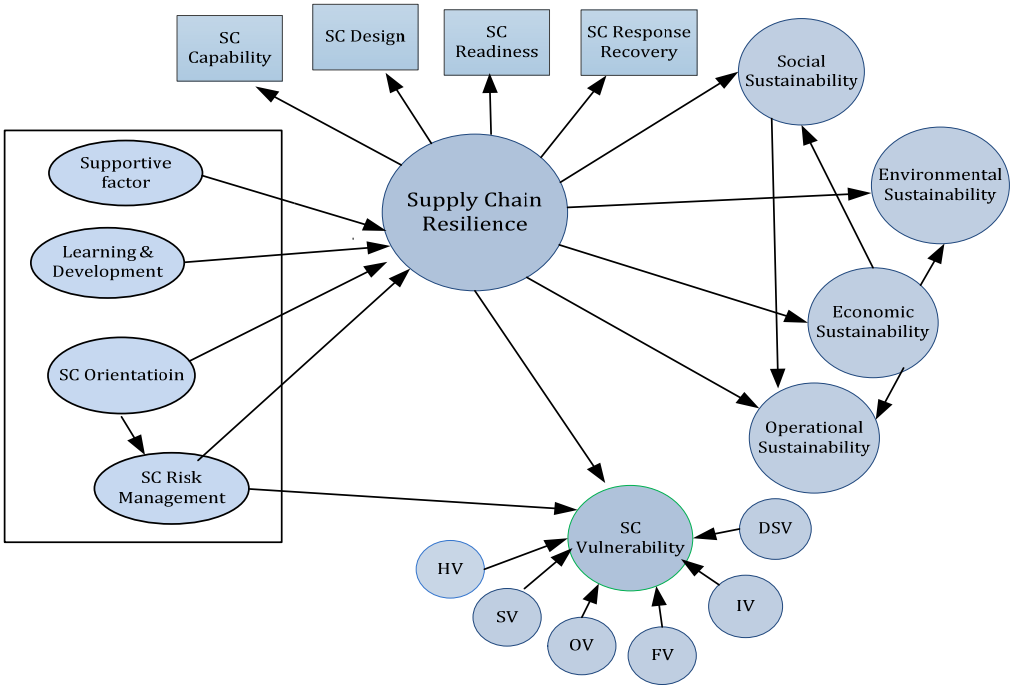


Figure 4.2: Field study model

SC=Supply chain, HV= Hazard vulnerability, SV= Strategic vulnerability, OV= Operational vulnerability, FV= Financial Vulnerability, IV= Infrastructural vulnerability, DSV= Demand-supply vulnerability.

4.5 COMPARISON BETWEEN FINDINGS OF THE FIELD STUDY AND THE INITIAL MODEL (2nd stage: deductive model)

This phase conducts a comparison between the conceptual model and the field study model to come up with a comprehensive model for this study. There are three steps in this phase.

In the first step, a comparison between the initial model and the field study model was carried out. From the comparison, all the constructs corresponding to supply chain resilience (SCR), and the antecedents of resilience and sustainability were verified.

Furthermore, the relationships among the constructs in the supply chain sustainability and resilience model were also reviewed. Overall, the comparison provided the applicability of the initial model in the research context. Further analysis was then undertaken in the next step.

In the second step, all the constructs and dimensions, including the relationships between the factors, were evaluated in terms of generality and commonality in the field study and literature review. It is important to mention that most of the variables discussed by the participants interviewed were supported by the literature. It was also observed that all the constructs mentioned in the conceptual model were supported by the field study outcome. Therefore, no construct was subject to deletion. However, some new factors emerged in the field study which were later included in the comprehensive research model (Figure 4.2). The newly extracted constructs were: "supply chain readiness" as a resilience measurement construct; "market strength" as a sub-construct of supply chain capability; "supportive factor" as an antecedent construct of supply chain resilience; and "operational sustainability" as a component of sustainability.

In the third step, the constructs and dimensions as obtained from the second step were justified through the lens of the existing literature. Tables 4.13 to 4.16 show the justification of each variable under the specific constructs. Finally, a comprehensive model that combines the appropriate findings from the field study model as well as the initial model was developed. Figure 4.3 on page 126 illustrates this comprehensive model.

4.6 JUSTIFICATION OF THE FINDINGS IN THE LITERATURE REVIEW

On the basis of support from the literature, this section provides the validation of selected constructs and variables that were developed from the field study. It is important to mention that the selected factors and variables in the field study were derived on the basis of commonality and consistency. Hence, this justification proves the competency and adequacy of each construct and variable in line with the literature. Tables 4.13 to 4.16 present the factors and the variables that have been selected finally with relevant literature support.

Table 4.13: Supply chain vulnerability factors

Factor	Variables	Sources
Hazard Vulnerability	Natural disaster	Christopher and Peck (2004); Sheffi and Rice (2005); Kleindorfer and Saad (2005); Blackhurst, Scheive and Johnson (2008).
	Fire and other accidental damage	Peck (2005); Kleindorfer and Saad (2005); Wu, Blackhurst and Chidambaram (2006); Blackhurst, Scheive and Johnson (2008); Blos et al. (2009).
	Labour unrest	Blos et al. (2009); Peck (2005); Kleindorfer and Saad (2005); Field study
	Political instability	Peck (2005); Sheffi (2005); Kleindorfer and Saad (2005); Wu, Blackhurst and Chidambaram (2006); Blackhurst, Scheive and Johnson (2008).
Strategic vulnerability	Increased competition	Haider (2007); Schoenherr (2008); Blos et al. (2009); Field study.
	Non-compliance of social and environmental factors	Islam and Deegan (2008); Field study.
	Relationships with buyer and supplier	Blos et al. (2009); Field study.
	Integration and real-time information	Gaudenzi and Borghesi (2006); Field study.
	Plant location problem	Field study.
	Currency fluctuation	Peck (2005); Blackhurst, Scheive and Johnson (2008); Manuj and Mentzer (2008); Blos et al. (2009).
	Economic recession	Xu (2008); Blos et al. (2009); Field study.
	Raw material price fluctuation	Xu (2008); Field study.
	Bank interest and funds	Blos et al. (2009); Field study.
	Bankruptcy	Blackhurst, Scheive and Johnson (2008); Manuj and Mentzer (2008); Field study.
Operational vulnerability	Shortage of skilled worker	Haider (2007); Field study.
	Switching and absenteeism of workers	Field study.
	Production planning and inventory management	Wu, Blackhurst and Chidambaram (2006); Field study.
	Failure of IT system and machinery	Blos et al. (2009); Field study.
	Disruption in utility supply	Blos et al. (2009); Field study.
	Product quality defects	Blos et al. (2009) Field study.
	Illiteracy of workers and supervisors	Field study.
Infrastructural vulnerabili	Delay in customs clearance and documentation	Colicchia, Dallaria and Melacini (2010); Field study.
	Inefficiency in port management	Colicchia, Dallaria and Melacini (2010); Blackhurst, Scheibe and Johnson (2008).
	Delay in land transportation	Blackhurst, Scheibe and Johnson (2008); Field study.
Demand–supply vulnerability	Suppliers' disruptions and delay	Blackhurst, Scheibe and Johnson (2008); Ponomarov and Holcomb (2009); Field study.
	Dependence on imported material	Haider (2007); Nuruzzaman (2009); Craighead et al. (2007); Peck (2005); Field study.
	Non-conformity of material	Blackhurst, Scheibe and Johnson (2008); Field study.
	Buyer disruptions and opportunism	Ponomarov and Holcomb (2009); Pettit, Croxton and Fiksel (2013); Field study.
	Demand fluctuation	Wu et al. (2006); Bansal et al. (2005); Field study.

HV=Hazard vulnerability, SV=Strategic vulnerability, FV=Financial vulnerability, OV=Operational vulnerability, IV=Infrastructural vulnerability, DSV=Demand–supply vulnerability

Table 4.14: Supply chain resilience factors

Supply chain capability	Variables	Sources
Flexibility	Flexibility in production	Duclos, Vokurka and Lummus (2003); Vickery et al. (1999); Field study.
	Product customization	Handfield and Bechtel (2002); Field study.
	Multi-skilled workforce	Duclos, Vokurka and Lummus, (2003); Field study.
	Contract flexibility (flexibility in order size)	Duclos, Vokurka and Lummus, (2003); Vickery et al. (1999); Field study.
	Cost effectiveness	Gunasekaran, Lai and Cheng (2008); Jüttner and Maklan (2011); Field study.
	Responsiveness	Jüttner and Maklan (2011)
	Introducing new product	Duclos, Vokurka and Lummus, (2003); Field study.
Redundancy	Reserve capacity (logistics & equipment)	Pettit, Croxton and Fiksel (2013); Christopher and Peck (2004); Field study.
	Buffer stock (stock of material and labour)	Pettit, Croxton and Fiksel (2013); Christopher and Peck (2004); Field study.
	Back-up utility source (electricity, water, gas, etc.)	Pettit, Fiksel and Croxton (2010); Field study.
Integration	Information sharing	Pettit, Croxton and Fiksel (2013); Peck (2005); Blackhurst et al. (2005); Field study.
	Internal integration	Erol, Sauser and Mansouri 2010); Field study.
	Collaboration	Erol, Sauser and Mansouri 2010); Field study.
	ICT adoption	Pettit, Fiksel and Croxton (2010); Peck (2005); Field study.
Efficiency	Waste reduction	Pettit, Croxton and Fiksel (2013); Fiksel (2003); Sheffi (2005); Field study.
	Worker efficiency	Pettit, Croxton and Fiksel (2013); Field study.
	Quality control and reducing defects	Pettit, Croxton and Fiksel (2013); Kleindorfer and Saad (2005); Field study.
Market strength	Buyer–supplier satisfaction	Pettit, Croxton and Fiksel (2013); Zhang, Vonderembse and Lim 2003; Field study.
	Preferred brand/loyalty	Pettit, Croxton and Fiksel (2013); Zhang, Vonderembse and Lim 2003); Field study.
	Buyer–supplier relationship	Pettit, Croxton and Fiksel (2013); Zsidisin and Ellram (2003); Field study.
Financial strength	Funds availability	Pettit, Croxton and Fiksel (2013); Tang (2006).
	Consistency of profit/margin	Pettit, Croxton and Fiksel (2013); Field study.
	Insurance	Pettit, Croxton and Fiksel (2013); Field study.
Supply chain design	Alternative sourcing	Craighead et al. (2007); Kleindorfer and Saad (2005); Colicchia, Dallaria and Melacini (2010); Field study.
	Alternative distribution	Craighead et al. (2007); Kleindorfer and Saad (2005); Colicchia, Dallaria and Melacini (2010); Field study.
	Alternative market	Craighead et al. (2007); Field study.
	Alternative production	Craighead et al. (2007); Field study.
	Backward linkage facilities	Manuj and Mentzer (2008); Ponomarov and Holcomb (2009); Field study.
Readiness	Readiness training	Pettit, Croxton and Fiksel (2013); Field study.
	Readiness resources	Hale (2005).
	Early warning signal	Pettit, Croxton and Fiksel (2013); Craighead et al. 2007; Field study.
	Forecasting	Pettit, Croxton and Fiksel (2013); Cranfield (2002,

		2003); Peck (2005); Sheffi and Rice (2005); Blackhurst et al. (2005); Field study.
	Security	Peck (2005); Sheffi and Rice (2005); Rice and Caniato (2003); Craighead et al. (2007); Field study.
Response and recovery	Quick response	Sheffi and Rice (2005); Norrman and Jansson (2004); Field study.
	Quick recovery	Sheffi and Rice (2005); Christopher and Peck (2004); Ponomarov and Holcomb (2009); Gunderson (2000); Field study.
	Loss absorption	Holling (1973); Dalziell and McManus (2004); Field study.
	Reduction of impact	Rose (2004); Dalziell and McManus (2004); Field study.
	Cost of recovery	Martin (2004); Vugrin, Warren and Ehlen (2011); Field study.

Table 4.15: Supply chain resilience antecedent factors

Factor	Variables	Sources
Supply chain orientation	Trust	Min and Mentzer (2004); Field study.
	Commitment	Min and Mentzer (2004); Field study.
	Cooperation	Min and Mentzer (2004); Field study.
	Management support	Min and Mentzer (2004); Field study.
Supportive environmental factors	Government support	Dowlah (1999); Cohen et al. (2004); Egeland et al. (1993); Field study.
	Factor endowment (raw material, labour and others)	Dowlah (1999); Field study.
	International support	Dowlah (1999); Field study.
	Trade body and facilitating services	Field study.
Learning and development (LD)	Training	Pettit, Fiksel and Croxton (2010); Sheffi (2005); Ritchie and Brindley (2007); Field study.
	Career improvement opportunity	Egan, Yang and Bartlett (2004); Field study.
	Research, development and innovation	Berkes (2007); Kaplan and Norton (1992); Field study.
	Past learning	Pettit, Fiksel and Croxton (2010); Templeton et al. (2002); Lindell, Prater and Perry (2006).
Supply chain risk management	Risk sharing	Jüttner and Maklan (2011); Manuj and Mentzer (2008); Field study.
	Effort to reduce risk	Jüttner and Maklan (2011); Manuj and Mentzer (2008); Field study.
	Knowing risk	Jüttner and Maklan (2011); Manuj and Mentzer (2008); Field study.
	Risk consideration	Christopher and Peck (2004); Field study.

Table 4.16: Supply chain sustainability factors

Factors	Variables	Sources
Social	Wages and payments	GRI (2011); ICHemE (2005); Minimum Wage Fixing Convention (1970); ILO Weekly Rest (Industry) Convention (1921); Field study.
	Benefits and facilities	GRI (2011); ICHemE (2005); Minimum Wage Fixing Convention (1970); Field study.
	Hazard and safety	ILO Occupational Safety and Health Convention (1981); GRI (2011); Field study.
	Health and sanitation	GRI (2011); ILO Occupational Safety and Health Convention (1981); ILO Working Environment (Air Pollution, Noise and Vibration) Convention (1977) (No. 148); Field study.
	Child labour	GRI (2011); ILO Minimum Age Convention (1973); Field study.
	Forced labour	GRI (2011); ILO Minimum Age Convention (1973); Forced Labour Convention (1930); Field study.
	Monitoring suppliers	TBL, GRI (2011); Epstein and Wisner (2001); Field study.
	Employee satisfaction	GRI (2011); Epstein and Wisner (2001).
Environmental	Water pollution	GRI (2011); IChemE (2005); Epstein and Wisner (2001); Field study.
	Air pollution	GRI (2011); IChemE (2005); Epstein and Wisner (2001); Field study.
	Soil pollution	GRI (2011); Epstein and Wisner (2001); Field study.
	Recycling wastes	CSD, Dashboard Index, Epstein and Wisner (2001).
	Controlling hazardous material	IChemE (2005); Epstein and Wisner (2001); Field study.
	Environmental certification and audit	GRI (2011); Epstein and Wisner (2001); Field study.
	Environmental legislation	GRI (2011); Field study.
	Monitoring environmental performance of suppliers	GRI (2011); Epstein and Wisner (2001); Field study.
Economic	Sales and business volume	GRI (2011); IChemE (2005); Field study.
	Cost	GRI (2011); IChemE (2005); Field study.
	Profit/net income	GRI (2011); IChemE (2005); Field study.
	Sales growth	Epstein and Wisner (2001); Field study.
Operational	Delivery lead time	Bicheno (1998); Bateman and David (2002).
	Quality	Bicheno (1998); Bateman and David (2002); Epstein and Wisner (2001); Field study.
	Reliability on specification	Duclos, Vokurka and Lummus (2003); Field study.
	Efficient and updated machinery and technology	Field study

SCS=Social sustainability, ENS=Environmental sustainability, ECS=Economic sustainability, OPS=Operational sustainability

4.7 THE COMPREHENSIVE RESEARCH MODEL

As explained before, a comparison was performed between the initial model and the findings of the field study to justify the selected constructs and variables. Therefore, this section puts forward a comprehensive model for the current research as demonstrated by Figure 4.3.

The comprehensive research model "supply chain sustainability and resilience" argues that a supply chain needs to be resilient in order to mitigate the vulnerability and to be sustainable in the long term. The model has three major constructs: supply chain vulnerability, resilience and sustainability. Supply chain vulnerability is measured by the dimensions: hazard vulnerability, and strategic, financial, operational, infrastructural and demand–supply vulnerability while supply chain resilience is measured by the dimensions: supply chain capability, supply chain design, supply chain readiness, and supply chain response and recovery. Supply chain orientation, supportive factor, learning and development, and supply chain risk management are the antecedent constructs of supply chain resilience. The outcome constructs of supply chain resilience are social sustainability, environmental sustainability, economic sustainability and operational sustainability. Except for the newly generated constructs from the field study (supply chain readiness, market strength, supportive environmental factors and operational sustainability as shown in Table 4.17), all constructs and sub-constructs were discussed in Chapter 2.

Corresponding to supply chain resilience, supply chain readiness which is newly extracted from the field study findings, was included in the comprehensive model. Supply chain readiness is indispensable for mitigating disruptions in the supply chain. Therefore, in accordance with the resource-based view, it can be argued that readiness to mitigate disruptions is an important and distinctive ability of an organization. It can be added that supply chain managers need to be proactive to achieve readiness for mitigating the disruptions (Peck 2005). The goal of preparedness is to reduce the probability of disruptions or to reduce the impact of loss from vulnerabilities because a resilient supply chain has a high level of readiness to take up alternative arrangements in order to reduce vulnerabilities (Ponomarov and Holcomb 2009). Pettit, Croxton and Fiksel (2013) stated that a supply chain needs to forecast, identify risk and monitor deviation to anticipate and prepare for mitigating disruptions. Pettit, Croxton and Fiksel (2013) also focus on the importance of a security system as security is a strategy to ensure protection against deliberate attack. Its objective is to prevent the occurrence of attacks either through deterrence, identification in advance or restrictions. The resilience capability of organizations is reflected by such preparedness activities during a disaster which has been proven by Nokia in the aftermath of the fire in the chip supplier's plant (Sheffi and Rice 2005). It is also a unique, inimitable and distinctive capability for organizations and their supply chains which is aligned with the spirit of the resource-based view (Wernerfelt 1984; Barney 1991).

The comprehensive model includes market strength as a newly developed construct from the field study findings. The construct "market strength" reflects the ability of a supply chain to strengthen its image in the market through creating a long-term, value-based and satisfactory relationship with supply chain partners as well as improving the image of a company or its products to the target markets. It assists the company to gain competitive edge and customer satisfaction. Pettit, Croxton and Fiksel (2013) use the concept of market position to measure supply chain capability. Market position is the presence of a company and represents the condition of the company with respect to other companies in the industry (Kotler 2000). Companies try to improve market positioning for gaining a competitive edge in the market (Kotler 2000). According to Pettit, Croxton and Fiksel (2013), market position refers to the status of a company or its products in specific markets. It can be assessed by a number of factors such as brand equity, customer loyalty, market share, product differentiation, customer relationships and customer communications (Pettit, Croxton, and Fiksel 2013). Aligned with Pettit, Croxton and Fiksel (2013), market strength is conceptualized as the position of the company's product in the market as well as the image of the company among the supply chain members and other actors in the market.

Concerning the antecedents of supply chain resilience, apart from the constructs as mentioned in the conceptual model, the comprehensive model includes the construct "supportive environmental factors" which is also newly extracted from the field study findings. The field participants identified supportive environmental factors as an important factor to improve resilience of the apparel supply chain in Bangladesh. Therefore, along with supply chain orientation, learning and development, and supply chain risk management, supportive environmental factors were also considered as an antecedent of supply chain resilience in the context of the apparel supply chain in Bangladesh.

The Government of Bangladesh assists the industry indirectly by providing some basic policy support, for example, back-to-back letters of credit, the duty drawback scheme, bonded warehouse facility and cash incentives (Haider 2007). In addition, there are some other notable initiatives of the Government of Bangladesh such as the adoption of conducive policies for investment and industry, inspiring foreign direct investment (FDI), establishment of export processing zones and organizing trade fairs both at home and abroad. The main objective behind such government initiatives is to encourage export-led industrialization. The Government of Bangladesh also provides the advantage of importing duty-free raw material which is used in the manufacturing

of export products to encourage and accelerate such industrialization (Haider 2007). In health science, Kim-Cohen et al. (2004) and Egeland, Carlson and Sroufe (1993) find that support to children in a vulnerable condition can improve their resilience. From multidisciplinary experience and from the field study outcomes, it can be deduced that supportive environmental factors also help in improving resilience of apparel supply chain members of Bangladesh.

In the outcome construct (sustainability part) of the comprehensive model, a new component named "operational sustainability" was added along with the traditional triple bottom line components of social, environmental and economic aspects. According to the participants, the apparel manufacturers and suppliers need to deliver products on time, and maintain quality and reliability as per the specifications of the buyers as well as using updated and efficient technology to continue their business and to sustain it in the long run. These issues are important for the sustainability of organizations and their supply chains consistent with the studies of Bateman and David (2002) and Duclos, Vokurka and Lummus (2003). Without meeting these operational aspects, a company cannot continue its business in the long term. Operational sustainability can be justified through the lens of stakeholder theory (Freeman 1984). It can be argued that operational issues as considered in this research are very important to satisfy and to meet the requirements of stakeholders, specifically the buyers and the ultimate customers. According to stakeholder theory, organizations need to satisfy the requirements of stakeholders for their sustainability. Aligned with this, it can be deduced that meeting operational requirements is essential for the sustainability of apparel supply chain members.

Besides the relationships mentioned in the conceptual model, a number of new relationships among the constructs have been explored in the field study and are therefore included in the comprehensive research model. For example, the relationship between SCO to SCRM and the relationship between SCRM to SCV have been explored from the field study. Table 4.17 presents the new findings from the field study.

Table 4.17: New findings from field study

New Factors	Variables under the factors
Market strength	Buyer–supplier satisfaction
	Preferred brand/loyalty
	Buyer–supplier relationship
Readiness	Readiness training
	Readiness resources
	Early warning signal
	Forecasting
	Security
Supportive environmental factors	Government support
	Factor endowment (raw material, labour and others)
	International support
	Trade body and facilitating services
Operational sustainability	Delivery lead time
	Quality
	Reliability on specification
	Efficient and updated machinery
New variables	
Non-compliance of social and environmental factors	
Plant location problem	
Shortage of skilled workers	
Switching and absenteeism of workers	
Illiteracy of workers	
Backward linkage facility	
Relationships among factors	
SCRM→SCV	
SCO→SCRM	
SCR → Operational sustainability	
Economic sustainability → Social sustainability	
Economic → Environmental sustainability	
Economic → Operational sustainability	
Social → Operational sustainability	

SCRM=Supply chain risk management, SCV=supply chain vulnerability, SCO=supply chain orientation, SCR=supply chain resilience.

Based on the review of explored factors as well as identified links in the conceptual model and the field study model, a comprehensive research model has been developed which is presented by Figure 4.3.

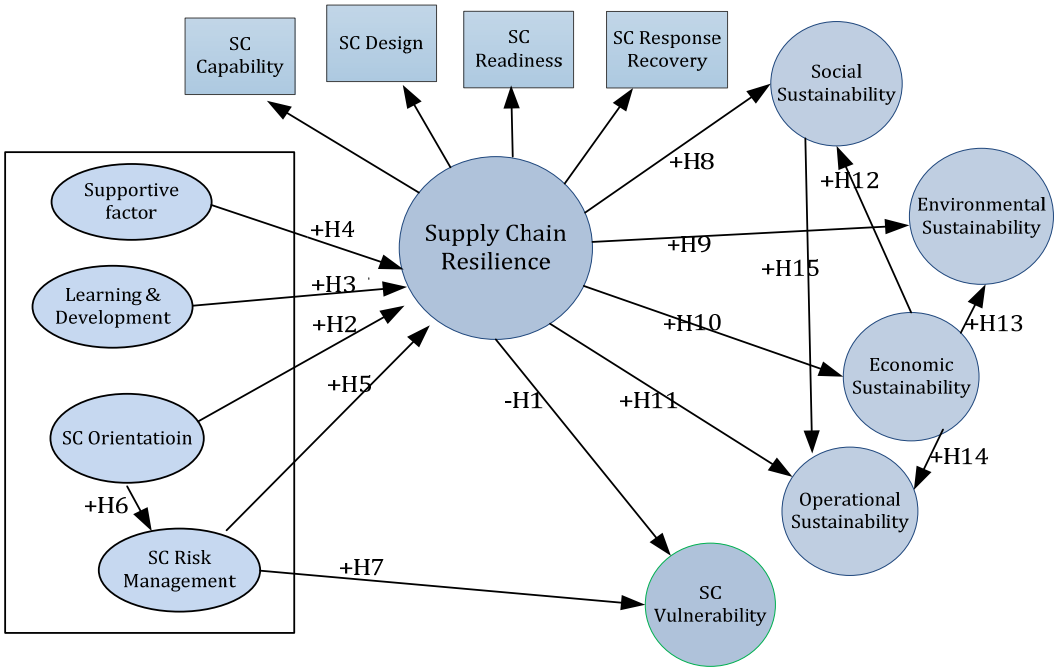


Figure 4.3: Comprehensive model: supply chain (SC) sustainability and resilience

Figure 4.3 represents a comprehensive and final testable model: supply chain sustainability and resilience which has been developed following a sequential process. At the first stage, an initial research model (Figure 2.2, page 49) was developed. Then, at the second stage, the initial research model was contextualised and validated by the findings of the field study. A field study model (Figure 4.2, page 116) was developed in this stage. A number of new constructs (e.g. market strength, supply chain readiness, supportive environmental factor, operational sustainability as shown in Table 4.17, page 125) was extracted from the field study. At the third stage, comparing the initial research model and the field study model a comprehensive and final testable model (Figure 4.3) was developed.

4.8 SUMMARY

This chapter has presented the findings of the qualitative field study and has proposed a research model. The main objective of this field study was to test the applicability of the initial model proposed from the literature review. Qualitative data were produced from 15 interviews conducted among the supply chain decision makers consisting of 10 apparel manufacturing companies and five accessory-producing companies in Bangladesh. Qualitative field study data were analysed in inductive and deductive phases by employing the content analysis technique. Factors and variables related to

supply chain vulnerability, supply chain resilience and supply chain sustainability as well as the relationships among factors were explored which were further scrutinized in the light of the literature review. Based on the comparison between the conceptual model and the field study model, a comprehensive model was developed. This model demonstrates the dimensions and the structural relationship among supply chain vulnerability, resilience and sustainability in the context of the apparel supply chain of Bangladesh. In the next chapter (Chapter 5), hypotheses will be developed from this comprehensive model which will be further examined with quantitative data (Chapter 6).

CHAPTER 5

HYPOTHESES AND INSTRUMENT DEVELOPMENT

5.1 INTRODUCTION

The previous chapter detailed the construction of the final and integrative research model. This integrative model is derived from the literature review and qualitative data analysis. The focus of this chapter is the development of hypotheses based on the relationships among the factors in the proposed research model (Figure 4.3 in Chapter 4). The hypotheses that are to be developed in this chapter are supply chain resilience (SCR) to supply chain vulnerability (SCV); SCR to social sustainability; SCR to environmental sustainability; SCR to economic sustainability; SCR to operational sustainability; social sustainability to economic sustainability; environmental sustainability to economic sustainability; operational sustainability to economic sustainability; social sustainability to operational sustainability; supply chain orientation (SCO) to SCR; learning and development to SCR; supportive environmental factors to SCR; supply chain risk management (SCRM) to SCR; SCO to SCRM; and SCRM to SCV. Along with the development of hypotheses, this chapter discusses the measurement instrument's development for the constructs used in this study. The developed survey instrument facilitates the measurement of constructs and testing of the developed hypotheses.

5.2 HYPOTHESES DEVELOPMENT

5.2.1 Hypothesis regarding SCR to SCV

The existence of disruptions makes supply chains vulnerable. Vulnerability can be defined as the severity of the impact from a disruptive event (Craighead et al. 2007; Sheffi and Rice 2005). The consequence of the disruptions may result in significant supply chain delays magnifying the rate of stock-outs, causing failure to meet the demand of customers on time and incurring the cost of customer dissatisfaction (Rice and Caniato 2003) which makes the supply chain seriously vulnerable and uncompetitive. The existence of supply chain disruptions means that the supply chain needs resilience capabilities to reduce its vulnerabilities (Christopher and Peck 2004; Ponomarov and Holcomb 2009; Pettit, Croxton, and Fiksel 2013) as resilience is the capacity of a system to get back to its original state or even to a better position by

reducing the impact of vulnerabilities (Christopher and Peck 2004; Ponomarov and Holcomb 2009). In other words, resilient supply chains are proactive and take actions to recover more effectively and to reduce the consequences of vulnerabilities (Jüttner and Maklan 2011; Sheffi and Rice 2005). The field study findings also support the need for proactive and resilient actions to mitigate the vulnerabilities. The above arguments infer that an increase in resilience capability helps to reduce the intensity of vulnerability in the supply chain which leads to the development of the following hypothesis:

Hypothesis 1 (H1): Supply chain resilience negetively impacts supply chain vulnerability in apparel industry in Bangladesh.

5.2.2 Hypothesis regarding SCO to SCR

Trust, cooperation, commitment, compatibility and top management support are important components of supply chain orientation (SCO) (Esper, Defee, and Mentzer 2010; Min and Mentzer 2004). Development of inter-organizational trust, cooperation and commitment helps the supply chain members to reduce uncertainty in the network (Handfield and Bechtel 2002; Gao, Sirgy, and Bird 2005). Aligned with this, Kleindorfer and Saad (2005) add that continuous coordination, cooperation, collaboration and trust among supply chain partners are needed for risk reduction and mitigation which in turn maximise the value and benefits for all. Jüttner and Maklan (2011) and Jüttner (2005) also emphasised the importance of trust and open communication in sharing supply chain information and risk in order to be more resilient. On the other hand, if joint responsibility for supply chain risk sharing is lacking, the supply chain members are affected (Jüttner 2005). As a result, the principal organizations try to manage the risks in the downstream supply chain through improving more trustful relationships, cooperation and collaboration (Ritchie and Brindley 2007). It is also noteworthy that the supply chain professionals need top management support to take actions for reducing risk events and their impacts (Giunipero and Eltantawy 2004). The field study analysis also found that trust, cooperation, commitment, etc. are preconditions for organizations to share risks, to reduce the chances of risks, to reduce the impact of risks and to develop resilience capability. The above arguments lead to the development of the following hypothesis:

Hypothesis 2 (H2): Supply chain orientation positively impacts supply chain resilience in apparel industry in Bangladesh.

5.2.3 Hypothesis regarding learning and development to SCR

According to Carpenter (2001) and Gunderson (2000), resilience is reflected by the adaptive capacity of a system which in turn depends on the learning aspect of system behaviour in response to disturbance. Comfort (1994) states that continuous learning is essential for maintaining creativity, adaptation in practice and resilience development. Korhonen and Seager (2008) also support similar findings. Furthermore, learning from prior experience of disruptions and their potential losses should lead organizations to take proactive actions to reduce the risk of losses from disruptions (Giunipero and Eltantawy 2004). The field study findings also confirmed that learning from previous experience helps the apparel supply chain members to take corrective and proactive actions for reducing risk. It is also asserted that to minimise risks, firms can undertake initiatives such as training programs and technology development (Omera and Bernard 2007). Similarly, training and development programs, especially technical expertise development, helps supply chain members to mitigate risks (Ritchie and Brindley 2007). For example, training in quality principles helps to reduce the risk of losses from quality failures (Giunipero and Eltantawy 2004). Berkes (2007) expounds that institutional learning such as training, learning by doing and learning from experience helps to overcome vulnerabilities and to build resilience. Such learning and development effort is also important for improved flexibility, the reduction of risk and higher resilience in the supply chain (Manuj and Mentzer 2008; Comfort 1994) which is also evident from the field study findings. Based on the above argument, it can be hypothesized that

Hypothesis 3 (H3): Learning and development positively influences supply chain resilience in apparel industry in Bangladesh.

5.2.4 Hypothesis regarding supportive environmental factors to SCR

Environmental factors have a substantial influence on the supply chain processes; for example, political stability, government policy, law and order situations, etc. have implications for supply chain structure and costs (Manuj and Mentzer 2008). During a critical situation, supportive environmental factors help organizations to compete and to be retained in the supply chain. Evidence has shown that government support to small-scale producers in Kenya and India helps them to meet the buyers' requirements and to exist in the supply chain (Narrod et al. 2009). The government may also help the supply chain process in a number of ways such as information services, infrastructure development, certification on quality and safety, etc. enabling supply chain members to remain competitive in the market (Narrod et al. 2009; Rich and Narrod 2005; Roth et

al. 2008). Aligned with this, it is important to mention that government efforts to ensure container security and safe trade through the Customs-Trade Partnerships Against Terrorism (C-TPAT) guideline helps to reduce vulnerability from security threats in the supply chain (Manuj and Mentzer 2008). Marsden, Banks and Bristow (2000) show the supportive role of institutions and associations in developing supply chain processes that ensure transportation security in the supply chain with this view also supported by Sheffi (2001). There is evidence that unfavourable government actions and policies create vulnerabilities in the supply chain (Manuj and Mentzer 2008). They create even more vulnerabilities in developing countries (Manuj and Mentzer 2008). Field study findings and previous literature (e.g. Nuruzzaman 2013; Haider 2007) also document that infrastructural limitations, non-supportive political and government role, and poor institutional support impose constraints and challenges to the logistics and supply functions in the context of the apparel industry of Bangladesh. Therefore, supportive environmental factors are needed to overcome the vulnerabilities arising from political, infrastructural and institutional challenges. Based on the above arguments, it can be hypothesized that:

Hypothesis 4 (H4): Supportive environmental factors positively influences supply chain resilience in apparel industry in Bangladesh.

5.2.5 Hypothesis regarding SCRM to SCR

Supply chain risk management (SCRM) highlights the identification and management of risks for the supply chain to reduce the impact of vulnerabilities arising from disruptions (Jüttner, Peck, and Christopher 2003). Supply chain resilience (SCR) focuses on building the adaptive capability so that a supply chain can prepare itself for unexpected events, respond to disruptions and recover from them (Ponomarov and Holcomb 2009). SCRM initiatives, for example, identifying and knowing the risks, increase the resilience capability of supply chains (Jüttner and Maklan 2011) which is also supported by authors such as Sheffi and Rice (2005) and Rao and Goldsby (2009). Attempts to manage and reduce risk effectively address the risk impact of disruptions which in turn increases the SCR ability. In this regard, it can be mentioned that a collaborative plan developed by the manufacturer and supplier as a means of risk management effort seems to have a positive impact on the supply chain's capacity to respond to and recover from disruption. In a similar vein, a multiple supplier base rather than a single sourcing policy increases the flexibility of a supply chain and has a positive impact on SCR in the case of uncertainty arising from the supply side (Pettit, Croxton, and Fiksel 2013). It can also be argued that undertaking a risk management

initiative to increase the knowledge about supply chain risks helps to create necessary preparedness in the supply chain which also has a positive impact on SCR (Manuj and Mentzer 2008). In the light of the above argument, it can be proposed that:

Hypothesis 5 (H5): Supply chain risk management positively influences supply chain resilience in apparel industry in Bangladesh.

5.2.6 Hypothesis regarding SCO to SCRM

Supply chain orientation (SCO) is attributed by the attributes of trust, cooperation, commitment, compatibility and top management support in the supply chain (Esper, Defee, and Mentzer 2010). Trust, cooperation and commitment are interdependent; for example, trust and commitment are needed for long-term cooperation in the supply chain, and fulfilling commitment is a must for a trustworthy relationship (Faisal, Banwet, and Shankar 2006). Trust has an important contribution to the long-term stability of an organization's supply chain (Spekman, Kamauff Jr, and Myhr 1998) as trust has a significant role in responsive and agile supply chains to reduce supply chain risks (Faisal, Banwet, and Shankar 2006). According to Jüttner (2005) and Min and Mentzer (2004), trust, cooperation, commitment, open communication and top management support are the prerequisites for supply chain risk management (SCRM). On the other hand, lack of trust is one of the major factors that contributes to supply chain risks (Sinha, Whitman, and Malzahn 2004). Similarly, cooperation and collaboration among the supply chain partners support the development of flexibility and responsiveness to reduce supply chain risk (Hoyt and Huq 2000). Furthermore, cooperation, coordination and collaboration are essential across the supply chain partners for continuous risk reduction, avoidance and mitigation (Kleindorfer and Saad 2005). Similar findings were also explored from the field study. Based on the above debate, it can be proposed that:

Hypothesis 6 (H6): Supply chain orientation positively influences supply chain risk management in apparel industry in Bangladesh.

5.2.7 Hypothesis regarding SCRM to SCV

Supply chain vulnerability (SCV) is the impact on supply chains arising from disruptions (Jüttner and Maklan 2011). Supply chain disruption is inevitable; however, in the face of disruption, some supply chains are more vulnerable and some are less vulnerable. SCRM initiatives such as risk sharing, hedging and risk management knowledge have an impact on reducing SCV (Jüttner and Maklan 2011; Jüttner 2005). Field study findings also confirm that the apparel supply chain managers take steps

such as keeping alternative and back-up capacity to reduce risks and vulnerabilities. Efforts to know about the risks, risk sources and analysis of risk are important functions of SCRM (Jüttner and Maklan 2011). Such activities are also effective to achieve readiness in the event of disruptions which in turn helps to reduce the probability of occurrences of risk or reduces the impact of risk (Ellegaard 2008; Pettit, Croxton, and Fiksel 2013). In the light of the above argument, it can be proposed that:

Hypothesis 7 (H7): Supply chain risk management negatively influences supply chain vulnerability in apparel industry in Bangladesh.

5.2.8 Hypothesis regarding SCR to social sustainability

Supply chains are also vulnerable to different types of social issues such as poor working conditions, failure to address health and safety factors, labour unrest and dissatisfaction, reputation loss in the market and others (Chowdhury, Sarker, and Afroze 2012; Sellnow and Brand 2001; Ageron, Gunasekaran, and Spalanzani 2012). Such disruptions may also create different operational vulnerabilities such as high absenteeism, turnover of workforce and labour strikes (Chowdhury, Sarker, and Afroze 2012; Islam, Bagum, and Choudhury 2012) which in turn are directed to financial vulnerability. The disruptions have even more lasting impact if consumers boycott the products of a company; for example, Nike's quarterly profits fell 70% due to the consumers' boycott after the sweatshop allegations (Sellnow and Brand 2001). Such events also have an impact on sales of the suppliers of focal firms (Austin and Reficco 2009). In the event of vulnerabilities, a resilient supply chain is highly important to remain competitive and sustainable (Christopher and Lee 2004) because a resilient supply chain is proactive and responds to the vulnerabilities by recovering quickly (Ponomarov and Holcomb 2009). Multi-disciplinary literature (e.g. Magis 2010; Folke et al. 2002) suggests that resilience is an important aspect of social sustainability. There is evidence that some supply chains become proactive to mitigate vulnerabilities arising from social issues which helps them to improve social sustainability performance. For example, after the sweatshop allegation against Nike, the company became more proactive in relation to social issues at their suppliers' plant to ensure social sustainability in the supply chain. Moreover, proactive organizations are supportive toward social issues such as responsible treatment of workers, customers and the environment (Seeger 1997; Hearit 1997). The field study findings also support the relevance of such proactive initiatives to ensure social sustainability in the supply chain. On the basis of the above arguments, it can be hypothesized that:

Hypothesis 8 (H8): Supply chain resilience positively influences social sustainability in apparel industry in Bangladesh.

5.2.9 Hypothesis regarding SCR to environmental sustainability

Community concern regarding environmental issues has increased significantly as customers, regulatory bodies and non-governmental organizations (NGOs) are increasingly demanding organizational initiatives to manage environmental issues (Carter and Easton 2011; Gupta 1995). Social and environmental issues are predominantly sensitive in the fashion supply chain owing to the penurious labour conditions in some regions and intensive use of chemical products which create a high social and environmental impact (de Brito, Carbone, and Blanquart 2008). Failure to comply with stakeholders' requirements regarding environmental issues leads to vulnerabilities such as negative media exposure, pressure from NGOs and government agencies, consumers' boycotts and reduction of sales (Tulder 2001; Islam and Deegan 2008). In this context, organizations and their supply chains need to be proactive and resilient to mitigate vulnerabilities arising from environmental issues. Taking proactive action toward environmental vulnerabilities leads companies and their supply chains to concentrate more on environmental issues and to achieve long-term sustainability (Korhonen and Seager 2008). As a result, leading companies recognize the critical importance of proactively managing the environmental impacts (Epstein and Wisner 2001) which helps them to be resilient and environmentally sustainable. For instance, a number of corporations such as Du Pont, 3M, AT&T, Xerox and others are proactively integrating various environmental policies and programs into their operations strategy such as product design/planning, process technology selection and quality management (Gupta 1995). The field study also revealed similar findings. Based on this evidence, the following hypothesis is proposed:

Hypothesis 9 (H9): Supply chain resilience positively influences environmental sustainability in apparel industry in Bangladesh.

5.2.10 Hypothesis regarding SCR to economic sustainability

With the growing complexities in international business, supply chains are exposed to numerous disruptions and vulnerabilities such as natural disaster, the loss of a critical supplier, accidents at plants, acts of terrorism, economic downturn, etc. (Christopher and Peck 2004; Sheffi and Rice 2005; Wu, Blackhurst, and Chidambaram 2006; Blackhurst, Scheibe, and Johnson 2008; Kleindorfer and Saad 2005; Pettit, Croxton, and Fiksel 2013). These disruptions and vulnerabilities demand a more resilient supply

chain in order to remain competitive and sustainable (Christopher and Lee 2004). Otherwise, the consequence will be the discontinuity of supply chain operations which adversely affects both revenue and costs of the whole chain (Ponomarov and Holcomb 2009). Disruption in one of the supply chain members may have a chain effect on the whole supply chain if this is not handled properly and in an appropriate time. Research by Hendricks and Singhal (2003) reveals that the announcement of supply chain disruptions such as an operational issue or a delay in shipment can cause a significant decrease in shareholder value. Mitigating the existing vulnerability in the supply chain's resilience capability is essential (Christopher and Peck 2004) because resilience capability helps a supply chain to get back to its original state or even to a better state following the disruption (Pettit, Fiksel, and Croxton 2010; Christopher and Peck 2004). Therefore, development of resilience capability reduces the vulnerabilities which in turn reduce the economic loss of the companies, and economic sustainability of the companies and their supply chains can be retained. These arguments lead to the development of the hypothesis that:

Hypothesis 10 (H10): Supply chain resilience positively influences economic sustainability in apparel industry in Bangladesh.

5.2.11 Hypothesis regarding SCR to operational sustainability

The multiplicity of disruptions in the supply chain creates numerous operational problems and vulnerabilities, specifically when the disruptions have a spiral effect on the supply chain network (Christopher and Lee 2004). Operational problems may arise due to unreliable utility supply, poor quality material, supply problems due to the loss of a key supplier or a problem in the supplier's plant, loss of key personnel, logistics mode and route disruptions, IT system failure, etc. (Blos et al. 2009). The production operations of the apparel industry are frequently disrupted by shortages and defects of material, equipment and machine failure, absenteeism and turnover of employees, labour strike, etc. (Islam, Bagum, and Choudhury 2012). These operational disruptions have a severe impact on the supply chain and on the firm as fashion products have a strict lead time due to their short life cycle. The impact of operational disruptions is far reaching and spread over the supply chain network; for example, disruptions in the supplier's plant have an impact on the production of the manufacturers and the sales of distributors. The operational disruptions may also create huge financial loss for the supply chain members; for example, a fire in the supplier's plant disrupted the supply of chips to the production plant of Ericsson which caused a revenue loss of $400 million for Ericsson (Tomlin 2006). Companies and their supply chains need to be

resilient to mitigate disruptions from different sources (Pettit, Fiksel, and Croxton 2010). Such resilience capability is also needed to overcome the operational vulnerabilities in the supply chain. The field study findings also correspond with similar results. The resilience capability thus helps to ensure operational sustainability by reducing operational disruptions. Based on the above argument, it can be hypothesized that:

Hypothesis 11 (H11): Supply chain resilience positively influences operational sustainability in apparel industry in Bangladesh.

5.2.12 Hypothesis regarding economic sustainability to social sustainability

Although sustainability is an integration of three interdependent elements: economic, social and environmental, economic sustainability is the most elusive component of the triple bottom line approach (Doane and MacGillivray 2001). There are debates regarding the interdependence of sustainability components. Some studies claim that economic sustainability is needed for social and environmental sustainability while it is also argued the other way round. Referring to Doane and MacGillivray (2001), it can be mentioned that brilliant social and environmental performance cannot prolong the life of a company which is not economically sustainable. They added that, if the company is not concerned with whether it can stay in business, all the community work (social performance) could disappear due to the pressure of the market. The dependence of social and environmental sustainability on economic sustainability is also emphasised by the study of Quaddus and Siddique (2001). Similarly, the World Summit for Social Development (1995) observed that broad-based and sustained economic growth in the context of sustainable development is required to sustain social development and social justice. To define economic sustainability, Zadek, Simon and Tuppen (2000) argue that economic sustainability largely contributes to social sustainability. For example, economic value creation has an impact on employment generation and other social goods such as development activities. There is evidence that employment generation is highly challenged when productive enterprises experience inefficiency due to numerous uncertainties (Doane and MacGillivray 2001). For example, during the global economic crisis, massive job cuts took place in organizations and created a substantial impact on the life of those people who were jobless. Moreover, a number of studies on green supply chain management (Ageron, Gunasekaran, and Spalanzani 2012; Orsato 2006; Barve and Muduli 2012) identify that cost is an important barrier to sustainability. The field study findings also echo the importance of cost (an economic factor) for improving social sustainability. From the multidisciplinary literature on

sustainability and specific findings on green supply chain management, the following hypothesis can be developed:

Hypothesis 12 (H12): Economic sustainability positively influences social sustainability in apparel industry in Bangladesh.

5.2.13 Hypothesis regarding economic sustainability to environmental sustainability

Economic sustainability has a substantial influence on environmental and social sustainability which has been iterated by a number of studies (Roseland 2000; Quaddus and Siddique 2001; Doane and MacGillivray 2001; Zadek, Simon, and Tuppen 2000). Social and environmental outcomes of an organization are generated from the economic value that it creates (Zadek, Simon, and Tuppen 2000). The findings of Roseland (2000) prove that both poverty and environmental degradation result largely from the economic conditions of people. He added that protecting against environmental degradation requires fundamental changes in the policy of economic progress. In reports on global environmental sustainability, poverty has been rightly identified as a major source of environmental degradation. For example, the collection and use of firewood by families in developing countries is one of the major reasons for deforestation (Roseland 2000). Similarly, adoption of environment-friendly technology needs organizational economic solvency without which environmental sustainability will not be achieved. The studies on green supply chain management barriers (Ageron, Gunasekaran, and Spalanzani 2012; Barve and Muduli 2012) also identify the importance of economic aspects such as cost, product price, investment, incentives to suppliers etc. on the implementation of green supply chain initiatives. The field study findings also support the need for economic sustainability in order to concentrate on environmental issues. From the multidisciplinary literature on sustainability and specific findings on green supply chain management, the following hypothesis can be developed:

Hypothesis 13 (H13): Economic sustainability positively influences environmental sustainability in apparel industry in Bangladesh.

5.2.14 Hypothesis regarding economic sustainability to operational sustainability

The field study found some operational aspects such as maintaining consistency in quality, lead time, meeting the specification of the customers and adopting efficient and updated technology to be very important elements for sustainability. In order to meet

quality and specification according to the requirements of customers, organizations need skilled employees and efficient technologies (Blackburn and Rosen 1993; de Brito, Carbone, and Blanquart 2008). However, the organization incurs costs in developing quality, adopting efficient technologies and developing the skills of its employees (Blackburn and Rosen 1993; de Brito, Carbone, and Blanquart 2008). Furthermore, maintaining the required lead time needs efficient supply chain management (Haider 2007) which requires investment for the deployment of skilled people and technology (Islam, Bagum, and Choudhury 2012, Akkermans et al. 2003). The field study also supported the impact of economic sustainability on operational sustainability. The interviews explored that some companies cannot achieve the desired quality, specifications and other operational requirements owing to their financial limitations, whereas the companies which are financially strong do not face many problems in quality, specification, lead time and other such areas. For example, a back-up generator is essential in the apparel factories of Bangladesh as interruption of the utility supply is frequent. The small companies cannot buy high-power generators owing to financial limitations: as a result, their production operation is hampered which ultimately affects the lead time and quality of the product. Based on the above discussion, it can be hypothesized that:

Hypothesis 14 (H14): Economic sustainability positively influences operational sustainability in apparel industry in Bangladesh.

5.2.15 Hypothesis regarding social sustainability to operational sustainability

Social sustainability issues such as fair wages and payment, hazard and safety issues, human rights, etc. are related to employee satisfaction (Hutchins and Sutherland 2008; Boyd et al. 2007). Employee satisfaction in turn has a significant impact on the firm's operational performance such as quality, efficiency, etc. (Huselid 1995). Studies have shown that activities such as training, good compensation and advancement opportunities are related to organizational effectiveness such as quality, customer satisfaction, improved profitability, productivity, reduced absenteeism, etc. (Delaney and Huselid 1996; Huselid 1995; Katz, Kochan, and Weber 1985). On the other hand, adversarial labour relation practices have a negative impact on the operations, retention of a quality workforce, quality and productivity of the organization and vice versa (Huselid 1995). It was also confirmed from the field study that a good working environment, good incentives and employee satisfaction have an impact on quality, productivity and employee turnover. From these arguments, it can be proposed that:

Hypothesis 15 (H15): Social sustainability positively influences operational sustainability in apparel industry in Bangladesh.

5.2.16 Hypotheses related to mediation relationship

The mediation role of SCR between SCRM and SCV is apparent in the studies (e.g. Jüttner and Maklan 2011) while the mediation roles of: SCRM between SCO and SCR; ECS between SCR and SCS; ECS between SCR and SCS; ECS between SCR and ENS; ECS between SCR and OPS; and SCS between ECS and OPS are not explicitly mentioned in the literature. However, based on logical and objective deductions from the previous literature (e.g. Seeger 1997; Hearit 1997; Doane and MacGillivary 2001; Foerstl et al. 2010 and others) and support from the field study, this study draws hypotheses regarding mediation relationships among the mentioned factors. Therefore, hypotheses H16, H17, H18, H19, H20 and H21 were presented in this study.

The mediation role of SCR between SCRM and SCV

Supply chain risk management (SCRM) focuses on the identification and management of risks for the supply chain in order to reduce its vulnerability (Jüttner, Peck, and Christopher 2003). The main objective of SCRM is to reduce supply chain vulnerability (SCV) (Jüttner, Peck, and Christopher 2003; Jüttner and Maklan 2011). However, SCRM also aims at increasing the resilience of the supply chain (Sheffi and Rice 2005; Rao and Goldsby 2009). It is argued that conventional risk management approaches are not always effective when a company is vulnerable to uncertain and unexpected disruptions (Pettit, Croxton, and Fiksel 2013). Supply chain resilience (SCR) develops the adaptive capability to prepare for unexpected events, to respond to disruptions and to recover from them (Ponomarov and Holcomb, 2009). Therefore, in addition to SCRM, supply chains need proactive and adaptive capability, that is, resilience capability to combat the vulnerabilities arising from uncertain disruptions. With this backdrop, it can be hypothesized that:

Hypothesis 16 (H16): SCR mediates the relationship between SCRM and SCV in apparel industry in Bangladesh.

The mediation role of SCRM between SCO and SCR

The elements of supply chain orientation such as trust, cooperation, commitment and top management support are preconditions for organizations to share risks and information among their supply chain partners (Min and Mentzer 2004). Furthermore, risk management efforts such as risk sharing, efforts to reduce risk, collaboration and information sharing help the supply chain members to develop resilience capability

and to mitigate vulnerability (Jüttner and Maklan 2011). Such risk management efforts are effective to reduce the chances of risks, to reduce the impact of risks and to develop resilience in the supply chain. Without concentration on risk management efforts, mere attempts to achieve supply chain orientation may not effectively address the proactive risk mitigation approaches. The field study also supports the role of SCRM for SCR. For example, some participants mentioned that if management does not concentrate on risk management efforts, it is difficult to overcome vulnerabilities which emphasise the importance of risk management efforts for risk mitigation of a supply chain. However, this also needs trust and cooperation among the supply chain partners to facilitate the risk management strategies of organizations (Mentzer et al. 2001). Based on the above argument, it can be hypothesized that:

Hypothesis 17 (H17): SCRM mediates the relationship between SCO and SCR in apparel industry in Bangladesh.

The mediation role of ECS between SCR and SCS

Organizations should undertake proactive actions towards improving social issues such as responsible treatment of workers, customers and the environment. Such proactive actions are effective to mitigate social problems which affect both society and the organization (Seeger 1997; Hearit 1997). Otherwise, an enduring social crisis may cause huge financial loss for organizations: for example, Nike's quarterly profits fell 70% after the sweatshop allegations (Sellnow and Brand 2001). Financial loss due to reputation loss in an organization has a chain effect on the whole supply chain: for example, loss of reputation and customers by fashion retailers has the impact of loss of sales orders on their suppliers from low-cost countries. Therefore, companies and their supply chains need a proactive and resilient approach to mitigate social sustainability challenges (Foerstl et al. 2010) as SCR is the capability of a supply chain to prepare for, respond to and recover from unexpected disruptions (Ponomarov and Holcomb, 2009; Pettit, Croxton, and Fiksel 2013). However, economic factors such as the cost and investment needed for improving social issues are major barriers to social sustainability initiatives (Walker, Di Sisto, and McBain 2008; Ageron, Gunasekaran, and Spalanzani 2012). In other words, economic sustainability is needed for social performance (Doane and MacGillivray 2001). Therefore, companies and their supply chains need to be economically sustainable and need to take proactive actions and to develop resilience capability against social sustainability challenges. Based on the above argument, it can be proposed that:

Hypothesis 18 (H18): ECS mediates the relationship between SCR and SCS in apparel industry in Bangladesh.

The mediation role of ECS between SCR and ENS

With rapid industrialization, the environmental impact is increasing which has a reverse effect on organizations and their supply chains as calamities and catastrophes often affect the processes of organizations. Pressure from stakeholder groups is mounting to reduce pollution and to implement environment-friendly technologies (Seuring and Muller 2008; Foerstl et al. 2010). In order to respond to uncertainty, consumer boycotts and reputational risks arising from social and environmental issues, firms should be proactive and develop their capabilities (Foerstl et al. 2010; Campbell 2007). However, to be resilient and able to reduce risk arising from environmental hazards by implementing proactive actions toward environmentally sustainable strategies, organizations need investment in supply chain sustainability development efforts (Foerstl et al. 2010). Previous research on green supply chain management barriers (Ageron, Gunasekaran, and Spalanzani 2012; Barve and Muduli 2012) also identifies the importance of economic aspects such as cost, product price, investment, incentives to suppliers, etc. on the implementation of green supply chain initiatives. Moreover, a number of studies (Roseland 2000; Quaddus and Siddique 2001; Doane and MacGillivray 2001; Zadek, Simon, and Tuppen 2000) support the fact that economic sustainability is a precondition for improving environmental performance. The field study participants also reported that the cost of implementation is one of the deciding factors towards undertaking a proactive approach to environmental sustainability issues such as controlling the use of hazardous chemicals, and establishing an effluent treatment plant (ETP), recycling operation and efficient use of resources. It was also revealed that proactive environmental actions increase the competitive strength of organizations as well as reducing the risk of rejection of consignment due to the existence of banned chemicals in the products. From the literature and the field study outcomes, it can be hypothesized that:

Hypothesis 19 (H19): ECS mediates the relationship between SCR and ENS in apparel industry in Bangladesh.

The mediation role of ECS between SCR and OPS

As derived from the field study findings, operational sustainability embraces the need for organizations to maintain consistency in quality and lead time, to meet the specification of the customers and to adopt efficient and updated technology in order to survive and to compete in the market for the long term. Studies (Blackburn and

Rosen 1993; de Brito, Carbone, and Blanquart 2008) identify that in order to meet quality and specification according to the requirements of customers, organizations need capabilities such as skilled employees, efficient technologies, etc. In other words, in order to reduce the risk of defects and customer dissatisfaction, companies need efficient employees and technologies. However, organizations need to incur costs to develop quality, to adopt efficient technologies and to develop the skills of their employees (Blackburn and Rosen 1993; de Brito, Carbone, and Blanquart 2008). Furthermore, maintaining the required lead time needs efficient supply chain management (Haider 2007) which requires investment for the deployment of skilled people and technology (Islam, Bagum, and Choudhury 2012; Akkermans et al. 2003). It has also been proven that to reduce operational disruptions arising from absenteeism, turnover of skilled human resources, poor quality, less productivity, etc., organizations should ensure fair wages and incentives to their employees (Absar 2009; Islam, Bagum, and Choudhury 2012; Boyd et al. 2007). Based on the above argument, it can be proposed that:

Hypothesis 20 (H20): ECS mediates the relationship between SCR and OPS in apparel industry in Bangladesh.

The mediation role of SCS between ECS and OPS

The economic strength of organizations is vital for improving and implementing operational sustainability issues such as quality, lead time, specifications of the buyers, etc (Blackburn and Rosen 1993). With the growth of economic parameters, organizations need to ensure that they address the social factors of their employees so that employees are motivated to play a more positive role in achieving the economic objectives of the organization. There is evidence that there is a positive relationship between financial incentives and employee satisfaction (Katzell and Thompson 1990). Furthermore, it is also true that there is a positive relationship between employee satisfaction and operational issues in terms of absenteeism, productivity, quality, etc. (Scott and Taylor 1985; Loher et al. 1985). At the other end of the spectrum, failure to address social issues such as fair payment, human rights, safety in the work environment, etc. creates worker dissatisfaction which in turn is the cause of different operational disruptions such as high absenteeism and turnover of the workforce, labour strikes and unrest (Chowdhury, Sarker, and Afroze 2012; Islam, Bagum, and Choudhury 2012). Based on the above argument it can be proposed that

Hypothesis 21 (H21): SCS *mediates the relationship between ECS and OPS in apparel industry in Bangladesh.*

5.3 SUMMARY OF DEVELOPED HYPOTHESES

Based on the comprehensive model, overall, 21 hypotheses describing 21 relationships have been developed. The comprehensive model as shown by Figure 4.3 in page number 126, consists of the factors and variables explored from both the literature review and the field study. Table 5.1 presents all the hypotheses developed above. These hypotheses were also shown in Figure 4.3 in page number 126.

Table 5.1: Summary of hypotheses and their sources

Hypothesis	Links	Statement	Main sources
H1	SCR→SCV	Supply chain resilience negatively impacts supply chain vulnerability in apparel industry in Bangladesh.	Pettit, Croxton and Fiksel (2013); Jüttner and Maklan (2011); Sheffi and Rice (2005); Field study.
H2	SCO→SCR	Supply chain orientation positively impacts supply chain resilience in apparel industry in Bangladesh.	Min and Mentzer (2004); Jüttner and Maklan (2011); Jüttner (2005); Field study.
H3	L&D→SCR	Learning and development positively influences supply chain resilience in apparel industry in Bangladesh.	Berkes (2007); Omera and Bernard (2007); Comfort (1994); Korhonen and Seager (2008); Field study.
H4	SF→SCR	Supportive environmental factors positively influences supply chain resilience in apparel industry in Bangladesh.	Manuj and Mentzer (2008); Nuruzzaman (2013); Field study.
H5	SCRM→SCR	Supply chain risk management positively influences supply chain resilience in apparel industry in Bangladesh.	Jüttner and Maklan (2011); Rao and Goldsby (2009); Field study.
H6	SCO→SCRM	Supply chain orientation positively influences supply chain risk management in apparel industry in Bangladesh.	Jüttner (2005); Mentzer, Min and Bobbitt (2004); Kleindorfer and Saad (2005); Field study.
H7	SCRM→SCV	Supply chain risk management negatively influences supply chain vulnerability in apparel industry in Bangladesh.	Jüttner and Maklan (2011); Jüttner (2005); Ellegaard (2008); Field study.
H8	SCR→SCS	Supply chain resilience positively influences social sustainability in apparel industry in Bangladesh.	Sellnow and Brand (2001); Seeger (1997); Field study.
H9	SCR→ENS	Supply chain resilience positively influences environmental sustainability in apparel industry in Bangladesh.	Korhonen and Seager (2008); Field study.
H10	SCR→ECS	Supply chain resilience positively influences economic sustainability in apparel industry in Bangladesh.	Ponomarov and Holcomb (2009); Pettit, Croxton and Fiksel (2013).

H11	SCR→OPS	Supply chain resilience positively influences operational sustainability in apparel industry in Bangladesh.	Tomlin (2006); Field study.
H12	ECS→SCS	Social sustainability positively influences economic sustainability in apparel industry in Bangladesh.	Doane and MacGillivray (2001); Quaddus and Siddique (2001); Field study.
H13	ECS→ENS	Environmental sustainability positively influences economic sustainability in apparel industry in Bangladesh.	Roseland (2000); Zadek, Simon and Tuppen (2000); Ageron, Gunasekaran and Spalanzani (2012); Quaddus and Siddique (2001); Field study.
H14	OPS→ECS	Operational sustainability positively influences economic sustainability in apparel industry in Bangladesh.	Blackburn and Rosen (1993); de Brito, Carbone and Blanquart (2008); Field study.
H15	SCS→OPS	Social sustainability positively influences operational sustainability in apparel industry in Bangladesh.	Huselid (1995a); Delaney and Huselid (1996); Field study.
H16	SCRM→SCR →SCV	SCR mediates the relationship between SCRM and SCV in apparel industry in Bangladesh.	Jüttner, Peck and Christopher (2003); Jüttner and Maklan (2011); Pettit, Croxton and Fiksel (2013); Ponomarov and Holcomb (2009); Field study.
H17	SCO→SCRM →SCR	SCRM mediates the relationship between SCO and SCR in apparel industry in Bangladesh.	Min and Mentzer (2004); Jüttner and Maklan (2011); Mentzer et al. (2001); Field study.
H18	SCR→ECS→ SCS	ECS mediates the relationship between SCR and SCS in apparel industry in Bangladesh.	Seeger (1997); Hearit (1997); Sellnow and Brand (2001); Foerstl et al. (2010); Ageron, Gunasekaran and Spalanzani (2012); Doane and MacGillivray (2001); Field study.
H19	SCR→ECS→ ENS	ECS mediates the relationship between SCR and ENS in apparel industry in Bangladesh.	Foerstl et al. (2010); Campbell (2007); Ageron, Gunasekaran and Spalanzani (2012); Barve and Muduli (2012); Field study.
H20	SCR→ECS→ OPS	ECS mediates the relationship between SCR and OPS in apparel industry in Bangladesh.	Blackburn and Rosen (1993); de Brito, Carbone and Blanquart (2008); Akkermans et al. (2003); Boyd et al. (2007); Field study.
H21	ECS→SCS→ OPS	SCS mediates the relationship between ECS and OPS in apparel industry in Bangladesh.	Katzell and Thompson (1990); Scott and Taylor (1985); Loher et al. (1985); Chowdhury, Sarker and Afroze (2012); Field study.

5.4 ROLE OF CONTROL VARIABLES (SIZE, EXPERIENCE AND SUPPLY CHAIN ENTITY) ON SUPPLY CHAIN RESILIENCE AND SUSTAINABILITY

5.4.1 Impact of firm size

Large firms are less vulnerable to uncertainties than their smaller counterparts (Zavgren 1985) because small companies lack the ability to spend on vulnerability mitigation processes (Telang and Wattal 2007) and have low risk tolerance capability

(Jüttner 2005; Walls and Dyer 1996). Similarly, larger firms are less likely to be vulnerable to uncertainty and opportunism by transaction partners than smaller firms (Nooteboom 1993). Studies also show that the size of the firm also has influence on the proactive and adaptive thinking corresponding to contingencies (Miller and Cardinal 1994). Similarly, from the studies of Gonzalez, Gasco and Llopis (2005) and Carmel and Nicholson (2005), it is evident that smaller firms are more vulnerable in outsourcing due to the lack of capability and resource constraints with regard to reducing the risk factors. Firm size also has an impact on sustainability: for example, smaller firms cannot take responsible action for sustainability due to their resource limitations (Lepoutre and Heene 2006). In addition, some small firms perceive that they have no time or resources to devote to social responsibility (Tilley 2000). Moreover, many small business owners and managers are not concerned about sustainability or even believe that their social and environmental impact is negligible (Hitchens et al. 2005; Petts et al. 1999). Based on the above argument, it appears that:

Size of the firms has an impact on supply chain resilience and sustainability.

5.4.2 Impact of supply chain entity

Some of the firms and their supply chains are more vulnerable to environmental uncertainties owing to the nature of the products, the type of business environments and the design of the supply chain (de Brito, Carbone, and Blanquart 2008; Craighead et al. 2007). It is also true that the intensity of risk and vulnerabilities differs at different tiers of the supply chain. For example, during uncertainty in demand, the bullwhip effect tends to be more intensive in the upstream supply chain than the downstream (Chen et al. 2000). To Craighead et al. (2007), vulnerability in the supply chain depends on the supply chain design factors because the factors associated with supply chain design such as density, complexity and criticality of the chain influence the intensity of supply chain vulnerability (Craighead et al. 2007). Different supply chain members have their own supply network: as a result, the complexity and criticality may differ. Therefore, the intensity of vulnerability also is different for different supply chain members. Based on the above argument, it can be inferred that:

The supply chain entity has an impact on supply chain resilience and sustainability.

5.4.3 Impact of experience of firm

With the increase in experience, redundant activities can be eliminated, and interruption in the production process can be reduced: as a result, the cost of

production can be kept down (Nooteboom 1993). Nooteboom (1993) adds that due to experience, individuals and organizations become increasingly expert on a particular system which helps the companies to achieve efficiency and to ensure economic sustainability. The extent of experience is also important for knowledge acquisition capability (Zahra and George 2002) which provides competencies by experiencing new things (Nooteboom 1993; Granovetter 1982). These types of diverse experiences in the past help a system to be more resilient because learning from past experience builds the adaptive capacity in response to disruption (Folke et al. 2005). Similarly, it can be argued that a firm with long-term experience on different disruptions can respond well and develop better adaptive capacity owing to familiarity with such incidents. This statement is also supported by the participants of the field study. Based on the above reasoning, it can be deduced that:

Experience of firms has an impact on supply chain sustainability and resilience.

5.5 QUESTIONNAIRE DEVELOPMENT FOR FINAL SURVEY

In order to collect survey data for this research, a questionnaire (Appendix B) was developed in the light of the relevant literature, theoretical support and the field study outcomes. The developed questionnaire was approved by the Curtin University Research Ethics Committee. The next section presents the development of questionnaire in detail.

5.5.1 Overview of the questionnaire

During questionnaire development, careful attention had been paid to item selection. For each construct, multiple items were considered to ensure reliable and valid measurement of the model. The first step was the extensive literature review of previously developed instruments to identify whether items could be adapted, adopted or needed to be developed for each construct. In addition, the items developed from the field study outcomes were reviewed and integrated into the questionnaire to contextualise the objects and to ensure content validity. The developed questionnaire was then subjected to a pre-test for necessary refinement. Chapter 3 detailed the pre-test procedure. Finally, the questionnaire was developed to collect the survey data to test the proposed research hypotheses presented in the comprehensive model as demonstrated by Figure 4.3 in Chapter 4.

The questionnaire was segregated into five sections. The ensuing sections of the questionnaire comprised 104 questions (excluding the demographic questions). A six-point Likert scale, which is suitable to avoid the bias of selecting the midpoint (Rossi,

Wright, and Anderson 1983), was used to design the questionnaire. The first section of the questionnaire included the demographic variables. The second section included supply chain vulnerability followed by supply chain resilience measurement dimensions (capability, supply chain design, readiness, and response and recovery vulnerability) in the third section. The fourth section was comprised of antecedents of supply chain resilience. Finally, sustainability factors were included in the fifth section.

5.5.2 Measurement instrument development

It was mentioned earlier that excluding the demographic questions, there were 104 items in the measurement instrument. Among the 104 items, 75 items were operationalized as reflective and the remaining 29 items as formative based on the decision rule suggested by Jarvis et al. (2003). The details about formative and reflective measurement decision criteria were mentioned in Chapter 3, pages 71-73.

5.5.2.1 Questionnaire Section 1: demographic variables

Demographic variables were measured by different types of scales using both open-ended and closed-ended questions. The demographic details included the position, type of product produced by the company (supply chain entity), number of years since the company was established (experience) and number of employees of the company (size). Table 5.2 presents the demographic items used in this study.

Table 5.2: Demographic variables

Items	Variable	Measure
Q1	Position	Nominate your position
Q2	Supply chain entity	Type of operation
Q3	Size	Number of employees
Q4	Experience	Number of years in business
Q5	Turnover	Amount of sales

Among the five questions in the demographic section, two questions (Q1 and Q2) used nominal scales (position and name of products produced); the other three (Q3, Q4 and Q5) used numeric values that represent a measure. It is worth mentioning that the type of product (Q2) infers the position of the company in the supply chain, that is, the supply chain entity. For example, companies producing apparel accessories (buttons, packaging, thread, fabrics, interlining and others) represent suppliers in the apparel supply chain.

5.5.2.2 Questionnaire Section 2: supply chain vulnerability factors

The objective of this section was to identify and measure the supply chain vulnerability factors. Six vulnerability dimensions: hazard vulnerability, strategic vulnerability,

financial vulnerability, operational vulnerability, infrastructural vulnerability and demand–supply vulnerability were measured in this section. Table 5.3 presents the items related to the six dimensions of supply chain vulnerability. For this section, the six-point Likert scale was designed as: 1-extremely low, followed by 2-very low, 3-low, 4-high, 5-very high and 6-extremely high. Each of the vulnerability dimensions was measured by formative indicators because the items caused the latent variable and the items were defining characteristics of the construct (Jarvis et al. 2003). Moreover, the items were assumed to be not correlated and they were not interchangeable (Jarvis et al. 2003; Chin 1998).

Hazard vulnerability refers to the vulnerabilities arising from uncontrollable and unpredictable events. It was measured by the items (HV1 to HV4): impact of natural disaster; fire and accidental damage; labour unrest; and political instability with reference to the previous literature (Pettit, Fiksel, and Croxton 2010; Kleindorfer and Saad 2005; Wu et al. 2006; Blackhurst, Scheibe, and Johnson 2008; Blos et al. 2009). These items were then validated by the field study findings.

Strategic vulnerability was comprised of strategic weaknesses and dilemmas. It was measured by the items (SV1 to SV5): the impact of increased competition; non-compliance of social and environmental issues; problem of relationship with supply chain partners; problem of integration and real-time information; and problem of plant location in reference to the previous literature (Schoenherr 2008; Blos et al. 2009; Pettit, Fiksel, and Croxton 2010) and were contextualised based on the findings from the field study. It is important to mention that the items: non-compliance of social and environmental issues (SV2); and plant location problem (SV5) were developed from the field study while also being supported by similar research (see Table 5.3).

Financial vulnerability refers to the susceptibility of organizations and their supply chains arising from uncertain financial conditions and losses. The items of financial vulnerability were measured by the items (FV1 to FV5): the impact of currency fluctuation; economic recession; raw material price fluctuation; high bank interest; and bankruptcy of supply chain members. All the items have been adapted from the previous literature (Peck 2005; Blackhurst, Scheibe, and Johnson 2008; Manuj and Mentzer 2008; Blos et al. 2009) and were contextualised based on the field study findings.

Operational vulnerability was comprised of the issues that are responsible for operational failure and uncertainties. It was measured by the items (OV1 to OV7): the impact of lack of skilled workers; switching and absenteeism of workers; fault in

production planning; IT system failure; disruption in utility supply; product quality problem; and illiteracy of workers. A number of the items: OV1, OV2 and OV7 were developed from the field study and were supported by similar research (see Table 5.3) while the items: OV3, OV4, OV5 and OV6 were selected from the previous literature (see Table 5.3) and were contextualised.

Infrastructural vulnerability described the impact of disruptions arising from poor infrastructure such as delay in customs, port inefficiency and land transportation problem. All the items (IV1 to IV3) of infrastructural vulnerability were adapted from the previous literature (Colicchia 2010; Blackhurst, Scheibe, and Johnson 2008; and others) and were contextualised.

Demand–supply vulnerability was comprised of the disruptions and complexities that arise from suppliers and buyers as well as material procurement and sales of finished goods. It was measured by the items (DSV1 to DSV5): impact of suppliers' disruptions; dependence on imported material; non-conformity of material; buyers' disruptions; and demand fluctuation. All the items except DSV2 were adapted from the previous literature (see Table 5.3). Each of these items was compared with the field study findings to ensure its validity. The item "dependence on imported material" was developed from the field study while also being supported by similar research (see Table 5.3).

Table 5.3: Measurement items and related statements of SCV

HV	Dimension	Statements	Sources
HV1	Natural disaster	Impact of natural disaster on our supply chain is (extremely low … extremely high)	Pettit, Fiksel and Croxton (2010); Kleindorfer and Saad (2005); Wu et al. (2006); Blackhurst et al. (2008); Field study.
HV2	Fire and other damages	Impact of fire and other accidental damage on our supply chain is	Kleindorfer and Saad (2005); Wu et al. (2006); Blackhurst et al. (2008); Blos et al. (2009); Field study.
HV3	Labour unrest	Impact of labour unrest and dissatisfaction on our supply chain is	Blos et al. (2009); Field study.
HV4	Political instability	Impact of political instability on our supply chain is	Peck (2005); Kleindorfer and Saad (2005); Wu et al. (2006); Blackhurst et al. (2008); Field study.
SV			
SV1	Increased competition	Impact of increased competition on our supply chain is	Schoenherr (2008); Blos et al. (2009); Field study.
SV2	Non-compliance	Impact of non-compliance of social and environmental factors	Islam and Deegan (2008); Field study.

		on our supply chain is	
SV3	Relationship with buyer and supplier	Impact of problem of relationship with buyer on our supply chain is	Blos et al. (2009); Pettit, Croxton and Fiksel (2013); Field study.
SV4	Integration and real-time information	Impact of problem of integration and real-time information on our supply chain is	Gaudenzi and Borghesi (2006); Field study.
SV5	Plant location problem	Impact of plant location problem on our supply chain is	Field study.
FV			
FV1	Currency fluctuation	Impact of currency fluctuation on our supply chain is	Peck (2005); Blackhurst et al. (2008); Manuj and Mentzer (2008); Blos et al. (2009); Field study.
FV2	Economic recession	Impact of economic recession on our supply chain is	Xu (2008); Blos et al. (2009); Field study.
FV3	Raw material price fluctuation	Impact of raw material price fluctuation on our supply chain is	Xu (2008); Field study.
FV4	Bank interest and funds	Impact of high bank interest and funds shortage on our supply chain is	Blos et al. (2009); Field study.
FV5	Bankruptcy	Impact of bankruptcy or credit default of any supply chain member on our supply chain is	Blackhurst et al. (2008); Manuj and Mentzer (2008); Field study.
OV			
OV1	Shortage of skilled worker	Impact of lack of skilled workers and productivity on our supply chain is	Haider (2007); Field study.
OV2	Switching and absenteeism of workers	Impact of switching and absenteeism of workers on our supply chain is	Field study.
OV3	Production planning and inventory management	Impact of fault in production planning and inventory management on our supply chain is	Wu et al. (2006); Field study.
OV4	Failure of IT system and machinery	Impact of IT system failure on our supply chain is	Blos et al. (2009); Field study.
OV5	Disruption in utility supply	Impact of disruption in utility supply on our supply chain is	Blos et al. (2009); Field study.
OV6	Product quality defects	Impact of product quality defects on our supply chain is	Blos et al. (2009); Field study.
OV7	Illiteracy of workers and supervisors	Impact of illiteracy of workers and supervisors on our supply chain is	Field study.
IV			
IV1	Delay in customs clearance and documentation	Impact of delay in customs clearance and other export documentation processing on our supply chain is	Colicchia (2010); Field study.
IV2	Inefficiency in port management	Impact of delay for congestion and inefficiency in port on our supply chain is	Colicchia (2010); Blackhurst et al. (2008); Field study.
IV3	Delay in land transportation	Impact of poor transportation infrastructure on our supply chain is	Blackhurst et al. (2008); Field study.
DSV			

DSV1	Suppliers' disruptions and delay	Impact of suppliers' disruption and delay on our supply chain is	Blackhurst et al. (2008); Ponomarov and Holcomb (2009); Field study.
DSV2	Dependence on imported material	Impact of dependence on imported material and poor backward linkage on our supply chain is	Haider (2007); Nuruzzaman (2009); Craighead (2007); Peck (2005); Field study.
DSV3	Non-conformity of material	Impact of fault in material supplied by supplier on our supply chain is	Blackhurst et al. (2008); Field study.
DSV4	Buyers' disruptions and opportunism	Impact of buyer disruption and opportunism on our supply chain is	Ponomarov and Holcomb (2009); Pettit, Fiksel and Croxton (2010); Field study.
DSV5	Demand fluctuation	Impact of demand fluctuation/uncertainty on our supply chain is	Wu et al. (2006); Bansal et al. (2005); Field study.

HV=Hazard vulnerability, SV=Strategic vulnerability, FV=Financial vulnerability, OV=Operational vulnerability, IV=Infrastructural vulnerability, DSV=Demand–supply vulnerability

5.5.2.3 Questionnaire Section 3: supply chain resilience factors

This section included the measurement items with respect to supply chain resilience. The higher-order construct "supply chain resilience" was measured by the dimensions: supply chain capability, supply chain design, supply chain readiness, and supply chain response and recovery. This section was segregated into two sub-sections, 3-A and 3-B. 3-A included the measurement instrument for the construct "supply chain resilience" with respect to supply chain capability and its dimensions, whereas 3-B included the measurement instrument for the construct "supply chain resilience" with respect to supply chain design, supply chain readiness, and supply chain response and recovery.

Questionnaire Section 3-A

This section comprised the measurement items for supply chain capability dimensions: flexibility, redundancy, integration, efficiency, market strength and financial strength. Table 5.4 presents the measurement items and related statements corresponding to each dimension. All these dimensions were measured by reflective indicators because: firstly, the indicators are manifestations of the construct and the indicators are expected to covary with each other (Jarvis et al. 2003). For example, the items of the construct "redundancy" such as maintaining adequate alternative and reserve capacity, keeping buffer stock and having a back-up utility source are related to each other and therefore they are expected to covary. Similarly, the items of the construct "efficiency" covary with each other. Secondly, the previous literature, for example, Braunscheidel and Suresh (2009) also measures the supply chain capability constructs such as flexibility and integration in the reflective mode. The details about the measurement of supply chain capability dimensions are described below.

The construct “supply chain flexibility” reflects the ability of the organizations and their supply chains to cope with and to respond to the market needs. It was measured by the items (FLX1 to FLX7): flexibility in production, product mix, multi-skilled workforce, contract flexibility, cost efficiency, responsiveness and ability to introduce new products. These items were selected from the previous literature (Gunasekaran, Lai, and Cheng 2008; Jüttner and Maklan 2011; Ducols 2003) and were contextualised through comparison with the field study findings.

The construct “integration” reflects the ability of a supply chain to assimilate the inter-organizational functions and the functions associated with supply chain members through the free flow of information. The items (INT1 to INT4) of integration were measured by: information sharing, internal integration, supply chain collaboration and ICT adoption. These items were derived from the previous studies (Erol, Sauser, and Mansouri 2010; Pettit, Fiksel, and Croxton 2010; Blackhurst et al. 2005; Peck 2005) and were contextualised by comparison with the field study findings.

The construct “redundancy” reflects the ability of a supply chain to meet sudden requirements from back-up sources or buffer stock. It was measured by the items (RD1 to RD3): reserve capacity, stock and back-up utility source. These items were mainly adapted from the study of Pettit, Croxton and Fiksel (2013). Most of the field study participants strongly supported the requirement of redundant capacities to meet uncertainties and, therefore, the selected items from the literature were contextualised based on the findings from the field study.

The construct “supply chain efficiency” reflects the ability of a supply chain to increase its competitiveness through reducing resources usage and improving quality. It was measured by (EF1 to EF3): waste reduction, worker efficiency and quality control. These items were mainly derived from previous studies (Pettit, Croxton, and Fiksel 2013; Fiksel 2003; Kleindorfer and Saad 2005) and then compared with the field study findings to be contextualised for this study.

The construct “market strength” reflects the ability of a supply chain to strengthen its position in the market through creating a long-term, value-based and satisfactory relationship with supply chain partners. It was measured by the items (MS1 to MS3): buyer–supplier satisfaction, preferred brand and buyer–supplier relationship. These items were mainly obtained from field study however, support from literature (e.g. Pettit, Fiksel and Croxton 2013) was also ascertained.

The construct "financial strength" reflects the ability of a supply chain to provide financial back-up to recover from disruptions. It was measured by (FS1 to FS3): availability of funds, consistent profit and insurance. The indicators of each construct were selected mainly from Pettit, Fiksel and Croxton (2010, 2013) and were contextualised based on the findings from the field study.

Table 5.4: Measurement items and related statements of supply chain capability

FLX	Dimension	Statements	Sources
FLX1	Flexibility in production	We have enough flexibility in production.	Duclos, Vokurka and Lummus (2003); Field study.
FLX2	Product customization	We are efficient to customize products as per buyers' requirement.	Handfield and Bechtel (2002); Field study.
FLX3	Multi-skilled workforce	Our workers are skilled to handle different tasks and product lines.	Duclos, Vokurka and Lummus (2003); Field study.
FLX4	Contract flexibility	We have enough flexibility in contracts with SC members.	Duclos, Vokurka and Lummus (2003); Field study.
FLX5	Cost effectiveness	We are cost effective in logistics and supply chain functions.	Gunasekaran, Lai and Cheng (2008); Jüttner and Maklan (2011); Field study.
FLX6	Responsiveness	We are very quick to respond to additional order or sudden demand.	Jüttner and Maklan (2011); Field study.
FLX7	Introducing new products	We are able to introduce new products for different types of customer group.	Duclos, Vokurka and Lummus (2003); Field study.
RD	Dimension	Statements	Sources
RD1	Reserve capacity	We maintain adequate alternative and reserve capacity.	Pettit, Croxton and Fiksel (2013); Field study.
RD2	Stock of material	We keep required stock for raw material.	Pettit, Croxton and Fiksel (2013); Field study.
RD3	Back-up utility source	We have effective back-up energy/utility source.	Pettit, Fiksel and Croxton (2010); Pettit, Croxton and Fiksel (2013); Field study.
INT	Dimension	Statements	Sources
INT1	Information sharing	Information sharing with our supply chain partners is satisfactory.	Peck (2005); Blackhurst et al. (2005); Field study.
INT2	Internal integration	We have communication and information flow between different functional areas to facilitate supply chain functions.	Erol, Sauser and Mansouri (2010); Field study.
INT3	Collaboration	We have collaborative planning with supply chain partners.	Erol, Sauser and Mansouri (2010)
INT4	ICT adoption	We have ICT-supported planning.	Pettit, Croxton and Fiksel (2013); Peck (2005); Field study.
EF	Dimension	Statements	Sources
EF1	Waste reduction	We reduce waste by efficient use of resources.	Pettit, Croxton and Fiksel (2013); Fiksel (2003); Sheffi (2005).
EF2	Worker efficiency	We try to increase efficiency and satisfaction of employees by providing training and other facilities.	Pettit, Fiksel and Croxton (2010); Field study.
EF3	Quality control	We have a low defect and rejection rate because of strict quality control.	Pettit, Croxton and Fiksel (2013); Kleindorfer and Saad (2005); Field study.
MS	Dimension	Statements	Sources
MS1	Buyer–supplier	Our buyers and suppliers are	Zhang, Vonderembse and Lim

	satisfaction	satisfied with us.	(2003); Pettit, Fiksel and Croxton (2010).
MS2	Preferred brand	We are a preferred supplier as we meet their requirements regarding social, environmental and operational issues.	Zhang, Vonderembse and Lim (2003); Field study.
MS3	Buyer–supplier relationship	We have strong relationships with our buyers, suppliers, employees and other stakeholders.	Zsidisin and Ellram (2003); Pettit, Croxton and Fiksel (2013); Field study.
FS	Dimension	Statements	Sources
FS1	Enough funds	We have enough funds to recover from crisis.	Pettit, Croxton and Fiksel (2013); Tang (2006).
FS2	Consistent profit	We have consistent profit and low risk of loss.	Pettit, Croxton and Fiksel (2013); Field study.
FS3	Insurance	We have insurance for all of our resources and employees.	Pettit, Croxton and Fiksel (2013); Field study.

FLX=Flexibility, RD=Redundancy, INT=Integration, EF=Efficiency, MS=Market strength, FS=Financial strength.

Questionnaire Section 3-B

This sub-section incorporated the measurement instrument for supply chain design (SCD), supply chain readiness, and supply chain response and recovery. The items under these constructs were operationalized in the reflective mode following the decision rules of Jarvis et al. (2003). More specifically, it can be reasoned that a supply chain with high readiness exhibits the attributes of readiness training, resources and other readiness efforts. Similarly, the ability of quick response and recovery of a resilient supply chain is reflected by the attributes of quick response to disruptions; quick recovery from crisis; loss absorption capacity; reduction of impact of loss; and low cost of recovery. Moreover, the dimensions: supply chain readiness, and supply chain response and recovery seemed to covary because of their interdependence. For example, if a supply chain has better readiness, it can respond and recover quicker. Based on the above argument, it can be inferred that the indicators are manifestations of the latent variable. Tables 5.5 to 5.7 present the measurement items and related statements corresponding to each dimension.

The construct "supply chain design" (SCD) reflects the attributes of a supply chain network with alternatives in sourcing, transportation, market positioning, production, etc. to overcome vulnerability from any source. Supply chain design was measured by the items (SCD1 to SCD5): alternative sourcing, alternative distribution, alternative market, alternative production and backward linkage. Except for SCD5, all of these items were adapted from the previous literature (see Table 5.5) and were contextualised based on the findings from the field study. The item "backward linkage" has been developed from the field study while being supported by similar research (see Table 5.5).

"Supply chain readiness" (RED) reflects the attributes of a supply chain to quickly prepare itself during a crisis. The construct "readiness" was measured by (RED1 to RED5): readiness training, readiness resources, early warning signal, forecasting and security. These items were derived from the previous studies (see Table 5.6) and were contextualised based on the findings of the field study.

The construct "response–recovery" (RR) refers to the attributes of a supply chain to ensure quick response and efficient recovery. This construct was measured by the items (RR1 to RR5): quick response, quick recovery, loss absorption, reduction of impact and cost of recovery. These items were adapted or adopted from the previous literature (see Table 5.7) and were contextualised based on the findings of the field study.

Table 5.5: Measurement items and related statements of SCD

Supply chain design	Dimension	Statements	Sources
SCD1	Alternative sourcing	We have alternative suppliers and sourcing options.	Colicchia, Dallaria and Melacini (2010); Craighead et al. (2007); Kleindorfer and Saad (2005); Field study.
SCD2	Alternative distribution	To overcome problems of sourcing and distribution, we easily arrange alternative shipping and rerouting arrangements.	Craighead et al. (2007); Kleindorfer and Saad (2005); Field study.
SCD3	Alternative market	We have markets/customers in different regions.	Field study.
SCD4	Alternative production	We have production in different locations.	Kleindorfer and Saad (2005); Craighead et al. (2007); Field study.
SCD5	Backward linkage	We have our own accessory plant to supply material to our company.	Manuj and Mentzer (2008); Ponomarov and Holcomb (2009); Field study.

Table 5.6: Measurement items and related statements of supply chain readiness (RED)

Read-iness	Dimension	Statements	Sources
RED1	Readiness training	We have better readiness training and inspection to overcome disruptions.	Pettit, Fiksel and Croxton (2010, 2013); Rousaki (2006).
RED2	Readiness resources	We do not have enough resources and accessibility to resources regarding mitigation of disruptions/disaster.	Hale (2005).
RED3	Early warning signal	We properly collect and analyse early warning signals.	Pettit, Fiksel and Croxton (2010); Craighead et al. (2007).
RED4	Forecasting	To prepare ourselves against	Pettit, Fiksel and Croxton

		disruptions, we have adequate forecasting and anticipation.	(2010); Cranfield (2002, 2003); Peck (2005); Sheffi (2005); Blackhurst et al. (2005).
RED5	Security	We have an adequate safety and security system.	Peck (2005); Sheffi and Rice (2005); Craighead et al. (2007); Hale and Moberg (2005).

Table 5.7: Measurement items of supply chain response and recovery (RR)

Response & recovery	Dimension	Statements	Sources
RRC1	Quick response	We respond quickly to uncertainties.	Sheffi and Rice (2005); Norrman and Jansson (2004).
RRC2	Quick recovery	We can recover quickly from highly vulnerable and highly probable disruptions.	Sheffi and Rice (2005); Christopher and Peck (2004); Willroth, Diez and Arunotai (2011); Gunderson (2000).
RRC3	Loss absorption	We can absorb a huge loss.	Holling (1973); Dalziell and McManus (2004).
RRC4	Reduction of impact	We can reduce the impact of loss.	Rose (2004); Dalziell and McManus (2004).
RRC5	Cost of recovery	We can recover at low cost.	Martin (2004); Vugrin, Warren and Ehlen (2011).

5.5.2.4 Questionnaire Section 4: measurement of antecedent factors of SCR

Based on the previous literature and with support from the field study, supply chain orientation, supportive environmental factors, learning and development, and supply chain risk management were considered as antecedents of supply chain resilience. The construct "supply chain orientation" was measured by (SCO1 to SCO4): trust, commitment, cooperation and top management support. The construct "supportive environmental factors" was measured by (SF1 to SF4): government support, factor endowment, international trade support and institutional support services. "Learning and development" was measured by (LD1 to LD4): training, career improvement opportunity, research and development, and past learning. Finally, "SCRM" was measured by (SCRM1 to SCRM4): risk sharing, effort to reduce risk, knowing risk and risk consideration in decision making. Among the four antecedent factors except for supportive environmental factors, the other constructs were measured by the items selected from the literature and then contextualised based on the field study findings. Table 5.8 details the items under each construct. The construct "supportive environmental factors" was developed primarily from the field study. The field study participants emphasised the need for supportive environmental factors for mitigating supply chain challenges and vulnerabilities. The supportive environmental factors extracted from the field study were also supported by the relevant literature. The

indicators of each of the antecedent dimensions of supply chain resilience were operationalized in the reflective mode which is aligned with the decision rules of Jarvis et al. (2003).

Table 5.8: Measurement items regarding antecedents of supply chain resilience

	Dimension	Statements	Sources
SCO			
SCO1	Trust	We have high level of trust with the supply chain members.	Min and Mentzer (2004); Jüttner and Maklan (2011); Jüttner (2005); Field study.
SCO2	Commitment	Level of commitment with our supply chain members is high.	Min and Mentzer (2004); Jüttner (2005); Field study.
SCO3	Cooperation	We have enough cooperation with the supply chain members.	Min and Mentzer (2004); Field study.
SCO4	Management support	Top management is actively engaged in supply chain decision making.	Min and Mentzer (2004); Field study.
SF			
SF1	Government support	Government provides us required support.	Narrod et al. (2009); Nuruzzaman (2013); Field study.
SF2	Factor endowment	We have adequate factor endowment.	Dowlah (1999); Field study.
SF3	International trade support	We have a favourable international trade environment.	Haider (2007); Dowlah (1999); Field study.
SF4	Institutional facilitating services	Our trade body and institutions support us sufficiently.	Dowlah (1999); Field study.
LD			
LD1	Training	Training and counselling system in our organization is high.	Pettit, Fiksel and Croxton (2010); Omera and Bernard (2007); Field study.
LD2	Career improvement opportunity	We provide enough opportunities for development of employees.	Hurley and Hault (1998); Field study.
LD3	Research and development	We have research and development for improvement of product, process and efficiency.	Brewer and Speh (2000); Field study.
LD4	Past learning	We use learning from past experience to mitigate risks.	Pettit, Fiksel and Croxton (2010); Giunipero and Eltantawy (2004); Field study.
SCRM			
SCRM1	Risk sharing	We have a high level of risk sharing activities with supply chain members.	Jüttner and Maklan (2011); Field study.
SCRM2	Effort to reduce risk	We cannot always take enough effort to reduce disruption.	Jüttner and Maklan (2011); Field study.
SCRM3	Knowing risk	Our effort to know about risk is high.	Jüttner and Maklan (2011); Field study.
SCRM4	Risk consideration	We consider risk in decision making properly.	Jüttner and Maklan (2011); Field study.

SCO=Supply chain orientation, SF=Supportive environmental factors, LD=Learning and development, SCRM=Supply chain risk management.

5.5.2.5 Questionnaire Section 5: sustainability factors

The main focus of this section was to identify and measure the supply chain sustainability factors: social, environmental, economic and operational sustainability. The six-point Likert scale namely: 1-strongly disagree, 2-disagree, 3-somewhat disagree, 4-somewhat agree, 5-agree and 6-strongly agree was used for this section. The indicators of social, environmental, economic and operational factors were operationalized in the reflective mode because the indicators are manifestations of the construct and indicators are expected to covary with each other (Jarvis et al. 2003). Previous studies, for example, Carter (2004); Chien and Shih (2007); Rao (2002); also measure the social, environmental and economic sustainability issues in the supply chain through reflective indicators. The items related to social, environmental, economic and operational sustainability in the supply chain are presented by Table 5.9.

Social sustainability in the supply chain includes the organizational and supply chain actions that are socially sustainable and that consider human factors in the organization (Hutchin and Sutherland 2008). In this study, social sustainability reflects the organizational actions toward ensuring human factors and complying with social sustainability requirements of the supply chain. To measure social sustainability, the GRI (2011); ICHemE (2005); Dow Jones index (2005); Carter (2004); and ILO conventions for the social sustainability dimension were mostly followed and were contextualised by comparison with the field study findings. More specifically, the measurement items (SCS1 to SCS8 in Table 5.9): wages; benefits; hazard and safety; health; child labour; forced labour; monitoring suppliers; and employee satisfaction were considered to evaluate social sustainability.

Environmental sustainability reflects the organizational actions toward reducing environmental pollution and complying with the environmental sustainability requirements of the supply chain. Environmental sustainability measures were selected from the GRI (2011); ICHemE (2005); and Dow Jones index (2005) as well as the items suggested by Carter (2004) and Epstein and Wisner (2001). The field study findings were incorporated to contextualise the items. The indicators (ENS1 to ENS8): water, air, soil pollution and pollution controlling measures were finally selected based on the literature and field study data to measure environmental sustainability.

Economic sustainability encompasses the financial strength of the organization to continue business profitably. Economic sustainability was measured by the items (ECS1 to ECS4): sales, cost, profit and sales growth with reference to the previous

literature (Epstein and Wisner, 2001; GRI 2011; IChemE 2005; and Dow Jones 2005) and was contextualised on the basis of the field study findings.

Operational sustainability infers the smooth functioning of operations to ensure expected lead time, quality, specifications of the buyers and use of updated and efficient machinery. Most field study participants emphasised the requirement of operational factors for continuing their business and to satisfy their buyers. The items (OPS1 to OPS4) of operational sustainability were considered mainly from the field study while being supported by similar research (see Table 5.9). These indicators are expected to covary due to interdependence among the indicators. For example, maintaining lead time, quality and specifications depend on the use of efficient and updated machinery.

Therefore, with reference to the decision rules of Jarvis et al. (2003) operational sustainability was measured in the reflective mode.

Table 5.9: Measurement items and related statements of social, environmental, economic and operational sustainability

Sustain-ability	Dimension	Statements	Sources
Social			
SCS1	Wages and payments	Our company provides standard wages and overtime payments.	GRI (2011); ICHemE (2005); Minimum Wage Fixing Convention (1970); ILO Weekly Rest Convention (1921); Field study.
SCS2	Benefits and facilities	Our company provides required benefits to the employees (e.g. leave benefit, medical benefit, child care facility, transportation, etc.).	GRI (2011); ICHemE (2005); ILO Weekly Rest Convention (1921); GRI (2011); ICHemE (2005); Field study.
SCS3	Hazard and safety	We take adequate precautions for hazards and safety of the employees (maintaining fire safety, building safety, personal protective equipment).	ILO Occupational Safety and Health Convention (1981); Field study.
SCS4	Health and sanitation	We take adequate measures for health and sanitation of the employees (pure drinking water, cleanliness, adequate toilets).	GRI (2011); ILO Occupational Safety and Health Convention (1981); ILO Working Environment Convention (1977) (No. 148); Field study.
SCS5	Child labour	We are strict about the child labour issue.	GRI (2011); ILO Minimum Age Convention (1973); Field study.
SCS6	Forced labour	We do not force to work and do not harass workers.	Forced Labour Convention (1930); Field study.
SCS7	Monitoring	We monitor the social compliance factors of our suppliers.	GRI (2011); Epstein and Wisner (2001); Field study.
SCS8	Employee satisfaction	Our employees are satisfied with us.	GRI (2011); Epstein and Wisner (2001); Field study.

Environ-mental	Dimension	Statements	Sources
ENS1	Water pollution	We take adequate measures to control water pollution (e.g. effluent treatment plant (ETP)).	GRI (2011); IChemE (2005); Epstein and Wisner (2001); Field study.
ENS2	Air pollution	We take adequate measures to control air pollution.	GRI (2011); IChemE (2005); Epstein and Wisner (2001); Field study.
ENS3	Soil pollution	We take adequate measures to control soil pollution.	GRI (2011); Epstein and Wisner (2001); Field study.
ENS4	Waste recycling	We recycle the wastes of our plant or sell the wastes to recyclers.	Epstein and Wisner (2001); Field study.
ENS5	Hazardous material	We control the use of hazardous materials and chemicals (lead, Azo or other banned chemicals etc.) in products.	IChemE (2005); Epstein and Wisner (2001); Field study.
ENS6	Certification and audit	We have environmental certification and audit.	GRI (2011); Epstein and Wisner (2001); Field study.
ENS7	Environ-mental legislation	We do not fulfil the criteria regarding environmental legislation of the country.	GRI (2011); Field study.
ENS8	Suppliers' performance	We evaluate the environmental performance of suppliers.	GRI (2011); Epstein and Wisner (2001); Field study.
Operation al	Dimension	Statements	Sources
OPS1	Lead time	We can meet the lead time set by our buyers.	Bicheno (1998); Bateman and David (2002); Field study.
OPS2	Quality	We meet a high quality standard.	Bicheno (1998); Bateman and David (2002); Epstein and Wisner (2001); Field study.
OPS3	Specifications	We can meet different specifications (design, size, colour, etc.) of the buyers properly.	Duclos, Vokurka and Lummus (2003); Field study.
OPS4	Updated technology	We use efficient and updated machinery and technology.	Field study.
Economic	Dimension	Statements	Sources
ECS1	Sales	We have adequate sales and business volume.	GRI (2011); IChemE (2005); Field study.
ECS2	Cost	We can produce at low cost.	GRI (2011); IChemE (2005); Field study.
ECS3	Profit	We can make required profit.	GRI (20110); IChemE (2005).
ECS4	Sales growth	Our sales growth is high.	Epstein and Wisner (2001); Field study.

5.6 PRE-TESTING PROCEDURE

The initial questionnaire was pre-tested by sending the questionnaire to 10 respondents: four supply chain management academics, one executive from Bangladesh Garment Manufacturers and Exporters Association (BGMEA), three apparel supply chain decision makers and two accessory producers. The researcher contacted the respondents over the telephone and then questionnaires were sent by email with a

feedback form. They were asked to review and comment on the selected items of each dimension. This would help to determine whether there was a need for revision of the survey instrument with respect to furnishing proper content, layout, wording and understandability, and the speed of completion. It would also help to clarify ambiguous measurement items if there were any.

Based on the opinion of the respondents, it was realized that some statements in the questionnaire needed further clarification for better understandability. For example, one respondent asked about the clarification of the term "different specification of the buyers" (see question 5.24, Appendix B, page 267). Another respondent asked that the word "non-compliance" of social and environmental factors be used instead of "violation" of social and environmental factors (see question 2.6, Appendix B, page 263). All the comments and suggestions were incorporated into the final design of the questionnaire. The final version of the questionnaire was then organized for the pilot study.

5.7 SUMMARY

This chapter presented the hypotheses which were developed in accordance with the final research model. The rationale and justification of the hypotheses were also explained aligned with previous studies and the field study findings. In total, 21 hypotheses were developed to describe the relationships among the variables as proposed in the comprehensive research model (see Figure 4.3, page 126). Finally, the chapter elucidated the measurement item development processes leading to the survey questionnaire design. The measurement items were selected based on both the literature and the field study outcomes. Excluding the demographic variables, 104 items were developed for the questionnaire. The developed questionnaire then underwent a pre-testing process for refinement. Once the questionnaire was fine-tuned based on the feedback from pre-testing, the pre-tested questionnaire was subjected to the pilot study to test its validity. Then, the final questionnaire was administered for the survey which is discussed in the next chapter.

CHAPTER 6

SURVEY AND QUANTITATIVE DATA ANALYSIS

6.1 INTRODUCTION

The previous chapter presented the hypotheses for this study and illustrated the questionnaire development process. After preparing the questionnaire, the developed instrument was used for pre-testing to identify and incorporate necessary improvements. Once the questionnaire was fine-tuned based on the feedback from pre-testing, a pilot study with 76 respondents was initiated to affirm the applicability of the questionnaire for the final survey. After the refinement of the questionnaire based on the pilot study outcome, the final questionnaire was used for administering the national survey. Data were collected mostly by face-to-face questionnaire survey although some of the responses were collected by mail survey. The findings from the collected data are explained in a number of phases. Thus, the organization of this chapter is as follows: this chapter starts with the findings on the pilot study followed by preliminary analysis of the survey data which is discussed in the next phase. Then the analysis of the survey data by using partial least squares (PLS)-based structural equation modelling (SEM) is presented. The PLS-based SEM analysis is segregated into two parts: analysis of the measurement model and analysis of the structural model.

6.2 PILOT STUDY

Following the reviews from the pre-test procedure, a pilot survey was conducted with the purpose of ensuring the applicability of the data. The pilot study was administered on 89 respondents with a set of pre-tested structured questionnaires. Finally, 76 completed responses were collected from respondents consisting of 54 managers from apparel manufacturers and 22 from accessory-supplying companies.

Data were collected by using a six-point Likert scale. The pilot study questionnaire was administered by email. The participants were encouraged and asked to give comments on the comprehensibility and complexity of the questions (items) in the survey. Eight of the respondents commented on encountering problems in understanding the wordings of some questions. They noted the wording of respective questions. In response to their feedback, the wording was revised for more understandability. Meanwhile, 11 participants mentioned that the survey instrument was lengthy as there were so many questions. Nevertheless, this problem could not be avoided due to the

complexity of the exploratory research model. Moreover, the accurate conceptualization of the large number of constructs in the model required a large number of items. It was also observed that some respondents were scoring high in some of the questions especially regarding social sustainability issues. The questions were further examined and a few adjustments were made with regard to the structure and wording; for example, in some cases, passive statements and negative statements were introduced to overcome the problems of bias (Rossi, Wright, and Anderson 1983). It is worth mentioning that the survey responses corresponding to the negative statements were coded appropriately in accordance with the six-point Likert scale used in this questionnaire survey.

6.2.1 Demographic information of pilot study samples

The participants in the pilot study answered five questions regarding demographic variables. The demographic information of the pilot study sample is presented by Table 6.1.

Table 6.1: Demographic information of pilot study respondents

Supply Chain Entity	**Number of Companies**	**%**
Apparel manufacturers	54	71
Apparel accessory suppliers	22	29
Number of Employees	**Number of Companies**	**%**
< =500	18	23.7
501-1000	20	26.3
1001-1500	15	20
1501-2000	9	11.8
2001+	14	18.2
Number of Years in Business	**Number of Companies**	**%**
< =5	28	37
6-10	21	27.6
11-15	12	16
16-20	7	9
21+	8	10.4
Turnover in Business (Million BDT)	**Number of Companies**	**%**
0-1000	34	45
1001-2000	21	28
2001-3000	13	17
3001+	8	10

Supply chain entity

Data were collected from two supply chain entities: apparel manufacturing companies and their suppliers. The respondents were asked to select whether they were affiliated with apparel manufacturing companies or accessory manufacturing companies. Table 6.1 shows the number of sample companies, respectively, for the two supply

chain entities targeted for this research. It was revealed that the majority of the respondents (71%) were from apparel manufacturing companies and the others (29%) were from accessory-supplying companies. This distribution is relevant because the number of backward linkage companies, that is, the apparel accessory-producing companies is not adequate in Bangladesh which is consistent with the findings of the study by Nuruzzaman (2009).

Size of the firm

Table 6.1 shows the number of employees in the sample firms. It was affirmed that firms within the range of 1000 employees comprised more than 50% of the total sample firms. This distribution is logical as most apparel factories and accessory-production firms in Bangladesh are small firms.

Number of years in business

Respondents were asked about the establishment year of their organizations which indicated the experience of the organizations in their respective businesses. Table 6.1 indicates the experience of the sample firms. It was revealed that most of the sample firms had less than 15 years of experience while only 20% of firms had more than 15 years of experience. This is reasonable because rapid growth in the apparel industry of Bangladesh has been observed since 1990 (Nuruzzaman 2009).

Turnover

Respondents were also asked about the turnover of their firms and the acquired information is presented in Table 6.1. It was evident that most of the sample companies had turnover of less than 2000 million BDT which is equivalent to USD25 million. This represents the overall scenario of the industry because the number of small apparel manufacturers is relatively higher and the turnover of small apparel manufacturers is low.

6.2.2 Descriptive statistics

After collecting data from 76 respondents, data were recorded in SPSS software for analysis. The search to find missing data revealed that almost all the responses were completed except in five cases with two to four missing data. No case was found to be missing significant data; therefore, they were estimated and replaced. The mean substitution technique was used in this regard as it is one of the commonly used methods for missing data analysis (Roth and Switzer 1995). The total number of usable responses from the pilot study was 76. A succinct picture of the descriptive statistics on

the pilot test data is demonstrated by Table 6.2. For each of the 104 scale items, descriptive statistical analyses such as mean and standard deviation were performed. Kurtosis values were also computed and analysed for identification of potential outliers. All the measurement items were scaled as “strongly disagree=1” to “strongly agree=6”; however, supply chain vulnerability was measured as “extremely low=1” to “extremely high=6”. The descriptive data analyses results showed that the range of mean values was from 3.8 to 5.39, while the range of mean values for supply chain vulnerability was from 2.35 to 4.25. Standard deviation for all items ranged from .716 to 1.256. These ranges have been considered acceptable in this analysis because they do not exhibit any extreme values. Kurtosis values for each of the items did not seem questionable as all kurtosis values were less than 2 except for SCS2, ENS3, DSV5 and SCO3. The items were further scrutinized and a few outliers were traced which were than normalized.

Table 6.2: Descriptive statistics of pilot study

Items	Mean Statistic	Std. Deviat-ion	Kurtosis Statistic	Items	Mean Statistic	Std. Deviat-ion	Kurtosis Statistic
HV1	3.0000	.72111	-1.020	SCD2	4.6863	.96933	-.942
HV2	3.0000	.84853	-.579	SCD3	4.2157	1.36108	-1.172
HV3	2.5882	.94184	-.232	SCD4	3.8824	1.01286	-.576
HV4	3.3333	.86410	-.312	SCD5	3.8431	.94599	-.032
SV1	3.7432	.99686	-.459	RED1	4.4902	.96690	-.910
SV2	3.0588	.88118	-.538	RED2	4.1373	1.09580	-.756
SV3	2.9412	.94682	-.573	RED3	4.3529	.91266	-.677
SV4	3.1765	.84157	-1.460	RED4	4.8039	1.00039	-.240
SV5	2.8431	1.06532	-.696	RR1	4.5882	.80440	-.378
FV1	3.4118	.85268	.677	RR2	4.2941	.92291	-.939
FV2	3.9412	.98817	-.503	RR3	4.3137	.94848	-.932
FV3	3.9412	.92546	-.299	RR4	4.5294	.83314	-.508
FV4	3.6078	.93975	-.391	SCO1	4.9412	.88118	-1.330
FV5	3.0588	.85818	-.327	SCO2	5.0588	.85818	-1.090
OV1	3.0392	.72002	-1.013	SCO3	4.8627	1.25958	-2.206
OV2	3.7432	.71675	-.430	SCO4	4.5294	1.02670	-.589
OV3	3.2157	.96569	-.665	SF1	4.3333	1.03280	-.379
OV4	3.0196	.92715	.616	SF2	4.8235	.76696	-.709
OV5	4.2549	1.26243	-.853	SF3	4.2941	1.10080	-.259
OV6	3.1569	.78416	-.321	SF4	4.4902	1.06532	.033
OV7	3.4706	1.02670	-.574	LD1	4.4320	1.02594	-1.099
IV1	3.3529	.86772	.702	LD2	4.2941	1.08248	-.963
IV2	3.4314	.96447	-.172	LD3	4.0588	1.25558	-1.061
IV3	3.3529	.97619	-.132	LD4	5.0784	.82081	-.810
DSV1	3.4118	.77914	-.242	SCRM1	4.7647	.90749	-1.208
DSV2	4.0588	.92546	-.559	SCRM2	4.6863	.94848	-.932
DSV3	3.0980	1.00509	-.657	SCRM3	4.4320	.96569	-.903
DSV4	3.2745	.77662	-.464	SCRM4	4.9412	.83455	-1.068
DSV5	3.3137	.90532	-2.856	SCS1	5.0588	.78326	-.557
FLX1	4.7059	.92291	-.786	SCS2	4.7843	1.00625	-2.885
FLX2	4.9020	.85452	-.801	SCS3	4.8824	1.3278	-1.889

FLX3	4.4902	.96690	-.916	SCS4	4.8431	.98737	-.972
FLX4	4.8039	.84899	-.559	SCS5	5.3922	.66569	-.583
FLX5	4.4706	1.04600	-.701	SCS6	5.0000	.84853	-.579
FLX6	4.4320	.94475	-.819	SCS7	4.0392	1.03848	.727
RD1	4.6275	.97900	-.956	SCS8	4.5882	.82889	-.503
RD2	4.0196	1.22458	-.760	ENS1	4.4320	.98618	-.953
RD3	4.6078	.96080	-.956	ENS2	4.1765	1.09006	-1.009
INT1	4.5490	1.00625	-1.475	ENS3	4.2745	1.11496	2.102
INT2	4.3922	1.05978	-.908	ENS4	4.8627	.72165	-.290
INT3	4.2941	1.04488	-1.194	ENS5	5.0980	.90011	-.781
INT4	3.9412	1.27140	-1.105	ENS6	4.8039	1.00039	-.780
EF1	4.5294	.78366	-.364	ENS7	4.7059	.87850	-.679
EF2	4.4320	.75667	-.198	ENS8	3.8039	1.05867	1.074
EF3	4.7432	.91309	-.847	OPS1	4.7259	.96528	-1.023
MS1	4.8235	.86501	-.648	OPS2	4.7059	.92291	-.786
MS2	4.5490	1.02594	-1.075	OPS3	4.9608	.91566	-.1775
MS3	4.9412	.98817	-1.271	OPS4	4.4314	1.13587	-.802
FS1	4.4320	1.00625	-.553	ECS1	4.6667	.95219	-.104
FS2	4.4706	1.00703	-.543	ECS2	4.0392	.87088	-.397
FS3	4.9804	1.02937	-.020	ECS3	4.2941	.96528	-.271
SCD1	4.9020	.90011	-1.435	ECS4	4.5686	1.11812	-.983

6.3 ADMINISTRATION OF SURVEY

The broad-based survey data were collected by means of a face-to-face personal survey and mail survey on the apparel manufacturing and accessories companies situated in Chittagong and Dhaka region of Bangladesh. The total targeted response was 350 to meet the adequacy of sample size for analysing the large and complex model developed in this research. From the directory of Bangladesh Garment Manufacturers and Exporters Association (BGMEA), 690 companies were contacted over the telephone. The officials of Bangladesh Garment Manufacturers and Exporters Association were also communicated with and asked to inform their members (the apparel manufacturers and suppliers) about the survey which helped to achieve a positive response from the companies. The survey's aim and the subject matter of the research were explained to the respondents. After being informed about the research, a total of 180 companies agreed to participate in the survey. This stage is considered as the first wave of data collection. Out of 180 respondents, 123 agreed to a face-to-face survey while 57 respondents requested that the questionnaire be sent to their office. Consequently, questionnaires were mailed to the respondents. Meanwhile, appointments were set up in accordance with the convenience of the respondents and data were collected accordingly from most of the respondents except for nine executives who missed their appointment. The researcher and two assistants were engaged in this process. Out of 57 respondents who agreed to the mail survey, seven

respondents did not provide any feedback. As a result, data were collected from 164 respondents which comprised of 114 by face-to-face survey and 50 by mail survey.

After collecting the data in the first step, the remaining respondents (690-180=510) who did not respond to the first contact were approached again. In this phase, 196 respondents were convinced to participate in the survey. This stage is considered as the second wave of data collection. From 196 companies, 121 companies requested that the questionnaire be sent to their office through the mail so that they could complete it at a convenient time. The other 75 companies indicated that they would advise about their participation in the survey later. Within seven days, 59 respondents from among the 121 respondents completed the questionnaire and these were collected accordingly. Meanwhile, the respondents were contacted again and out of the remaining companies, 14 respondents completed the survey instrument. As a whole, in the second wave of the data collection, 73 (59+14) responses were collected. Therefore, in the data collection process, the total responses were 313 including the pilot study responses of 76. The details about the survey response rate are shown on Table 6.3

Table 6.3: Survey response rate

Respondents	Number	Percent (%)
Total target population	350	100
Total responses	313	95.71
Pilot study	76	21.70
First wave	164	46.86
Second wave	73	21
Unusable samples	19	4.86
Total usable samples	296	84.57

6.3.1 Data examination

It was necessary to assess the properties of the collected data before going to final analysis. Researchers should review the responses of each individual questionnaire before transferring the information from questionnaires to software for statistical analysis (Neuman 2000). All questionnaires were checked for inappropriate responses or incompleteness and to determine the usability of the data. Out of 313 responses, seven responses were found to be incomplete and removed from the data set. The screening of the raw data also found that there were some missing values which were not significant in number in each question. The missing values were thus imputed by the estimated means method (Roth and Switzer 1995). The data set was then further examined to trace whether there were any outliers. In all, 15 outlier cases were identified from the data set which is shown by Table 6.4.

Table 6.4: Data examination

Scale	Outlier Cases
SCS2 (Benefits)	38, 189, 41, 295
OPS3 (Specifications)	76, 93
HV3 (Labour unrest)	167
SV4 (Integration)	137, 55, 133
DSV5 (Demand fluctuation)	49, 45
INT1 (Information sharing)	42, 212
RED1 (Readiness inspection)	199

In addition, box plot analysis was also conducted to identify whether there were any extreme outliers. The extreme outlier is detected if any point is beyond the outer fence of the box (see box plot in Figure 6.1). The lower outer fence and the upper outer fence of the box are determined by Q1-3*IQ and Q3+3*IQ, where Q1 and Q3 refer to the first quarter and third quarter, respectively, and IQ refers to the interquartile range. The box plot analysis, as shown by Figure 6.1, identifies that 10 responses were found to be extreme outliers. These responses were separated and removed from the further analysis. Therefore, overall, the survey responses were reported as having 17 invalid responses (seven incomplete responses plus 10 outliers). Finally, the total number of usable responses was 296, which was comprised of 234 from the first wave and 62 from the second wave of data collection.

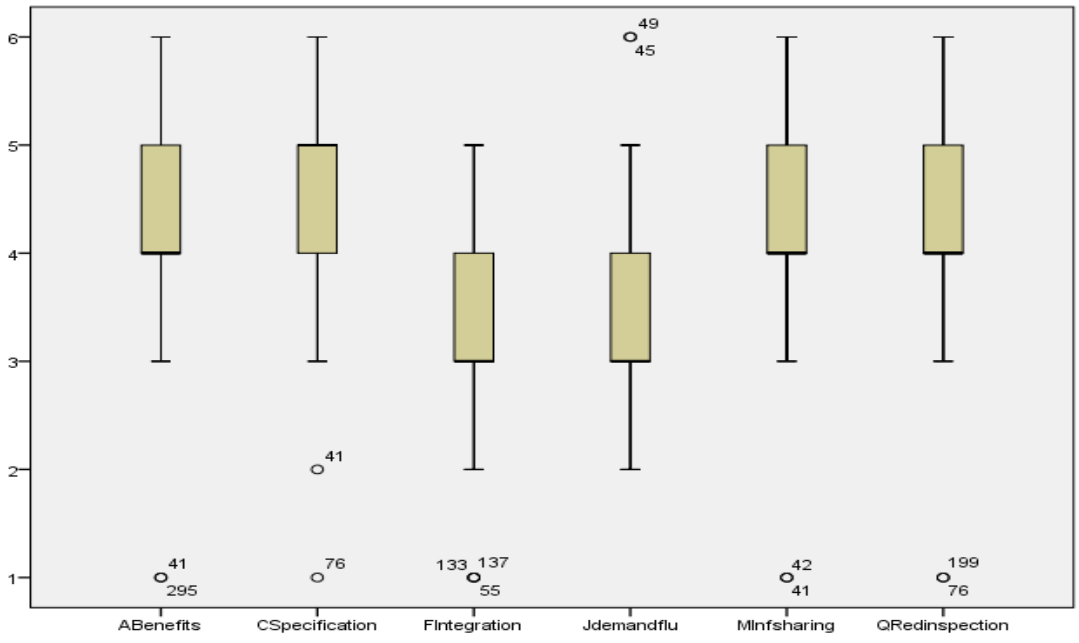


Figure 6.1: Box plot analysis

6.3.2 Sampling errors and non-response bias

Any survey may encounter the problem of non-response bias which limits the representativeness of the survey data. The sample data should represent the

population and, therefore, the data of respondents and non-respondents (the first wave and second wave of data) should be similar. To perform a comparison between the two waves of data, the differences on selected scale items were tested. Before this was done, firstly, the Kolmogrov–Smirnov test was applied to the data to check whether the data were normally distributed. The result of the normality test is shown on Table 6.5.

Table 6.5: Kolmogrov–Smirnov test of normality

Constructs	***t*-value**	**Significance**
CAP	.119	.000
ENS	.095	.000
ECS	.132	.000
EF	.187	.000
FLX	.112	.000
FS	.142	.000
INT	.132	.000
LD	.113	.000
MS	.175	.000
OPS	.113	.000
RD	.108	.000
SCD	.116	.000
RED	.117	.000
SCR	.124	.000
RR	.102	.000
SCO	.173	.000
SCRM	.143	.000
SCS	.071	.000
SF	.067	.003
SCV	.051	.043

It is revealed from Table 6.5 that the test for all the constructs was significant at $p < 0.05$. Therefore, we could accept the alternative hypothesis that the sample data were not normally distributed which necessitated a non-parametric test. In this regard, to ensure the suitability of the data, a non-response bias test was conducted by using the Mann–Whitney test because this non-parametric test is generally used to determine the difference between two independent samples (Malhotra et al. 2004). It also ensures that the sample data do not differ significantly from the population (Groves 2006). In order to conduct the test, this study scrutinized the differences between early (n=234) and late respondents (n=62) in terms of their responses corresponding to the measurement scale items. It was hypothesized that there were differences in the responses between the first wave and the second wave of data with regard to the selected measurement items. The difference between samples was evaluated based on some selected scale items for this study. The test result is depicted by Table 6.6.

Table 6.6 Mann–Whitney test results

Construct	*Z*-Value	Significance (1-tailed)
HV3	-.569	.570
SV2	-1.736	.083
FV4	-1.852	.064
OV1	-.146	.884
IV1	-1.831	.067
DSV3	-2.197	.07
FLX3	-.342	.733
RD1	-.729	.466
INT1	-1.432	.152
EF3	-.713	.476
MS1	-.274	.784
FS1	-.576	.564
SCD1	-1.509	.131
RED4	-1.3	.193
RR2	-.472	.637
SCO1	-1.839	.066
SF2	-.969	.333
LD4	-1.172	.241
SCRM1	-1.252	.211
SCS1	-.735	.462
ENS1	-1.811	.07
OPS1	-1.590	.112
ECS1	-1.119	.263

From Table 6.6, it is revealed that *z*-values are not significant at (*p=.05*): as a result, the hypothesis is rejected. Therefore, there was no difference between the two groups corresponding to the variables and items evaluated in the test. From this result, it can be concluded that non-response bias did not exist in the data set.

6.3.3 Common method variance

One of the limitations in survey data is the prevalence of common method bias which is a potential threat to the validity of the results in survey research (Podsakoff et al. 2003). Several initiatives were taken to reduce the chance of common method bias in this research. Firstly, data were collected carefully from the respondents who possessed relevant knowledge on the subject area. For example, the supply chain managers or the people dealing with supply chain functions in an organization were selected. Secondly, the respondents were assured that the anonymity of their responses would be maintained. Thirdly, the questions were constructed to be simple and specific to avoid ambiguity. Some of the terminologies were explained with relevant examples so that the respondents could easily understand the intended meaning of the scale item. As an example, to measure the item "specifications of the buyers", the questionnaire was developed as: "we meet different specifications (such as design, size, colour, etc.) of the buyers properly". Here, the examples of specifications

by design, size and colour helped the respondents to easily understand the question. Fourthly, the researcher tried to avoid double-barrelled questions. Fifthly, the order of independent and dependent variables in the survey was distanced (Podsakoff et al. 2003). In addition, this study applied the Harman one-factor test (Podsakoff and Organ 1986). In this process all the items (38 items) of main criterion variable (SCRE) in the research model were entered into factor analysis. The unrotated factor solution emerged 9 factors with eigen value greater than 1. The cumulative variance for the factors is 73.103% and no single factor account for majority of the covariance (highest variance 13.23%) in the criterion variable (Podsakoff and Organ 1986). Therefore, common method variance was not considered a major concern in this study.

6.3.4 Demographic information of the sample

Table 6.7 sums up the demographic information of the survey respondents (including pilot study respondents) in terms of supply chain entity, size of the firms, number of years in business and turnover of the sample firms.

Table 6.7: Demographic information of survey respondents

Supply Chain Entity	**Number of Companies**	**Percentage (%)**
Apparel manufacturers	219	74
Accessory producers	77	26
Number of Employees	**Number of Companies**	**Percentage (%)**
Less than 500	73	24.65
501-1000	78	26.35
1001-1500	57	19.30
1501-2000	41	13.85
2001+	47	15.85
Number of Years in Business	**Number of Companies**	**Percentage (%)**
< =5	78	26.35
6-10	84	28.35
11-15	58	19.6
16-20	40	13.5
21+	36	13.2
Turnover (Million BDT)	**Number of Companies**	**Percentage (%)**
0-1000	118	39.8
1001-2000	85	28.7
2001-3000	57	19.3
3001+	36	12.2

Supply chain entity

Table 6.7 shows the data regarding the position of sample firms in the supply chain. The respondents were selected from two supply chain entities: the apparel manufacturing firms and accessory-producing firms. It was revealed that 74% of the

respondents were from apparel manufacturing companies whereas 26% of the respondents were from accessory-supplying companies.

Size of the firm

Table 6.7 also summarises the data regarding the size of the firms surveyed in this research. It reveals that the majority of respondents were from the companies with 0–1000 employees which constituted 51% of the sample. The highest representation was the companies with 501–1000 employees, whereas the lowest representation (41%) was the companies with 1501–2000 employees. The results also indicated that a good range of companies, based on the number of employees, contributed to this study.

Number of years in business

The experience of sample firms in terms of the number of years in business is also presented in Table 6.7. It was evident that most of the sample firms had less than 15 years of experience while only 27% of firms had more than 15 years of experience. This is reasonable because rapid growth in the apparel industry of Bangladesh has been observed since 1990 (Nuruzzaman 2009).

Turnover

The analysis about the turnover of the sample firms can be obtained from Table 6.7: it was evident that the majority of the respondents (68.5%) were from companies with a turnover of from 0–2000 million BDT. The highest number of respondents was from companies that have a turnover of from 0–1000 million BDT. The lowest number of responses was from companies that have a turnover of more than 3001 million BDT.

6.4 PLS-BASED STRUCTURAL EQUATION MODELLING (SEM)

In this study, data analysis was performed by applying structural equation modelling (SEM). Partial least squares (PLS)-based SEM was used in this study in line with the objective of the research. Generally, PLS performs model assessment in two sequential stages:

- Assessment of measurement model
- Assessment of structural model.

These sequential assessments were conducted to ensure that reliable and valid measurement of constructs was attained before the relationships among constructs in the model were finalised. The sequential assessments are shown by Table 6.8.

Table 6.8: Sequential assessments of the model

Stage	Analysis	Analysis	Constructs
1	Assessment of measurement model	i- Item reliability ii- Internal consistency iii- Discriminant validity iv- Absolute importance of items v- Multi-collinearity test	Reflective Reflective Reflective Formative Formative
2	Assessment of structural model	i- Amount of variance explained (R^2) ii- Path coefficient (β) iii- Statistical significance of *t*-values	Both Both Both

The sequential assessments as mentioned in Table 6.8 are discussed in the subsequent sections.

6.4.1 Assessing measurement model

In this study, the comprehensive model consisted of 26 constructs (including first-, second- and higher-order) which were either reflective or formative. Among the constructs, supply chain resilience (SCR), supply chain capability (CAP) and supply chain vulnerability (SCV) were hierarchical and multidimensional. At the higher-order level, the hierarchical construct (SCR) was measured by the reflective constructs: capability (CAP), supply chain design (SCD), supply chain readiness (RED) and supply chain response–recovery (RR). In the second-order level, SCR was measured by CAP which itself was measured by six reflective-type sub-constructs: supply chain flexibility (FLX), redundancy (RD), integration (INT), efficiency (EF), market strength (MS) and financial strength (FS) at first-order level. Another hierarchical construct (SCV) was measured by six formative-type sub-constructs at first-order level, namely: hazard vulnerability (HV), strategic vulnerability (SV), operational vulnerability (OV), financial vulnerability (FV), infrastructural vulnerability (IV) and demand–supply vulnerability (DSV). Moreover, the comprehensive model included four antecedent of SCR: supply chain orientation (SCO), supportive environmental factors (SF), learning and development (LD) and supply chain risk management (SCRM). The constructs: social sustainability (SCS), environmental sustainability (ENS), operational sustainability (OPS) and economic sustainability (ECS) were modelled as the outcome of the construct SCR. Figure 6.2 demonstrates the constructs and their items in the model.

It was mentioned in Table 6.8 that the reflective measurement model was assessed based on item reliability, internal consistency, average variance extracted (AVE), correlation of the constructs and the item cross-loading matrix, whereas the formative model was assessed by the item level weight and collinearity statistics of the constructs. The analysis of the measurement properties based on the outcome of the PLS run is discussed in the following sections.

6.4.1.1 Assessing reflective measurement model

In this research, the reflective measurement model consisted of both first-order and higher-order level constructs. Firstly, the first-order measurement model was assessed. Once the first-order measurement model was refined, the higher-order model was evaluated thereafter.

6.4.1.1.1 First-order reflective measurement model

With reference to Figure 6.2, it is evident that the comprehensive model includes as many as 17 first-order reflective-type constructs: (SCS), (ENS), (OPS), (ECS), (FLX), (RD), (INT), (EF), (MS), (FS), (SCD), (RED), (RR), (SCO), (SF), (LD) and (SCRM). These constructs and their measurement properties were assessed in terms of item reliability, internal consistency and discriminant validity with reference to previous studies (Hair, Ringle, and Sarstedt 2011; Barclay, Higgins, and Thompson 1995; Henseler, Ringle, and Sinkovics 2009).

Item reliability

Following the suggestion of researchers (e.g. Hair, Ringle, and Sarstedt 2011; Barclay, Higgins, and Thompson 1995; Henseler, Ringle, and Sinkovics 2009), the cut-off value settled on for this study was 0.7, with the aim of maximising the convergent validity of the measurement model. Table 6.9 shows the details of the item loadings with corresponding *t*-values.

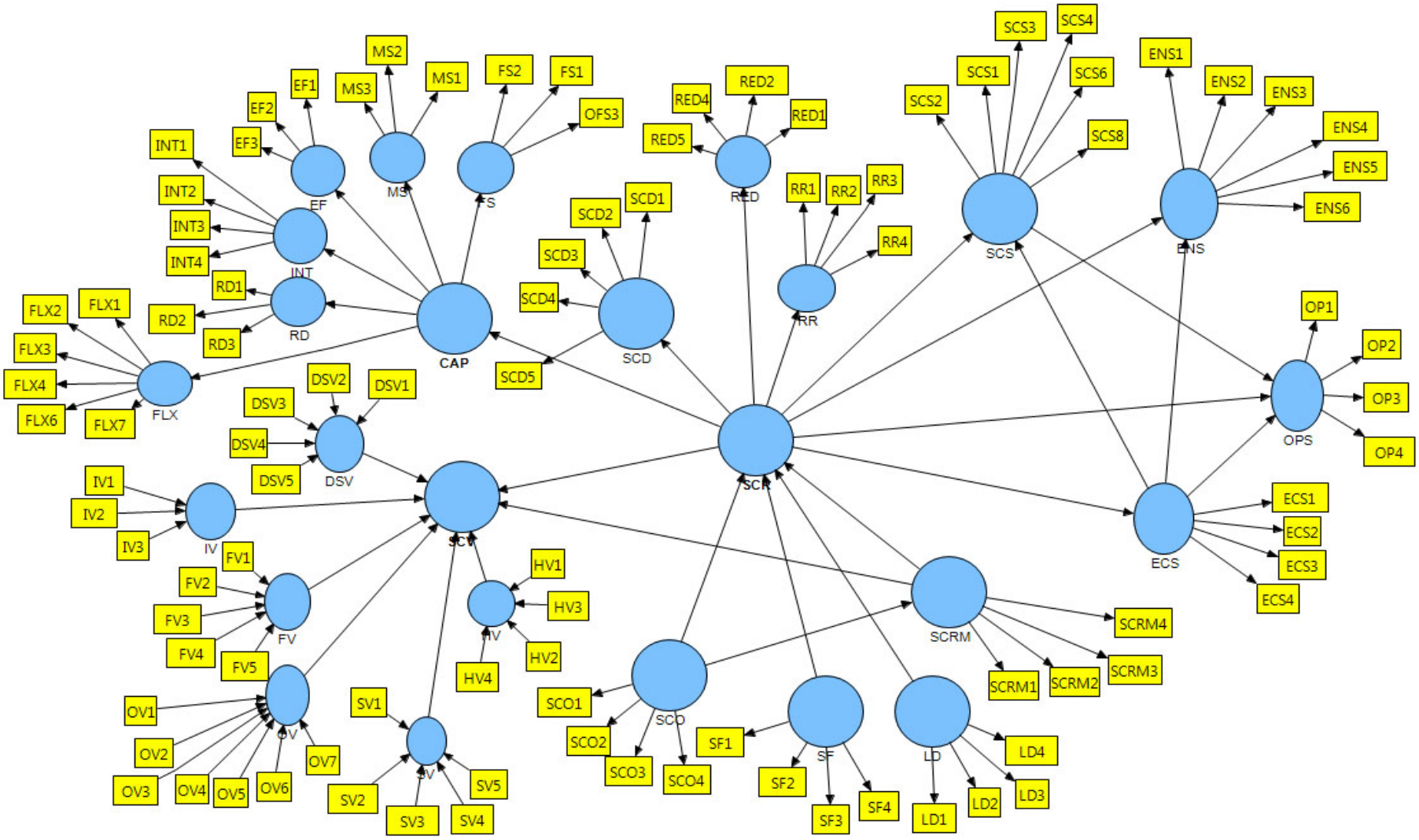


Figure 6.2: Complete model

Table 6.9: Assessment of reliability, CR and AVE for first-order constructs

Constructs	Items	Loading	*t*-Value	CR	AVE
Flexibility (FLX)	FLX1-Production flexibility	0.827	40.79	0.9315	0.6602
	FLX2-Customization	0.7964	34.76		
	FLX3-Multi-skilled workforce	0.7948	35.36		
	FLX4-Contract flexibility	0.8029	31.79		
	FLX5-Cost effectiveness	0.7899	30.53		
	FLX6-Responsiveness	0.8423	51.01		
	FLX7-New product	0.8286	45.74		
Redundancy (RD)	RD1-Reserve capacity(logistical capability)	0.9074	95.61	0.8276	0.6268
	RD2-Buffer stock of material	0.7282	16.12		
	RD3-Back-up utility source	0.8802	63.13		
Integration (INT)	INT1-Information sharing	0.8591	55.72	0.9247	0.7544
	INT2-Internal integration	0.881	56.31		
	INT3-Collaboration	0.8675	52.50		
	INT4-ICT adoption	0.8643	52.17		
Efficiency (EF)	EF1-Waste reduction	0.8387	37.10	0.9041	0.7588
	EF2-Worker efficiency	0.8725	46.66		
	EF3-Quality control	0.9003	91.77		
Market strength (MS)	MS1-Buyer–supplier satisfaction	0.9367	151.85	0.9412	0.8422
	MS2-Preferred brand	0.9242	114.03		
	MS3-Buyer–supplier relationship	0.8929	67.73		
Financial strength (FS)	FS1-Funds availability	0.9055	73.74	0.9134	0.779
	FS2-Profit consistency	0.916	99.90		
	FS3-Insurance	0.8239	48.21		
Supply chain design (SCD)	SCD1-Alternative sourcing	0.8265	45.018	0.9178	0.6914
	SCD2-Alternative transportation	0.8605	58.88		
	SCD3-Alternative market	0.8509	57.92		
	SCD4-Alternative production	0.8765	59.04		
	SCD5-Backward linkage	0.7345	22.20		
Readiness (RED)	RED1-Readiness training	0.9199	114.05	0.9492	0.789
	RED2-Readiness resources	0.8611	44.81		
	RED3-Early warning signal	0.462	9.02		
	RED4-Forecasting	0.8655	53.43		
	RED5-Security	0.8997	104.00		
Response and recovery (RR)	RRC1-Quick response	0.8875	77.767	0.9406	0.7604
	RRC2-Quick recovery	0.9099	86.58		
	RRC3-Loss absorption	0.8998	73.37		
	RRC4-Impact reduction	0.8599	64.73		
	RRC5-Cost of recovery	0.7951	26.34		
Supply chain orientation (SCO)	SCO1-Trust	0.9101	82.60	0.9315	0.7731
	SCO2-Commitment	0.8632	73.14		
	SCO3-Cooperation	0.9221	102.82		
	SCO4-Top management support	0.8165	37.49		
Supportive environment-al factors (SF)	SF1-Government support	0.6631	13.87	0.8397	0.5689
	SF2-Factor endowment	0.7361	21.01		
	SF3-International trade support	0.8491	50.16		
	SF4-Trade body/institutional support	0.7566	20.24		
Learning and develop-ment (LD)	LD1-Training	0.9334	120.18	0.9531	0.8357
	LD2-Career improvement opportunity	0.9146	99.96		
	LD3-Research & development	0.9272	113.57		

	LD4-Past learning	0.8783	62.76		
Supply chain risk management (SCRM)	SCRM1-Risk sharing	0.9157	111.88	0.9251	0.7557
	SCRM2-Effort to reduce risk	0.8722	60.05		
	SCRM3-Knowing risk	0.87	61.88		
	SCRM4-Considering risk in decisions	0.8157	45.38		
Social sustain-ability (SCS)	SCS1-Wages	0.8749	63.77	0.9478	0.6953
	SCS2-Benefits	0.8802	72.31		
	SCS3-Hazard & safety	0.8467	47.52		
	SCS4-Health	0.9109	84.15		
	SCS5-Child labour	0.7342	33.33		
	SCS6-Forced labour	0.7894	32.96		
	SCS7-Supply chain monitoring	0.777	22.95		
	SCS8-Employee satisfaction	0.8441	51.49		
Environmental sustain-ability (ENS)	ENS1-Water pollution	0.8759	58.44	0.9424	0.7009
	ENS2-Air pollution	0.8856	51.64		
	ENS3-Soil pollution	0.8921	66.71		
	ENS4-Waste recycling	0.781	30.04		
	ENS5-Hazardous material	0.7987	42.60		
	ENS6-Certification and audit	0.8435	48.65		
	ENS7-Environmental legislation	0.481	12.54		
	ENS8-Supplier evaluation	0.7759	29.85		
Operational sustain-ability (OPS)	OPS1-Lead time	0.8257	34.96	0.9295	0.7675
	OPS2-Quality	0.8713	38.19		
	OPS3-Specifications	0.9077	82.70		
	OPS4-Updated technology	0.8953	70.56		
Economic sustain-ability (ECS)	EC1-Sales	0.9108	105.81	0.924	0.7538
	EC2-Cost	0.7462	22.84		
	EC3-Profit	0.8809	62.63		
	EC4-Sales growth	0.9233	110.77		

Table 6.9 reveals that two items (RED3 and ENS7) have loadings less than 0.7. These low loading items were considered for deletion during the second PLS run following the recommendation of Hair, Ringle and Sarstedt (2011) and Barclay, Higgins and Thompson 1995).

Internal consistency

Table 6.9 presents internal consistency (composite reliability) values for all the constructs used in this study. It is revealed that internal consistency values for all constructs surpassed the recommended minimum requirement of 0.7, following the recommendation of Hair, Ringle and Sarstedt (2011), Fornell and Larcker (1981), Barclay, Higgins and Thompson (1995) and Nunally (1978). It is also noteworthy that internal consistency values for all constructs except RD (.8265) and SF (.8396) were more than 0.9.

Average variance extracted (AVE)

Apart from item reliability and internal consistency this study also assessed average variance extracted (AVE) of each construct. Table 6.9 shows the result of AVE for each

construct in the model. Table 6.9 demonstrates that the AVE values for all the constructs used in this study exceeded the recommended minimum threshold of 0.5 aligned with the guidelines of Fornell and Larcker (1981); Henseler, Ringle and Sinkovics (2009); and Hair, Ringle and Sarstedt (2011).

Discriminant validity

To affirm the discriminant validity of each construct, a comparison between the square root of average variance extracted (AVE) of the constructs and the correlations among the constructs was performed consistent with the recommendation of Fornell and Larcker (1981) and Henseler, Ringle and Sinkovics (2009). The value of the square root of AVE (bold diagonal numbers) and the correlation scores of latent variables (off-diagonal elements) are presented by Table 6.10. Table 6.10 indicates that the square root of AVE is greater than the off-diagonal elements across the row and down the column except for ENS, OPS, MS, FLX, EF, SCD and RED. These items were identified for further evaluation.

Discriminant validity of the measurement model was also checked by a cross-loading matrix (see Table 6.11). According to Hair, Ringle and Sarstedt (2011) and Henseler, Ringle and Sinkovics (2009), the loading of an item with the corresponding construct shall be greater than its loading with other constructs. Table 6.11 implies that seven items did not fulfil the criteria of discriminant validity as loading of the items with their corresponding construct was less than the loading with any other construct. From Table 6.9 and Table 6.11, seven items altogether were found to have problems with convergence validity and discriminant validity. These items were removed and then the second PLS run was performed. The refined measurement model was evaluated again and it was affirmed that all loadings were above the cut-off point of 0.7 as shown in Table 6.12. It also transpired that in the refined model (after items were removed), the problem of discriminant validity did not exist any longer as shown on Table 6.13 and Table 6.14.

Table 6.10: Inter-correlations of the first-order constructs (generated by SmartPLS)

	SCS	ENS	OPS	ECS	FLX	RD	INT	EF	MS	FS	SCD	RED	RR	SCO	SF	LD	SCRM
SCS	**0.834**																
ENS	0.882	**0.837**															
OPS	0.871	0.831	**0.876**														
ECS	0.806	0.777	0.787	**0.868**													
FLX	0.833	0.798	0.82	.745	**0.813**												
RD	0.67	0.621	0.704	.631	.781	**0.792**											
INT	0.814	0.79	0.788	.701	.783	.614	**.869**										
EF	0.819	0.805	0.779	.764	.823	.685	.809	**.871**									
MS	0.845	0.794	0.823	.786	.846	.733	.826	.881	**.918**								
FS	0.794	0.758	0.782	.750	.833	.763	.752	.798	.830	**.883**							
SCD	0.739	0.706	0.656	.706	.765	.637	.708	.744	.757	.745	**.832**						
RED	0.817	0.807	0.783	.759	.835	.665	.785	.844	.833	.804	.834	**.888**					
RR	0.822	0.774	0.778	.765	.823	.720	.791	.829	.853	.822	.837	.902	**.872**				
SCO	0.764	0.723	0.734	.696	.768	.674	.736	.763	.801	.770	.723	.784	.777	**.879**			
SF	0.522	0.462	0.451	.472	.541	.407	.511	.468	.494	.530	.560	.479	.496	.562	**.754**		
LD	0.841	0.84	0.765	.759	.810	.612	.831	.810	.841	.799	.791	.869	.847	.816	.550	**.914**	
SCRM	0.784	0.759	0.734	.740	.806	.662	.780	.800	.835	.808	.772	.832	.812	.806	.526	.877	**.869**

Table 6.11: Cross-loading (generated by SmartPLS)

	SCS	ENS	OPS	ECS	FLX	RD	INT	EF	MS	FS	SCD	RED	RR	SCO	SF	LD	SCRM
SCS1	0.8756	0.7726	0.7654	0.6749	0.7454	0.6063	0.6738	0.7227	0.7451	0.6892	0.6401	0.7293	0.7343	0.6943	0.4586	0.7483	0.713
SCS2	0.8798	0.796	0.7717	0.7302	0.7589	0.6045	0.6994	0.7201	0.7502	0.7141	0.6257	0.7219	0.725	0.6506	0.4883	0.7255	0.7091
SCS3	0.8468	0.7321	0.7591	0.6618	0.7414	0.5627	0.7228	0.7044	0.7138	0.6615	0.6658	0.7162	0.72	0.6564	0.4918	0.7238	0.6933
SCS4	0.91	0.7176	0.8127	0.756	0.765	0.6306	0.7566	0.7324	0.7814	0.7097	0.6706	0.7474	0.7649	0.6937	0.477	0.7785	0.7172
SCS5	0.7338	0.609	0.628	0.5831	0.6087	0.5598	0.5599	0.5663	0.5794	0.5901	0.5913	0.5706	0.5788	0.6224	0.4767	0.5665	0.5381
SCS6	0.7899	0.6814	0.6958	0.6593	0.6195	0.5432	0.6527	0.6418	0.6529	0.6329	0.5508	0.6256	0.6066	0.6059	0.3243	0.6393	0.5664
SCS7	0.7759	0.7059	0.6502	0.6569	0.629	0.4774	0.6142	0.6338	0.6534	0.6077	0.5711	0.6307	0.6382	0.5395	0.412	0.6762	0.6155
SCS8	0.8441	0.7771	0.7242	0.6678	0.6847	0.59	0.7366	0.7383	0.7412	0.684	0.6083	0.6941	0.6946	0.6291	0.3999	0.7358	0.6663
ENS1	0.7774	0.8754	0.7708	0.659	0.7345	0.6243	0.7288	0.73	0.7313	0.6751	0.5925	0.7039	0.6834	0.6607	0.3894	0.7363	0.6684
ENS2	0.7343	0.8863	0.7041	0.6417	0.6828	0.514	0.6746	0.6639	0.6318	0.6108	0.5502	0.6814	0.6323	0.5854	0.3862	0.7137	0.6352
ENS3	0.7428	0.8921	0.6867	0.6832	0.709	0.5509	0.6642	0.696	0.6718	0.6524	0.6173	0.7052	0.6744	0.6202	0.4396	0.7462	0.6669
ENS4	0.6404	0.7811	0.5728	0.5715	0.5248	0.3945	0.5563	0.6088	0.5489	0.5375	0.4922	0.5738	0.5139	0.5146	0.2972	0.5937	0.5391
ENS5	0.7736	0.7987	0.7283	0.703	0.7403	0.6463	0.6937	0.6992	0.7372	0.7027	0.673	0.6766	0.6795	0.6782	0.5206	0.7151	0.6932
ENS6	0.7111	0.8433	0.8053	0.6983	0.7298	0.6107	0.7312	0.6942	0.7322	0.719	0.6371	0.7347	0.7188	0.6432	0.4229	0.7389	0.6516

ENS7	0.6881	0.7716	0.606	0.613	0.5567	0.3938	0.6279	0.6358	0.6007	0.5421	0.5869	0.6262	0.6296	0.5335	0.2843	0.6786	0.6006
ENS8	0.6881	0.7742	0.6059	0.613	0.5567	0.3915	0.6279	0.6356	0.6004	0.5422	0.5867	0.649	0.6299	0.5336	0.2853	0.6786	0.6003
OP1	0.6489	0.6363	0.8262	0.6311	0.6224	0.5577	0.582	0.622	0.6207	0.6178	0.4677	0.6085	0.5769	0.5592	0.2969	0.5587	0.5407
OP2	0.7654	0.7562	0.8727	0.6582	0.7375	0.6314	0.731	0.7115	0.7346	0.6849	0.6214	0.7128	0.715	0.6519	0.4662	0.7211	0.6782
OP3	0.7211	0.7684	0.908	0.7041	0.7493	0.6268	0.7063	0.6753	0.732	0.67	0.5878	0.6865	0.684	0.6663	0.4122	0.6871	0.644
OP4	0.7197	0.7636	0.8952	0.7682	0.7681	0.6844	0.7359	0.7264	0.7909	0.7645	0.6182	0.7331	0.7447	0.6927	0.4286	0.7111	0.7063
ECS1	0.7753	0.7385	0.7561	0.9106	0.7132	0.5916	0.6534	0.7235	0.752	0.7101	0.6601	0.7443	0.7139	0.6576	0.4195	0.7137	0.7105
ECS2	0.5287	0.5071	0.5406	0.7469	0.477	0.4365	0.4815	0.5104	0.5062	0.5026	0.4782	0.5103	0.52	0.4615	0.3815	0.5005	0.4933
ECS3	0.6962	0.685	0.6886	0.8803	0.6721	0.6136	0.6276	0.6788	0.6987	0.6734	0.6169	0.645	0.6758	0.6128	0.3878	0.671	0.6551
ECS4	0.7779	0.757	0.7359	0.9236	0.7123	0.5935	0.6542	0.7211	0.7524	0.7031	0.6823	0.7176	0.7312	0.669	0.4706	0.7308	0.6947
FLX1	0.6122	0.6194	0.629	0.5462	0.8287	0.6237	0.565	0.6094	0.6483	0.63	0.6489	0.6736	0.6485	0.6039	0.5142	0.607	0.5962
FLX2	0.6761	0.6459	0.6432	0.5804	0.7973	0.5906	0.6017	0.6369	0.6543	0.6426	0.5867	0.6748	0.6515	0.5981	0.3371	0.6475	0.596
FLX3	0.7287	0.737	0.6959	0.6516	0.7956	0.5701	0.7287	0.729	0.727	0.6776	0.6146	0.7272	0.7132	0.66	0.3885	0.7627	0.7243
FLX4	0.6054	0.552	0.62	0.5587	0.804	0.6595	0.5375	0.5991	0.6145	0.6491	0.6154	0.6022	0.61	0.5538	0.5278	0.5695	0.6134
FLX5	0.6832	0.6615	0.6971	0.6582	0.7898	0.6849	0.6767	0.6947	0.7143	0.7177	0.5995	0.6908	0.689	0.6013	0.3776	0.6642	0.6564
FLX6	0.7055	0.6734	0.7085	0.6284	0.8422	0.7272	0.6719	0.7073	0.7328	0.7245	0.6288	0.6976	0.6875	0.693	0.4566	0.6669	0.6964
FLX7	0.7277	0.6771	0.6852	0.6343	0.8284	0.6659	0.6838	0.7144	0.7201	0.6976	0.657	0.6833	0.6817	0.6579	0.4943	0.6932	0.7033
RD1	0.6994	0.6468	0.7023	0.6563	0.7914	0.9078	0.631	0.7082	0.7624	0.7443	0.6821	0.6947	0.7499	0.6981	0.4438	0.6569	0.6994
RD2	0.2123	0.1625	0.2894	0.1821	0.2989	0.7282	0.1901	0.2012	0.2442	0.2851	0.1313	0.1696	0.2258	0.2243	0.0315	0.1536	0.1677
RD3	0.5867	0.578	0.6115	0.5673	0.6792	0.88	0.5533	0.6197	0.6365	0.6938	0.5821	0.6051	0.6331	0.5886	0.4032	0.542	0.5949
INT1	0.7118	0.7236	0.707	0.5835	0.7081	0.5903	0.8592	0.7282	0.745	0.6697	0.6057	0.6687	0.6819	0.683	0.4221	0.7252	0.684
INT2	0.69	0.6792	0.7009	0.6243	0.6529	0.5186	0.8823	0.6755	0.6934	0.6081	0.5779	0.6748	0.6622	0.6104	0.4123	0.7098	0.6494
INT3	0.71	0.6954	0.6659	0.5954	0.7213	0.5839	0.8678	0.7118	0.7328	0.6971	0.6792	0.6895	0.7162	0.6536	0.498	0.7285	0.7222
INT4	0.7172	0.6875	0.6704	0.6363	0.6527	0.4927	0.8647	0.7017	0.7016	0.6415	0.5995	0.6972	0.6901	0.6165	0.4664	0.7258	0.6585
EF1	0.6293	0.6092	0.6272	0.6475	0.6504	0.5705	0.6216	0.8402	0.6929	0.6149	0.5732	0.6863	0.6535	0.6333	0.3608	0.6091	0.6408
EF2	0.7251	0.7565	0.6427	0.6636	0.72	0.5865	0.7255	0.8719	0.74	0.7093	0.6779	0.741	0.7332	0.6302	0.4055	0.7445	0.707
EF3	0.7814	0.742	0.7653	0.6905	0.784	0.6781	0.7652	0.9002	0.8641	0.758	0.6917	0.7764	0.7764	0.7305	0.4759	0.7592	0.7424
MS1	0.7793	0.7643	0.7622	0.7106	0.7748	0.6809	0.7975	0.8429	0.9368	0.7583	0.6732	0.7661	0.7916	0.7294	0.4373	0.7739	0.7718
MS2	0.8402	0.7817	0.7842	0.7669	0.7942	0.6706	0.8146	0.8285	0.9236	0.7941	0.7141	0.7808	0.8192	0.7378	0.4915	0.8291	0.7707
MS3	0.704	0.6518	0.7243	0.6961	0.7669	0.7154	0.662	0.758	0.8922	0.7339	0.7006	0.7476	0.7365	0.7397	0.4535	0.7123	0.7569
FS1	0.6978	0.6956	0.704	0.6599	0.7478	0.7069	0.7031	0.7254	0.7491	0.9048	0.6811	0.7281	0.7429	0.6799	0.4527	0.7308	0.7419
FS2	0.7504	0.7214	0.7284	0.7252	0.754	0.6962	0.7155	0.7643	0.7939	0.9163	0.6468	0.7452	0.7813	0.6944	0.3953	0.76	0.743
FS3	0.6521	0.5972	0.6397	0.6039	0.71	0.6505	0.5703	0.6218	0.6498	0.8239	0.6462	0.6524	0.6465	0.6661	0.5755	0.6182	0.6511
SCD1	0.6068	0.5627	0.538	0.5264	0.6403	0.5989	0.5501	0.5979	0.5838	0.602	0.8263	0.6707	0.6663	0.63	0.4896	0.6155	0.6111

SCD2	0.6601	0.5943	0.5611	0.5867	0.6517	0.5012	0.6305	0.6352	0.6453	0.6266	0.8615	0.7047	0.7098	0.6123	0.548	0.69	0.6762
SCD3	0.6577	0.6713	0.5964	0.653	0.6905	0.5244	0.6682	0.6695	0.6726	0.6416	0.8513	0.7419	0.7157	0.614	0.5099	0.7151	0.6933
SCD4	0.654	0.6356	0.5828	0.6536	0.6678	0.6027	0.6361	0.6631	0.7074	0.6634	0.8762	0.7422	0.7692	0.6256	0.4717	0.7169	0.6604
SCD5	0.477	0.4822	0.4493	0.5156	0.5183	0.5135	0.4455	0.5248	0.5278	0.5571	0.7347	0.5993	0.6116	0.5202	0.2958	0.5405	0.5652
RED1	0.7853	0.7923	0.7457	0.7243	0.7812	0.6424	0.7483	0.7806	0.7781	0.7446	0.7755	0.9204	0.8183	0.7537	0.4932	0.8242	0.7726
RED2	0.6953	0.7003	0.6845	0.6878	0.7342	0.6122	0.6741	0.7445	0.7366	0.7089	0.7331	0.8626	0.7671	0.654	0.3901	0.7415	0.7304
RED3	0.7411	0.7426	0.6686	0.659	0.7398	0.5806	0.7619	0.7731	0.7463	0.7088	0.7459	0.462	0.8163	0.6954	0.402	0.817	0.7555
RED4	0.6422	0.6361	0.6576	0.6246	0.7237	0.5736	0.6379	0.7201	0.6995	0.6745	0.684	0.8659	0.7729	0.683	0.4076	0.6993	0.7275
RED5	0.7621	0.7198	0.7255	0.6855	0.7352	0.6282	0.6643	0.7329	0.7392	0.7327	0.7646	0.8999	0.8286	0.6948	0.4631	0.775	0.7118
RR1	0.7366	0.7281	0.7027	0.6919	0.7285	0.6331	0.7172	0.7641	0.7632	0.7141	0.7328	0.8133	0.8883	0.6941	0.4198	0.7471	0.7311
RR2	0.7738	0.7138	0.7554	0.7073	0.7446	0.6656	0.7247	0.7623	0.8103	0.7302	0.7544	0.8199	0.9104	0.7218	0.4338	0.7801	0.7317
RR3	0.7493	0.6862	0.7527	0.693	0.7695	0.7143	0.741	0.7476	0.7711	0.8025	0.733	0.8111	0.9009	0.7066	0.413	0.7357	0.7237
RR4	0.6901	0.6412	0.6211	0.6639	0.7248	0.6657	0.6681	0.708	0.7436	0.7178	0.7665	0.7725	0.8597	0.687	0.5069	0.7278	0.7374
RR5	0.6259	0.621	0.5557	0.5834	0.6195	0.4929	0.5944	0.6308	0.6203	0.6105	0.6622	0.7097	0.7959	0.5737	0.4192	0.7007	0.6171
SCO1	0.7076	0.6488	0.6657	0.6291	0.717	0.6425	0.6508	0.6792	0.7419	0.7048	0.659	0.6817	0.6966	0.9106	0.5437	0.7411	0.7404
SCO2	0.643	0.6246	0.6265	0.6252	0.6334	0.5712	0.5779	0.6744	0.6941	0.6422	0.6182	0.6835	0.6503	0.8634	0.4068	0.6892	0.6925
SCO3	0.6912	0.6537	0.6617	0.614	0.7182	0.6458	0.6745	0.67	0.7194	0.7112	0.6578	0.7018	0.719	0.9219	0.5442	0.7405	0.7154
SCO4	0.6438	0.6301	0.6349	0.5893	0.6358	0.5617	0.6944	0.6671	0.6598	0.6464	0.6067	0.6915	0.6684	0.8173	0.5014	0.7001	0.6888
SF1	0.4091	0.3475	0.3788	0.4148	0.3677	0.2551	0.3955	0.4047	0.4096	0.3766	0.3245	0.4038	0.3962	0.432	0.6625	0.4753	0.3833
SF2	0.3539	0.2785	0.3205	0.3063	0.3948	0.3738	0.3618	0.3002	0.353	0.3873	0.3875	0.2771	0.3502	0.4332	0.7344	0.314	0.3379
SF3	0.4862	0.4565	0.4282	0.4016	0.5048	0.4152	0.4657	0.43	0.4512	0.4642	0.5309	0.4393	0.4434	0.5039	0.8499	0.5036	0.5091
SF4	0.3233	0.3173	0.2392	0.3065	0.3495	0.2285	0.3203	0.2858	0.2787	0.3623	0.4304	0.3244	0.3075	0.3275	0.7584	0.3711	0.3478
LD1	0.802	0.811	0.7483	0.726	0.7829	0.5956	0.7918	0.7854	0.7931	0.7735	0.7492	0.823	0.8029	0.7759	0.5623	0.934	0.8179
LD2	0.7896	0.7877	0.7214	0.7024	0.7314	0.5776	0.7927	0.7558	0.772	0.7253	0.6876	0.7749	0.7666	0.7385	0.5135	0.9152	0.7557
LD3	0.7817	0.7849	0.7092	0.71	0.7654	0.594	0.7934	0.7501	0.7833	0.7421	0.7583	0.8282	0.8005	0.749	0.5264	0.9274	0.8439
LD4	0.7009	0.6975	0.6253	0.6442	0.6896	0.5397	0.6585	0.6741	0.729	0.6786	0.6999	0.7505	0.7231	0.7231	0.4409	0.8792	0.7925
SCRM1	0.7336	0.7039	0.6753	0.6732	0.7444	0.6247	0.6924	0.7086	0.7547	0.7438	0.6952	0.748	0.7489	0.7442	0.51	0.8082	0.9158
SCRM2	0.6455	0.6266	0.6298	0.631	0.6809	0.5945	0.6768	0.6891	0.7226	0.6779	0.6321	0.7076	0.6772	0.667	0.4342	0.7431	0.8724
SCRM3	0.7504	0.7313	0.6948	0.6925	0.7251	0.5687	0.7493	0.7404	0.7648	0.7116	0.6696	0.7692	0.7638	0.713	0.4236	0.8181	0.8705
SCRM4	0.5931	0.5861	0.5557	0.5819	0.6581	0.5821	0.5958	0.6471	0.657	0.674	0.6914	0.6659	0.6317	0.6794	0.4854	0.6765	0.8158

Table 6.12: Assessment reliability, CR and AVE after elimination of items

Cons	Items	L	*t*-Value	CR	AVE
FLX	FLX1	0.8447	48.9042	0.9266	0.678
	FLX2	0.8079	39.391		
	FLX3	0.7849	37.2476		
	FLX4	0.8096	32.8558		
	FLX5	-	-		
	FLX6	0.85	57.1049		
	FLX7	0.8411	54.0169		
RD	RD1	0.908	93.2228	0.8276	0.6268
	RD2	0.729	17.2799		
	RD3	0.8814	63.6259		
INT	INT1	0.8589	57.0467	0.9247	0.7544
	INT2	0.8822	57.455		
	INT3	0.868	54.8218		
	INT4	0.8659	51.4471		
EF	EF1	0.8394	36.1912	0.9041	0.7588
	EF2	0.8716	50.4154		
	EF3	0.9002	90.8027		
MS	MS1	0.9368	159.6332	0.9412	0.8422
	MS2	0.9238	113.8619		
	MS3	0.8933	68.4824		
FS	FS1	0.9045	76.9663	0.9134	0.779
	FS2	0.9168	99.5158		
	FS3	0.824	47.3092		
SCD	SCD1	0.8255	42.2978	0.9177	0.6914
	SCD2	0.863	58.9294		
	SCD3	0.8544	58.7152		
	SCD4	0.8768	60.5277		
	SCD5	0.7288	19.9358		
RED	RED1	0.9257	119.7425	0.9415	0.8009
	RED2	0.8738	55.941		
	RED3	-	-		
	RED4	0.8716	56.3513		
	RED5	0.9077	93.7404		
RR	RRC1	0.8894	73.6088	0.9444	0.8095
	RRC2	0.9228	101.3131		
	RRC3	0.9161	87.0585		
	RRC4	0.8709	68.3584		
	RRC5	-	-		
SCO	SCO1	0.9109	83.4102	0.9315	0.7731
	SCO2	0.8631	71.667		
	SCO3	0.9224	94.236		
	SCO4	0.8169	36.8732		
SF	SF1	0.6672	14.032	0.8395	0.5685
	SF2	0.7478	23.16		
	SF3	0.8471	45.6412		
	SF4	0.7444	18.8996		
LD	LD1	0.9348	134.5977	0.9531	0.8357
	LD2	0.917	110.7824		
	LD3	0.9269	119.4073		
	LD4	0.877	62.7905		
SCRM	SCRM1	0.9161	115.3574	0.9251	0.7557
	SCRM2	0.8736	62.2623		
	SCRM3	0.8715	64.3009		
	SCRM4	0.8155	45.4784		

SCS	SCS1	0.8837	73.7623	0.9477	0.7516
	SCS2	0.8939	81.1087		
	SCS3	0.8537	52.1824		
	SCS4	0.9204	96.9221		
	SCS5				
	SCS6	0.7903	34.2555		
	SCS7				
	SCS8	0.8545	55.7892		
ENS	ENS1	0.8874	70.6546	0.941	0.7273
	ENS2	0.8868	52.7892		
	ENS3	0.8928	69.1618		
	ENS4	0.7864	30.3584		
	ENS5	0.811	44.5589		
	ENS6	0.8484	56.4481		
	ENS7	-	-		
	ENS8	-	-		
OPS	OPS1	0.8283	34.0641	0.9295	0.7675
	OPS2	0.8728	36.6423		
	OPS3	0.9083	87.8957		
	OPS4	0.8957	71.7669		
ECS	EC1	0.9109	107.6977	0.924	0.7537
	EC2	0.7469	23.3367		
	EC3	0.8815	62.1987		
	EC4	0.9242	106.7352		

Table 6.13: Inter-correlations of the first-order constructs (generated by SmartPLS)

	ECS	EF	ENS	FLX	FS	INT	LD	MS	OPS	RD	RED	RR	SCD	SCO	SCRM	SCS	SF
ECS	**868**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EF	0.7664	**0.87**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ENS	0.7773	0.8027	**0.85**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FLX	0.7312	0.8119	0.8009	**0.83**	0	0	0	0	0	0	0	0	0	0	0	0	0
FS	0.7532	0.8002	0.7672	0.816	**0.88**	0	0	0	0	0	0	0	0	0	0	0	0
INT	0.7018	0.8117	0.7964	0.7705	0.7543	**0.87**	0	0	0	0	0	0	0	0	0	0	0
LD	0.7621	0.8124	0.8341	0.8016	0.7995	0.8326	**0.91**	0	0	0	0	0	0	0	0	0	0
MS	0.7902	0.8832	0.7984	0.832	0.8308	0.8278	0.8421	**0.92**	0	0	0	0	0	0	0	0	0
OPS	0.7908	0.7822	0.8403	0.808	0.7838	0.7901	0.7686	0.8253	**0.88**	0	0	0	0	0	0	0	0
RD	0.6492	0.7047	0.6609	0.7781	0.7758	0.6306	0.6314	0.7499	0.716	**0.79**	0	0	0	0	0	0	0
RED	0.7615	0.8324	0.7908	0.8192	0.7997	0.7624	0.8504	0.8258	0.7868	0.6868	**0.89**	0	0	0	0	0	0
RR	0.7661	0.8287	0.7625	0.8112	0.8244	0.7927	0.8308	0.8583	0.7882	0.7533	0.8852	**0.9**	0	0	0	0	0
SCD	0.7093	0.7465	0.7019	0.7605	0.7446	0.7108	0.7926	0.7585	0.6594	0.6584	0.8272	0.8293	**0.83**	0	0	0	0
SCO	0.699	0.7649	0.7283	0.7654	0.77	0.739	0.8169	0.8013	0.7365	0.6897	0.7788	0.7807	0.7234	**0.88**	0	0	0
SCRM	0.7433	0.8019	0.7575	0.7984	0.8081	0.7823	0.8777	0.8351	0.7372	0.6814	0.8222	0.812	0.773	0.8071	**0.87**	0	0
SCS	0.7989	0.8194	0.8766	0.8197	0.7871	0.8159	0.8381	0.844	0.8716	0.6807	0.8056	0.8183	0.7249	0.7562	0.7833	**0.87**	0
SF	0.4781	0.479	0.485	0.5508	0.5323	0.5194	0.5597	0.504	0.4635	0.4321	0.4906	0.4932	0.5619	0.5717	0.5328	0.5105	**0.75**

Table 6.14: Cross-loading (generated by SmartPLS)

	SCS	ENS	OPS	ECS	FLX	RD	INT	EF	MS	FS	SCD	RED	RR	SCO	SF	LD	SCRM
SCS1	0.8838	0.7664	0.7653	0.6753	0.737	0.6062	0.6738	0.7227	0.7451	0.6892	0.6406	0.729	0.7341	0.6943	0.4602	0.7483	0.7131
SCS2	0.8939	0.772	0.7716	0.7305	0.7484	0.6044	0.6994	0.7201	0.7502	0.7141	0.6262	0.7111	0.7228	0.6507	0.4883	0.726	0.7092
SCS3	0.8529	0.7233	0.7591	0.6619	0.7393	0.5627	0.7228	0.7044	0.7138	0.6615	0.6662	0.7103	0.7178	0.6565	0.4928	0.7241	0.6935
SCS4	0.92	0.7163	0.8126	0.7362	0.7605	0.6306	0.7566	0.7324	0.7814	0.7097	0.6715	0.7384	0.7703	0.6938	0.4774	0.779	0.7171
SCS6	0.7908	0.6779	0.6957	0.6593	0.6041	0.5432	0.6527	0.6418	0.6528	0.6329	0.5513	0.6198	0.6175	0.6059	0.3249	0.6398	0.5664
SCS8	0.8545	0.7774	0.7241	0.668	0.6643	0.59	0.7366	0.7383	0.7412	0.684	0.6092	0.6761	0.6853	0.629	0.4	0.7362	0.6662
ENS1	0.7822	0.8874	0.7708	0.6593	0.7147	0.6243	0.7288	0.73	0.7313	0.6751	0.593	0.6961	0.6758	0.6607	0.3901	0.7366	0.6684
ENS2	0.7406	0.8858	0.704	0.6421	0.6716	0.514	0.6746	0.6639	0.6318	0.6108	0.5507	0.6651	0.6163	0.5853	0.3847	0.7143	0.6352
ENS3	0.7331	0.8934	0.6867	0.6833	0.6977	0.5509	0.6642	0.696	0.6718	0.6524	0.6178	0.6906	0.6531	0.6202	0.4383	0.7465	0.6669
ENS4	0.6418	0.7866	0.5727	0.5718	0.5209	0.3945	0.5563	0.6088	0.5489	0.5375	0.493	0.566	0.5111	0.5142	0.2968	0.594	0.539
ENS5	0.7587	0.8107	0.7284	0.7031	0.7387	0.6463	0.6937	0.6992	0.7372	0.7027	0.6739	0.6702	0.6862	0.6784	0.5215	0.7155	0.6931

ENS6	0.807	0.847	0.8052	0.6985	0.7197	0.6107	0.7312	0.6942	0.7322	0.719	0.6375	0.7365	0.7271	0.6431	0.4233	0.7393	0.6516
OP1	0.6418	0.6391	0.8263	0.631	0.6043	0.5577	0.582	0.622	0.6207	0.6178	0.4682	0.6155	0.5786	0.559	0.2991	0.5593	0.5408
OP2	0.7625	0.7542	0.8729	0.6581	0.7291	0.6314	0.731	0.7115	0.7346	0.6849	0.6221	0.7095	0.7145	0.652	0.4663	0.7217	0.6782
OP3	0.7129	0.7741	0.9076	0.7044	0.7394	0.6268	0.7063	0.6753	0.732	0.67	0.5884	0.6913	0.6891	0.6663	0.4134	0.6874	0.644
OP4	0.7205	0.7663	0.8953	0.7285	0.7463	0.6844	0.7359	0.7264	0.7909	0.7645	0.618	0.733	0.7643	0.6926	0.4319	0.7113	0.7063
ECS1	0.7642	0.7355	0.7561	0.9107	0.7	0.5916	0.6534	0.7235	0.752	0.7101	0.6607	0.7472	0.7149	0.6573	0.4198	0.7135	0.7105
ECS2	0.511	0.4914	0.5407	0.7453	0.4557	0.4365	0.4815	0.5104	0.5062	0.5026	0.4784	0.5056	0.5099	0.4615	0.3811	0.5011	0.4933
ECS3	0.6955	0.6829	0.6885	0.8813	0.6531	0.6136	0.6276	0.6788	0.6987	0.6734	0.6165	0.6433	0.6785	0.6128	0.3881	0.6713	0.6551
ECS4	0.7673	0.7529	0.7359	0.9237	0.6946	0.5935	0.6542	0.7211	0.7524	0.7031	0.6828	0.7181	0.7295	0.6688	0.4712	0.7309	0.6947
FLX1	0.6106	0.6352	0.629	0.5465	0.8458	0.6236	0.565	0.6094	0.6483	0.63	0.6496	0.6809	0.6424	0.6041	0.515	0.6069	0.596
FLX2	0.6811	0.6562	0.6431	0.5808	0.8085	0.5906	0.6017	0.6369	0.6543	0.6426	0.5871	0.6671	0.649	0.5983	0.3388	0.6476	0.5959
FLX3	0.7304	0.7289	0.6959	0.6519	0.7846	0.5701	0.7287	0.729	0.727	0.6776	0.6148	0.7047	0.7005	0.6599	0.3885	0.7629	0.7245
FLX4	0.6003	0.5683	0.6201	0.559	0.8097	0.6595	0.5375	0.5991	0.6145	0.6491	0.6158	0.6048	0.6139	0.5542	0.5288	0.5695	0.6134
FLX6	0.699	0.6814	0.7085	0.6286	0.8492	0.7272	0.6719	0.7073	0.7328	0.7245	0.6294	0.7051	0.7069	0.6931	0.4579	0.667	0.6964
FLX7	0.7157	0.6757	0.6852	0.6345	0.8407	0.6659	0.6838	0.7144	0.7201	0.6976	0.6581	0.6772	0.685	0.658	0.4943	0.6931	0.7033
RD1	0.6968	0.6585	0.7023	0.6567	0.7795	0.9077	0.631	0.7082	0.7624	0.7443	0.682	0.696	0.763	0.6983	0.4465	0.6568	0.6993
RD2	0.2122	0.1773	0.2895	0.1824	0.2755	0.729	0.1901	0.2012	0.2442	0.2851	0.1296	0.1679	0.2424	0.2242	0.0352	0.1542	0.1677
RD3	0.5765	0.5927	0.6116	0.5674	0.6636	0.88	0.5533	0.6197	0.6365	0.6938	0.5821	0.6099	0.6439	0.5887	0.4052	0.5421	0.5949
INT1	0.7175	0.7239	0.707	0.5836	0.6993	0.5903	0.8592	0.7282	0.745	0.6697	0.6067	0.6478	0.6839	0.683	0.4238	0.7256	0.684
INT2	0.6968	0.6761	0.7009	0.6244	0.6324	0.5186	0.8823	0.6755	0.6934	0.6081	0.5783	0.6544	0.6652	0.6104	0.4136	0.7104	0.6495
INT3	0.7075	0.6931	0.6659	0.5956	0.7064	0.5839	0.8678	0.7118	0.7328	0.6971	0.6798	0.6756	0.7149	0.6537	0.4987	0.7286	0.7222
INT4	0.7116	0.6709	0.6705	0.6364	0.6341	0.4927	0.8647	0.7017	0.7016	0.6415	0.6006	0.6702	0.6879	0.6164	0.4663	0.7267	0.6586
EF1	0.6276	0.6088	0.6273	0.6476	0.6401	0.5705	0.6216	0.8402	0.6929	0.6149	0.5734	0.6764	0.6585	0.633	0.3617	0.6093	0.6407
EF2	0.7222	0.743	0.6428	0.6637	0.7041	0.5865	0.7255	0.8719	0.74	0.7093	0.6783	0.7223	0.7167	0.6301	0.4043	0.7448	0.7071
EF3	0.7816	0.7383	0.7653	0.6909	0.7697	0.6781	0.7652	0.9002	0.8641	0.758	0.692	0.7719	0.7831	0.7305	0.4777	0.7596	0.7424
MS1	0.7805	0.7604	0.7622	0.711	0.7595	0.6809	0.7975	0.8429	0.9368	0.7583	0.6735	0.7579	0.7956	0.7294	0.4392	0.7739	0.7719
MS2	0.8388	0.7784	0.7843	0.767	0.7696	0.6706	0.8146	0.8285	0.9236	0.7941	0.7146	0.7631	0.8133	0.7378	0.4928	0.8297	0.7707
MS3	0.7007	0.6555	0.7244	0.6964	0.7621	0.7154	0.662	0.758	0.8922	0.7339	0.7008	0.7529	0.7526	0.7397	0.4554	0.7119	0.7569
FS1	0.6942	0.6959	0.7041	0.6602	0.7218	0.7069	0.7031	0.7254	0.7491	0.9048	0.6807	0.7247	0.7328	0.6799	0.4528	0.7308	0.7419
FS2	0.75	0.7193	0.7285	0.7253	0.7304	0.6962	0.7155	0.7643	0.7939	0.9163	0.6467	0.7253	0.781	0.6944	0.3966	0.7604	0.743
FS3	0.6353	0.6112	0.6397	0.604	0.7107	0.6505	0.5703	0.6218	0.6498	0.8239	0.6466	0.6662	0.6645	0.6661	0.5758	0.6182	0.6508
SCD1	0.5905	0.563	0.5381	0.5264	0.6348	0.5989	0.5501	0.5979	0.5838	0.602	0.8264	0.67	0.6729	0.63	0.4901	0.6151	0.6109
SCD2	0.653	0.5883	0.561	0.5868	0.6566	0.5011	0.6305	0.6352	0.6453	0.6266	0.862	0.6992	0.6976	0.6124	0.5462	0.6894	0.676
SCD3	0.6494	0.6581	0.5964	0.653	0.6904	0.5243	0.6682	0.6695	0.6726	0.6416	0.8538	0.7316	0.7022	0.614	0.5085	0.715	0.6931

SCD4	0.639	0.6236	0.5828	0.6537	0.6641	0.6027	0.6361	0.6631	0.7074	0.6634	0.8764	0.733	0.758	0.6257	0.4715	0.7169	0.6603
SCD5	0.4614	0.4668	0.4494	0.5159	0.4975	0.5135	0.4455	0.5248	0.5278	0.5571	0.7305	0.5944	0.6089	0.5201	0.2952	0.5402	0.5652
RED1	0.782	0.7888	0.7457	0.7244	0.7773	0.6423	0.7483	0.7806	0.7781	0.7446	0.776	0.9248	0.8159	0.7535	0.4931	0.8243	0.7726
RED2	0.6962	0.697	0.6846	0.6879	0.7145	0.6122	0.6741	0.7445	0.7366	0.7089	0.7332	0.874	0.7582	0.6537	0.389	0.7414	0.7304
RED4	0.6396	0.6279	0.6577	0.6246	0.7144	0.5736	0.6379	0.7201	0.6995	0.6745	0.6843	0.8726	0.7656	0.683	0.4087	0.6989	0.7274
RED5	0.7605	0.7103	0.7255	0.6856	0.7241	0.6282	0.6643	0.7329	0.7392	0.7327	0.7647	0.9073	0.8281	0.6947	0.4614	0.7748	0.7118
RR1	0.7394	0.7203	0.7027	0.6922	0.7199	0.6331	0.7172	0.7641	0.7632	0.7141	0.7332	0.8022	0.8894	0.6941	0.4196	0.7471	0.7311
RR2	0.7701	0.7044	0.7554	0.7075	0.7297	0.6656	0.7247	0.7623	0.8103	0.7302	0.7543	0.8094	0.9221	0.7218	0.4359	0.7801	0.7318
RR3	0.7495	0.684	0.7527	0.6933	0.7486	0.7243	0.741	0.7476	0.7711	0.8025	0.7323	0.8037	0.916	0.7066	0.4147	0.7356	0.7238
RR4	0.6841	0.6348	0.6212	0.6638	0.7208	0.6657	0.6681	0.708	0.7436	0.7178	0.7668	0.7702	0.8704	0.6871	0.5086	0.7276	0.7373
SCO1	0.7011	0.6547	0.6657	0.6294	0.7171	0.6425	0.6508	0.6792	0.7419	0.7048	0.6589	0.6797	0.7014	0.9114	0.546	0.741	0.7402
SCO2	0.632	0.6251	0.6264	0.6254	0.6227	0.5711	0.5779	0.6744	0.6941	0.6422	0.6179	0.6779	0.6511	0.8627	0.41	0.6889	0.6924
SCO3	0.6831	0.6576	0.6617	0.614	0.7205	0.6458	0.6745	0.6701	0.7194	0.7112	0.6582	0.6946	0.7195	0.9223	0.5467	0.7404	0.7153
SCO4	0.6402	0.6229	0.635	0.5894	0.626	0.5617	0.6944	0.6671	0.6598	0.6464	0.607	0.6872	0.6712	0.8169	0.5019	0.7004	0.6888
SF1	0.4086	0.3516	0.3788	0.4144	0.3643	0.2551	0.3955	0.4047	0.4096	0.3766	0.3248	0.4126	0.3989	0.432	0.6652	0.4759	0.3834
SF2	0.3242	0.3018	0.3205	0.3063	0.4002	0.3738	0.3618	0.3002	0.353	0.3873	0.3883	0.2827	0.3496	0.4335	0.7466	0.3143	0.3377
SF3	0.4738	0.4629	0.4282	0.4016	0.5107	0.4152	0.4657	0.43	0.4512	0.4642	0.532	0.444	0.4283	0.5042	0.8472	0.5037	0.509
SF4	0.3038	0.3209	0.2392	0.3063	0.3613	0.2285	0.3203	0.2858	0.2787	0.3623	0.4313	0.3187	0.29	0.3278	0.7459	0.3713	0.3476
LD1	0.7031	0.7046	0.7483	0.7262	0.7709	0.5955	0.7918	0.7854	0.7931	0.7735	0.7499	0.8093	0.787	0.7759	0.5608	0.9346	0.8178
LD2	0.7854	0.7819	0.7215	0.7025	0.7169	0.5776	0.7927	0.7558	0.772	0.7253	0.6881	0.7493	0.7438	0.7385	0.5135	0.9169	0.7557
LD3	0.7817	0.7678	0.7093	0.7101	0.7552	0.5939	0.7934	0.7501	0.7833	0.7421	0.7589	0.8082	0.7852	0.749	0.5251	0.9269	0.844
LD4	0.6886	0.6902	0.6252	0.6445	0.6846	0.5397	0.6585	0.6741	0.729	0.6786	0.7	0.7407	0.7197	0.7231	0.4406	0.8772	0.7926
SCRM1	0.732	0.7017	0.6754	0.6734	0.7362	0.6247	0.6924	0.7086	0.7547	0.7438	0.6955	0.7366	0.7455	0.7443	0.5106	0.8076	0.9159
SCRM2	0.6458	0.612	0.6299	0.6311	0.6707	0.5945	0.6768	0.6891	0.7226	0.6779	0.6318	0.7028	0.6797	0.6669	0.4344	0.7424	0.873
SCRM3	0.7578	0.723	0.6948	0.6928	0.7056	0.5687	0.7493	0.7404	0.7648	0.7116	0.6696	0.7494	0.7549	0.7129	0.4231	0.818	0.8705
SCRM4	0.5772	0.5888	0.5558	0.5819	0.6605	0.5821	0.5958	0.6471	0.657	0.674	0.6919	0.6669	0.6368	0.6794	0.4852	0.676	0.815

From the above analysis, in terms of item reliability, internal consistency and discriminant validity, it is evident that the measurement model was considered satisfactory with reference to meeting the criteria of convergent validity (loadings > 0.70, AVE > 0.50, CR > 0.80) and discriminant validity (*AVE* > correlations). The first-order measurement model was thus confirmed to be satisfactory and was employed for testing the higher-order measurement model and the structural model in the next sections.

6.4.1.1.2 Higher-order reflective measurement model

At this stage, the study estimated the measurement properties of the higher-order reflective constructs: supply chain resilience (SCR) and supply chain capacity (CAP). As mentioned in Chapter 3, the measurement properties of the reflective constructs were assessed by reliability, internal consistency and AVE which are shown by Table 6.15 and Table 6.16. Figure 6.3 represents the hierarchical relationships of supply chain resilience (SCR) with supply chain capability (CAP), supply chain design (SCD), supply chain readiness (RED) and supply chain response and recovery (RR).

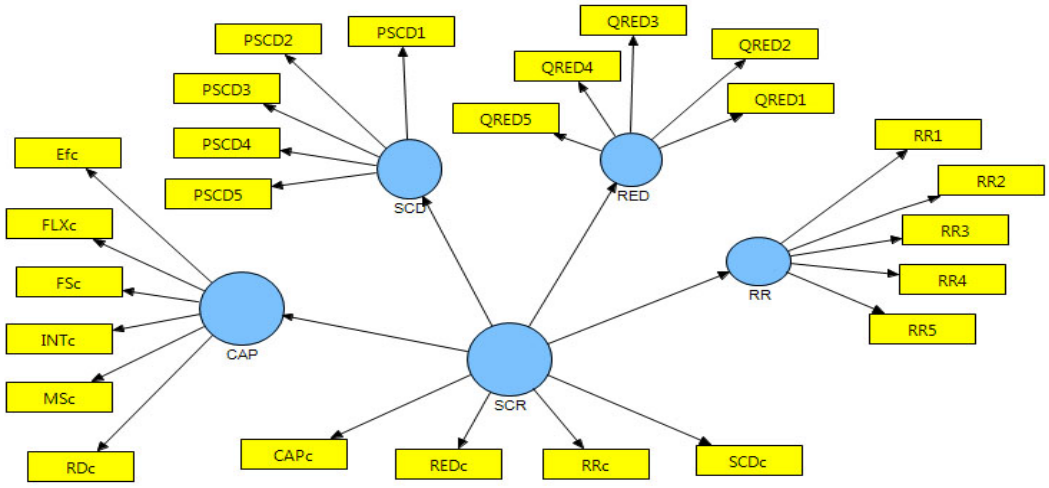


Figure 6.3: Reflective measurement model for SCR

At the higher-order level, the construct: supply chain resilience was measured by reflective constructs: capability (CAP), supply chain design (SCD), readiness (RED), and response–recovery (RR). The details of these measurement constructs were described in Chapter 5. Using the two-stage approach (see Chapter 3) (Ringle et al. 2012; Wetzels et al. 2009), the construct scores (CAPc, SCDc, REDc and RRc) of the dimensions: capability, supply chain design, readiness, and response and recovery were operationalized as the proxies to measure the higher-order (third-order) construct SCR. The results of the analysis regarding the measurement of supply chain resilience (SCR) (at third-order level) are shown on Table 6.15.

Table 6.15: Reliability, CR and AVE for higher-order construct: SCR

Higher-order Constructs	**Second-order Construct Score**	**Loading**	***t*-Value**	**CR**	**AVE**
Supply Chain Resilience (SCR)	Capability (CAPc)	0.9521	54.92	0.97	0.89
	Supply chain design (SCDc)	0.9147	33.27		
	Supply chain readiness (REDc)	0.9502	58.49		
	Supply chain response and recovery (RRc)	0.9597	56.16		

CAP=Capability; SCD=Supply chain design, RED=Supply chain readiness, RR=Response and recovery.

Table 6.15 reveals that the loading of each construct score corresponding to supply chain resilience is more than 0.9 which is far above the cut-off value 0.7 (Hair, Ringle, and Sarstedt 2011). It is also apparent that all the *t*-values corresponding to loadings of the construct scores are significant.

In addition, Table 6.15 presents evidence that the internal consistency (CR) for this study far exceeds the acceptable limit of 0.7 (Hair, Ringle, and Sarstedt 2011). The AVE value also proved the convergent validity of this model as it is more than the minimum threshold level of 0.5, with reference to Hair, Ringle and Sarstedt (2011).

It is noteworthy that the construct CAP itself is a higher-order construct. Using the two-stage approach (Ringle, Sarstedt, and Straub 2012; Wetzels, Odekerken-Schroder, and Van Oppen 2009), this was measured by the construct scores/latent variable scores (FLXc, RDc, INTc, EFc, MSc and FSc) derived from the first-order constructs: flexibility, redundancy, integration, efficiency, market strength and financial strength (see Table 6.16). The measurement model of supply chain capability (before replacing the first-order construct by the latent variable scores) is shown by Figure 6.4. The theoretical justification about the first-order constructs of CAP and their measurement were described in Chapter 5.

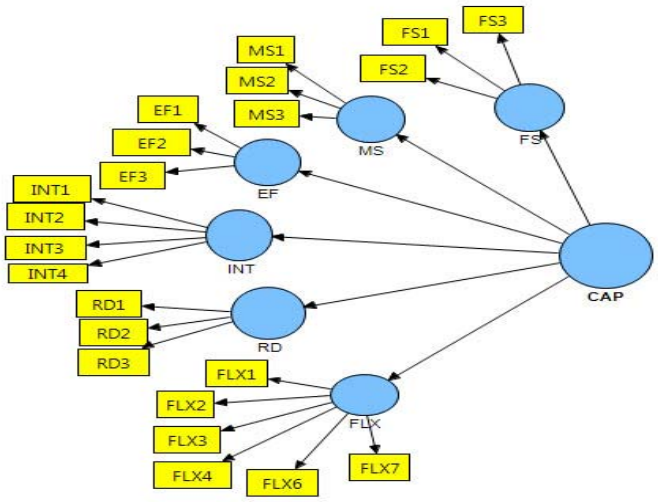


Figure 6.4: Reflective measurement model for CAP

Table 6.16: Reliability, CR and AVE for second-order reflective construct: CAP

Higher-order Construct	First-order Construct Score	Loading	*t*-Value	CR	AVE
Capability (CAP)	FLXc	0.9341	74.3968	0.9664	0.8274
	RDc	0.8525	24.5286		
	INTc	0.8822	35.1106		
	EFc	0.9235	54.6911		
	MSc	0.9447	73.344		
	FSc	0.9166	45.1574		

FLX=Flexibility, RD=Redundancy, INT=Integration, EF=Efficiency, MS=Market strength, FS=Financial strength.

Table 6.16 shows that the loadings corresponding to all measurement items (construct scores) are more than the minimum requirement of 0.7 with reference to previous studies (Hair, Ringle, and Sarstedt 2011; Barclay, Higgins, and Thompson 1995; Henseler, Ringle, and Sinkovics 2009). The corresponding *t*-values are also significant at *p=.01.* Therefore, all items (construct scores) are reliable to represent the higher-order construct CAP.

Table 6.16 also shows the results of CR and AVE with respect to supply chain capability. It is evident that both CR and AVE are more than the minimum threshold level (0.5) considered in this research.

6.4.1.2 Assessing formative measurement model

6.4.1.2.1 First-order formative measurement model

In this research, supply chain vulnerability (SCV) was operationalized as the first-order formative and second-order formative mode. In line with the two-stage approach (see Chapter 3), the higher-order construct SCV was measured by the construct scores: HVc, SVc, FVc, OVc, IVc and DSVc as proxies of the first-order constructs: hazard vulnerability (HV); strategic vulnerability (SV); financial vulnerability (FV); operational vulnerability (OV); infrastructural vulnerability (IV) and demand–supply vulnerability (DSV). Figure 6.5 illustrates the formation of the construct SCV and Figure 6.6 shows the measurement model of supply chain vulnerability (SCV) before replacing the first-order construct with the latent variable scores. The measurement properties for formative constructs were assessed by evaluating the significance of indicator weight and loading scores as well as examining the multi-collinearity in the formative indicators (Hair, Ringle, and Sarstedt 2011; Henseler, Ringle, and Sinkovics 2009). The following sub-sections explicate the relevant details in this regard.

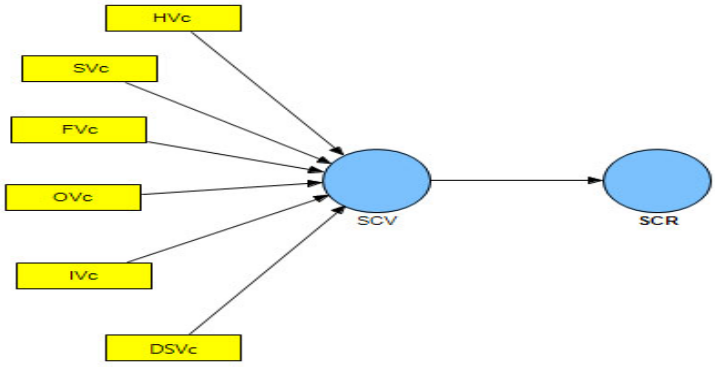


Figure 6.5: Formative measurement model for SCV

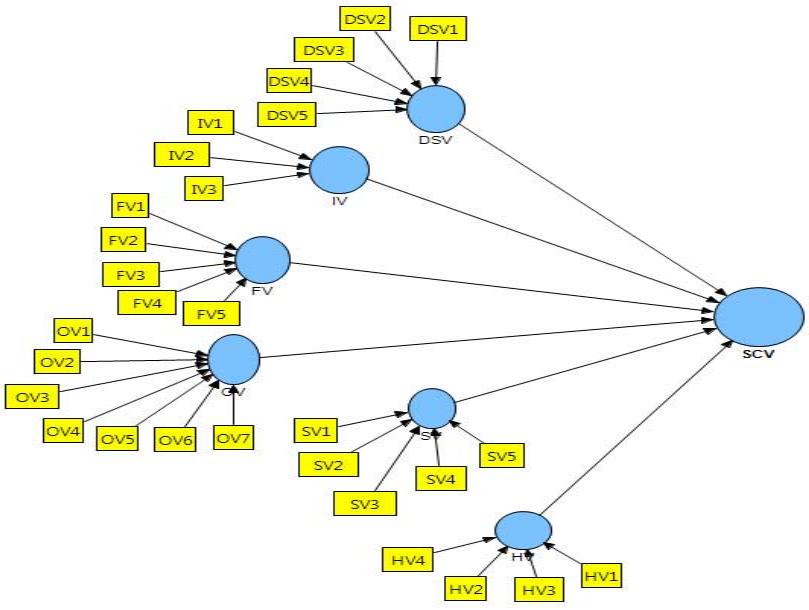


Figure 6.6: Formative measurement model for SCV before shrinking

Weight and loading (first-order level)

Consistent with previous studies (Hair, Ringle, and Sarstedt 2011; Henseler, Ringle, and Sinkovics 2009), the formative measurement model was assessed by evaluating the significance of indicator weight and loading scores. In this regard, the result of bootstrapping from the PLS run is shown by Table 6.17.

Table 6.17 shows that most of the indicators have significance on the respective constructs. Although some of the indicator weights were not very significant as far as the concern of item loading, these were significant (Hair et al. 2011). Only one item was not significant based on the aggregate criteria of item level weight and loading, as suggested by Hair, Ringle and Sarstedt (2011). However, in this research, the item was

not deleted because omission of the indicator might change the definition of the construct (Bollen and Lennox 1991). The studies of Fornell, Lorange and Roos (1990)and Santosa, Wei and Chan (2005) also support the view that all formative items should be included even if the weight is very low or negative.

Table 6.17: First-order formative constructs

First-Order Construct	Item	Weight	*t*-Value	Loading	*t*-Value
HV	HV1-Natural disaster	0.2121	1.0054	0.5919	3.5839
	HV2-Fire and accident	0.3195	1.6497	0.7181	5.2481
	HV3-Labour unrest	0.2788	1.4485	0.7397	6.2343
	HV4-Political instability	0.5004	3.1973	0.6753	4.8467
SV	SV1-Competition	0.3315	1.3768	0.6352	6.0877
	SV2-Non-compliance	0.2118	1.6549	0.747	5.243
	SV3-Buyer and supplier relationship	0.2931	2.2146	0.624	5.5259
	SV4-Integration	0.2058	0.9727	0.6496	5.1973
	SV5-Plant location	0.2655	1.8873	0.7192	7.2577
FV	FV1-Currency fluctuation	0.1709	1.0259	0.0527	0.5067
	FV2-Economic recession	0.4173	3.1567	0.7393	7.4915
	FV3-Raw material price fluctuation	0.0676	0.4574	0.5091	4.1406
	FV4-Bank interest	0.4744	3.5081	0.7603	8.3522
	FV5-Bankruptcy	0.3604	2.0368	0.65	5.3007
OV	OV1-Skill shortage	0.0121	0.1269	0.6245	6.153
	OV2-Switching and absenteeism	0.2587	1.9374	0.7171	9.2302
	OV3-Production planning	0.2297	1.6587	0.6544	5.5891
	OV4-IT system failure	0.1901	1.4217	0.3141	2.1264
	OV5-Utility disruption	0.2611	1.8979	0.7137	7.8812
	OV6-Product quality	0.1319	0.7942	0.6175	4.8233
	OV7-Illiteracy	0.2419	1.0879	0.7263	6.1982
IV	IV1-Delay in customs	0.15	0.6529	0.5488	2.9089
	IV2-Inefficiency in port	0.3682	1.822	0.7606	6.6234
	IV3-Poor land transportation	0.6247	2.4244	0.8561	8.2144
DSV	DSV1-Supplier's disruptions	0.3588	2.7664	0.6595	6.3144
	DSV2-Import dependency	0.363	2.9222	0.6778	6.9115
	DSV3-Non-conformity of material	0.1092	0.1911	0.5214	2.5252
	DSV4-Buyer's disruptions	0.4153	2.8521	0.7123	6.8048
	DSV5-Demand fluctuation	0.1033	0.6955	0.4747	3.3065

Collinearity test for formative constructs

In line with Hair, Ringle and Sarstedt (2011), and Henseler, Ringle and Sinkovics (2009), collinearity among the first-order constructs: HV, SV, FV, OV, IV and DSV, was checked by calculating the variance influence factor (VIF) values which are presented on Table 6.18.

Table 6.18 demonstrates that VIF values for each indicator corresponding to the respective construct is less than 5; therefore, the multi-collinearity problem does not

exist in this case, with reference to Hair, Ringle and Sarstedt (2011) and Henseler, Ringle and Sinkovics (2009).

Table 6.18: Collinearity test for formative construct

Construct	Item	VIF	Construct	Item	VIF
HV	HV1	1.554	OV	OV1	1.234
	HV2	1.898		OV2	1.591
	HV3	1.672		OV3	1.537
	HV4	1.104		OV4	1.396
SV	SV1	1.349		OV5	1.595
	SV2	2.176		OV6	1.545
	SV3	1.553		OV7	1.755
	SV4	1.462	IV	IV1	1.267
	SV5	1.823		IV2	1.456
FV	FV1	1.122		IV3	1.418
	FV2	1.454	DSV	DSV1	1.313
	FV3	1.495		DSV2	1.419
	FV4	1.335		DSV3	1.306
	FV5	1.243		DSV4	1.353
				DSV5	1.335

6.4.1.2.2 Higher-order formative measurement model

As this study used the two-stage approach (Ringle, Sarstedt, and Straub 2012; Wetzels, Odekerken-Schroder, and Van Oppen 2009), each of the first-order constructs were replaced by their construct scores to measure SCV at the higher-order level (see Figures 6.4 and 6.5). The measurement of the second-order construct SCV is depicted on Table 6.19.

Table 6.19: Measurement of second-order formative construct: SCV

Higher-order Construct	First-order Constructs	Weight	*t*-Value	Loading	*t*-Value
Supply Chain Vulnerability (SCV)	**HVc**	0.2478	1.7235	0.6885	3.1383
	SVc	0.3818	2.4144	0.7224	5.8769
	FVc	0.2728	1.7292	0.7738	5.7659
	OVc	0.3667	2.1752	0.7545	4.8895
	IVc	0.4406	3.2538	0.5306	3.4452
	DSVc	0.1014	0.6265	0.6393	6.7213

Table 6.19 shows that, with the exception of one construct (DSV), the weights of all first-order constructs are significant in the formation of the higher-order construct: supply chain vulnerability (SCV). However, as far as the concern of item loading, all the constructs including DSV are significant as *t*-values are more than 1.96 at p=.05. Therefore, with reference to Hair, Ringle and Sarstedt (2011), all elements of SCV show adequate measurement properties.

The result of the analysis of the higher-order formative construct SCV revealed that the six first-order construct scores (HVc, SVc, FVc, OVc, IVc and DSVc) have the required

measurement properties corresponding to the higher-order construct: supply chain vulnerability (SCV). Therefore, it could be remarked that the dimensions of supply chain vulnerability carry adequate importance to form the higher-order construct.

Once the measurement model was refined, the refined model was then put forward for structural model analysis (Henseler et al. 2009). The analysis of the refined measurement model showed that all the measurement items were consistent and showed good measurement properties. These findings led to considering the measurement model as valid for structural model assessment.

6.4.2 Assessing structural model

As mentioned in Chapter 3, this step evaluates the statistical significance of the path loadings, path coefficients and corresponding *t*-values among the constructs (Barclay, Higgins, and Thompson 1995; Hair, Ringle, and Sarstedt 2011). In addition, the explanatory power of the proposed model was assessed by estimating the percentage of variance explained or R-squared (R^2) value of the endogenous constructs (Hair, Ringle, and Sarstedt 2011). Moreover, the nomological validity of the multidimensional constructs and the predictive validity of the constructs were assessed. It is worth mentioning that studies in line with partial least squares (PLS)-based SEM suggest the use of two non-parametric approaches to test the relationship between constructs, namely: the jackknife and bootstrap techniques (Santosa et al. 2005; Gefen et al. 2000). For the data analysis in this research, the bootstrapping method was chosen as it is considered to be a more advanced approach than the jackknife method (Chin 1998a).

6.4.2.1 Path coefficient (β) and *t*-value

Path coefficients and corresponding *t*-values were calculated to assess the relationships among the constructs as hypothesized in this research (Ringle 2012; Hair, Ringle, and Sarstedt 2011). A positive value of a path coefficient indicates that there is a positive relationship between the constructs and vice versa. The *t*-value evaluates whether the relationships among the constructs are significant. The path coefficient and *t*-values are depicted by Figures 6.7 and 6.8, and Table 6.20. It is to mention that the models as shown in Figure 6.7 and 6.8 embrace the impact of control varibles such as size, experience (exp) and supply chain entity (SCENT) on the endogeneous constructs: supply chain resilience (SCRE), social sustainability (SCS) environmental sustainability (ENS), economic sustainability (ECS) and operational sustainability (OPS).

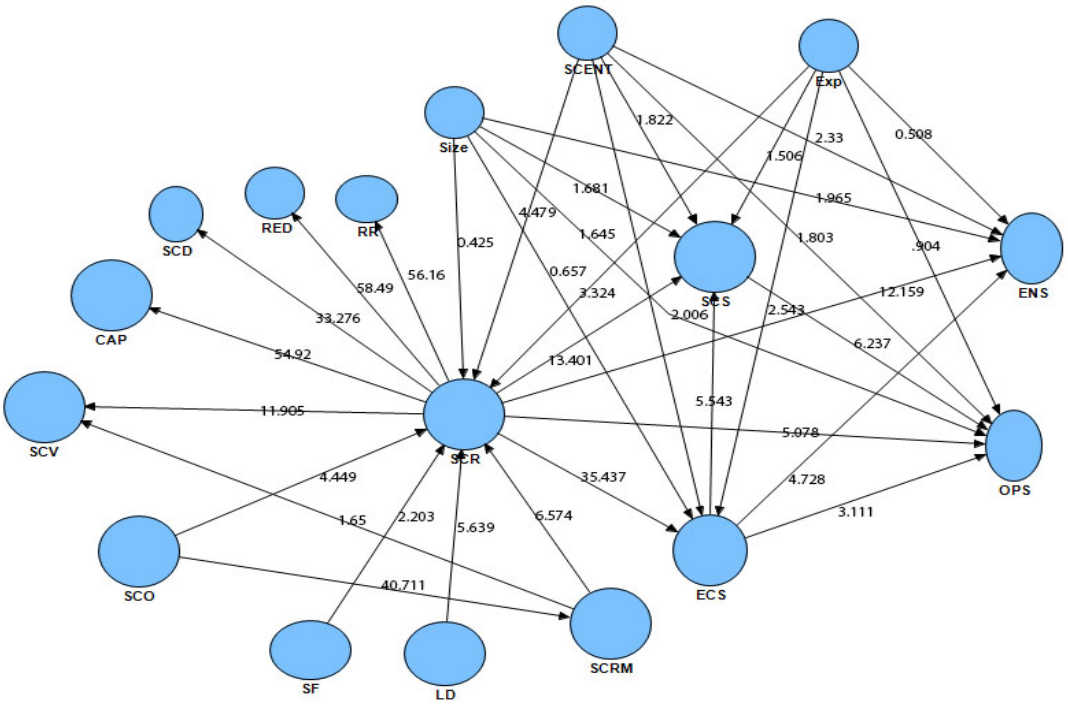


Figure 6.7: *t*-values from bootstrapping output of study model

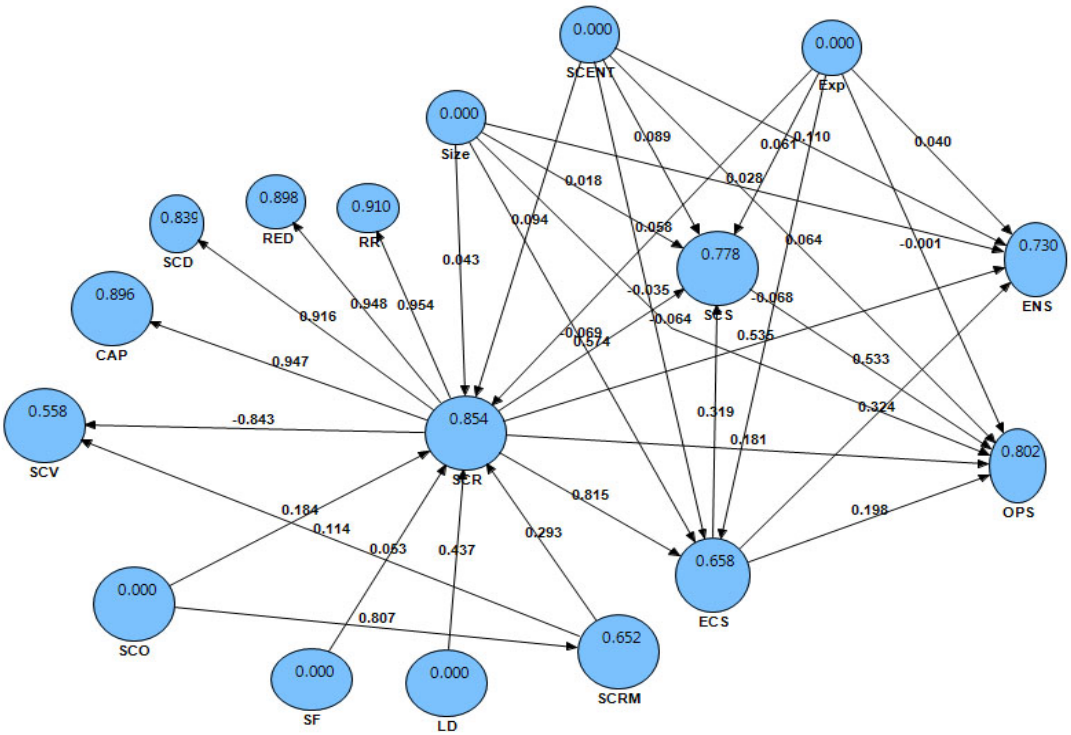


Figure 6.8: Path coefficient values from PLS algorithm output of study model

Table 6.20: Path coefficient (β) values and *t*-values

Hypothesis	Link	Standardized Path Coefficient	*t*-Value	Outcome
H1	SCR→SCV (-)	-0.843	11.905***	Supported
H2	SCO→SCR (+)	0.184	4.4492***	Supported
H3	L&D→SCR (+)	0.437	5.6392***	Supported
H4	SF→SCR (+)	0.053	2.203**	Supported
H5	SCRM→SCR (+)	0.293	6.5736***	Supported
H6	SCO→SCRM (+)	0.807	40.7114***	Supported
H7	SCRM→SCV (-)	0.114	1.65	Not Supported
H8	SCR→SCS (+)	0.574	13.4011***	Supported
H9	SCR→ENS (+)	0.535	12.1594***	Supported
H10	SCR→ECS (+)	0.815	35.4368***	Supported
H11	SCR→OPS (+)	0.181	5.0781***	Supported
H12	ECS→SCS (+)	0.319	5.5434***	Supported
H13	ECS→ENS (+)	0.324	4.728***	Supported
H14	ECS→OPS (+)	0.198	3.1113***	Supported
H15	SCS→OPS (+)	0.533	6.2372***	Supported

*Significant *p < 0.05, **p < 0.01, ***p < 0.005* and critical values are 1.645 at *p*=.05; 1.96 at *p*=0.025; and 2.32 at *p*=0.01.

6.4.2.2 Coefficient of determination (R^2)

The R^2 values evaluate the ability of the model to explain and predict the endogenous latent variables (Ringle, Sarstedt, and Straub 2012; Hair, Ringle, and Sarstedt 2011). The R^2 values of endogenous latent constructs in this model are depicted by Table 6.21.

Table 6.21: Coefficient of determination (R^2)

Constructs	R^2		R^2
Supply chain resilience (SCR)	0.854	Supply chain risk management (SCRM)	0.652
Supply chain vulnerability (SCV)	0.558	Social sustainability(SCS)	0.778
Capability (CAP)	0.896	Environmental sustainability (ENS)	0.730
Supply chain design (SCD)	0.839	Economic sustainability (ECS)	0.658
Supply chain readiness (RED)	0.898	Operational sustainability (OPS)	0.802
Supply chain response & recovery (RR)	0.910		

Table 6.21 reveals that all the R^2 values are above 0.5 which indicates either the large or at least the moderate explanatory power of the endogenous constructs (Hair et al. 2011). It also confirms the nomological validity of the endogenous constructs with respect to their exogenous constructs. Moreover, the model itself has adequate merits

in the sense that the important endogenous construct: supply chain resilience (SCR) can explain 85.4% of the variance in the supply chain sustainability and resilience model.

6.4.2.3 Nomological validity of multidimensional constructs

This study examined the adequacy of the multidimensional structure for the constructs SCR and SCV as suggested by Edwards (2001) and Mackenzie (2012) to validate the dimensions of SCR and SCV in the nomological net. In this regard, the indirect effects of the antecedent construct (SCRM) on the sub-dimensions of SCR: CAP, SCD, RED and RR and the direct effects of SCRM on the sub-dimensions (see Table 6.22) were assessed. Furthermore, the endogenous multidimensional construct (SCV) with formative indicators/dimensions were evaluated by assessing the direct effects of the antecedent (SCRM) on each sub-dimension: HV, SV, FV, OV, IV and DSV (without the focal construct in the model) (see Table 6.22).

Table 6.22: Assessment of nomological validity for multidimensional constructs

Direct effect of SCRM on sub-dimensions of SCR		Indirect effect of SCRM on sub-dimensions of SCR		Direct effect of SCRM on sub-dimensions of SCV	
CAP	.18	CAP	.83	HV	.51
SCD	.10	SCD	.84	SV	.53
RED	.002	RED	.84	FV	.51
RR	.08	RR	.80	IV	.42
				OV	.57
				DSV	.59

Table 6.22 affirms that the indirect effect of the antecedent construct SCRM on the dimensions of SCR is substantially larger than the direct effect of SCRM on the dimensions of SCR. While examining the direct effect of the antecedent construct (SCRM) on the formative dimensions of SCV, it is affirmed that the direct effects are nearly the same and that they scored in a range of .50 to .60 except in the case of infrastructural vulnerability. However, based on theoretical relevance and field study support, this research retained infrastructural vulnerability as one of the dimensions of supply chain vulnerability.

6.4.2.4 Predictive relevance

In addition to measuring predictive accuracy by R^2, this study used Stone–Geisser's Q^2 (Stone 1974; Geisser 1975) to test the predictive relevance of the focal multidimensional construct (SCR) of the model. Based on the blindfolding procedure

and the cross-validated redundancy approach, the predictive relevance values were calculated as presented in Table 6.23.

Table 6.23: Predictive relevance for SCR

Predictive relevance with respect to SCR	Q^2 values
SCV	0.2347
SCS	0.5384
ENS	0.5246
OPS	0.6053
ECS	0.3564

Table 6.23 shows that the predictive validity for almost all the constructs is high. The satisfactory values of predictive relevance for the outcome constructs of SCR (SCV, SCS, ENS, OPS and ECS) also reflect that SCR has good predictive relevance/power corresponding to its outcome constructs.

6.4.2.5 Effect size

In addition to examining the R^2 and Q^2 values, the effect size (f^2) was also calculated for the endogenous constructs. The effect size (f^2) is the measure of the impact of a specific predictor construct on an endogenous construct (Newsome 2000).

Table 6.24: Effect size

	Effect size (f^2)				
Constructs	SCR	SCS	OPS	ENS	ECS
SCO	0.146				
SF	0.006				
LD	0.184				
SCRM	0.153				
SCR		.791	0.154	.61	.213

Table 6.24 shows that the effect size (f^2) of the antecedent constructs SCO, SF, LD and SCRM on SCR are .146, .006, .184 and .153, respectively. In a similar fashion, the effect size (f^2) of the hierarchical construct SCR is .791, .154, .61 and .213 on the outcome constructs SCS, OPS, ENS and ECS, respectively.

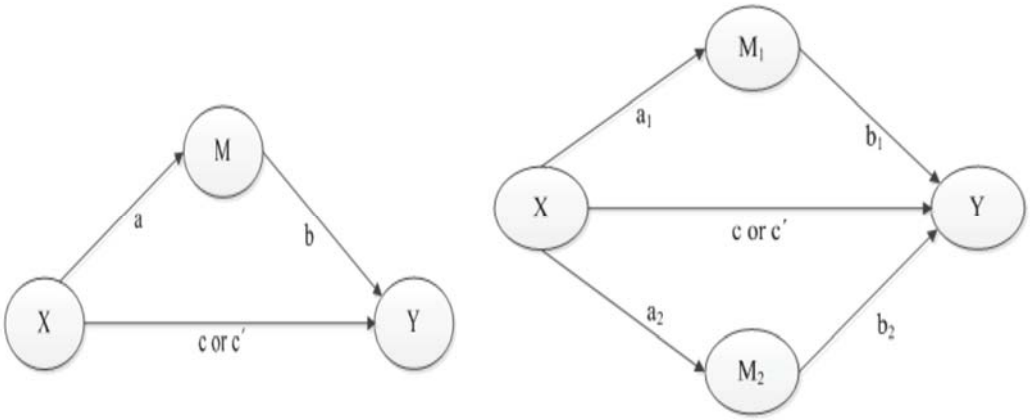
6.4.2.6 Results of hypotheses testing

The results of the hypotheses testing, as depicted by Table 6.20 in sub-section 6.4.2.1, imply that 14 out of the 15 hypotheses are supported as the *t*-values corresponding to the hypotheses are more than the critical values. The relationship between SCRM and SCV was not supported because the path coefficient was supposed to be negative whereas the result showed a positive relationship. Therefore, this hypothesis is rejected. A close scrutiny of the relationship between SCRM and SCV revealed that the

direct relationship between SCRM and SCV produced a negative and significant relationship; however, when the whole model was run together, the relationship became inconsequential. It is predicted that the construct: supply chain resilience (SCR) explains most of the variances with SCV while SCRM is linked with SCV via SCR. From the results of the analysis of the relationships between SCRM, SCR and SCV, it seems that SCR mediates the relationship between SCRM and SCV. There is also an indication of this relationship in the literature (Jüttner and Maklan 2011). Therefore, the relationship between SCRM and SCV would be further clarified from the mediation test result. Among the surviving hypotheses, the influence of SCO on SCRM was found to be most significant, whereas the relationship between SF to SCR was found to be least significant.

6.4.3 Mediation analysis

Mediation exists when there is at least one intervening variable or mediator between the predictor and the predictor variable which affects the relationship between the two (Baron and Kenny 1986). Figure 6.9 illustrates mediation models with single and multiple intervening variables.



Mediation model (single mediator) Mediation model (multiple mediators)

X=Independent variable, Y=Dependent variable, M=Mediating variable

Figure 6.9: Mediating models

In addressing the mediating relationship, Baron and Kenny (1986) and Jude and Kenny (1981) discussed four characteristics of mediation as stated below:

Step 1: The predictor variable (X) should have a significant relationship with the outcome variable (Y).

Step 2: The predictor variable (X) should have a significant relationship with the mediating variable (M).

Step 3: The mediating variable (M) should have a significant relationship with the criterion variable (Y).

Step 4: In control of the mediating variable, the relationship between the predictor variable and criterion variable is no longer significant if there is a full mediation, whereas, if the relationship is still significant, a partial mediation exists between the two variables.

Hypotheses *H16, H17, H18, H19, H20* and *H21* were developed to examine the role of mediation. Table 6.25 and Figures 6.10 to 6.15 show the mediation relationships in the model.

Table 6.25: Results of mediation analysis

Hypotheses and propositions	**Structural model**	**Path coefficients**				**Stand-ard Error**	**Mediat-ion Effect**
		Direct effect	**Indirect effect**	**Total effect**	**VAF**		
H16 (*SCR mediates the relationship between SCRM and SCV)*	SCRM-SCV (without mediation)	-.633 (*t*=19.13)					Full mediat-ion
	SCRM-SCR	0.870 (*t*=52.3)				.0166	
	SCR-SCV	-0.845 (*t*=9.31)				.0908	
	SCRM-SCV	0.115 (*t*=1.16)	-.735 (*z*=-9.16)	-.620 (*t*=14.74)	1.19	.0996	
H17 (SCRM mediates the relationship between SCO and SCR)	SCO-SCR (without mediation)	.807 (*t*=43.91)					Partial mediat-ion
	SCO-SCRM	.807 (*t*=42.4)				.0199	
	SCRM-SCR	.585 (*t*=11.9)				.0496	
	SCO-SCR	.353 (*t*=7.1)	.472 (*z*=11.4)	.825 (*t*=43.38)	.572	.0522	
H18 (ECS mediates the relationship between SCR and SCS)	SCS-SCR (without mediation)	.882 (*t*=73.1)					Partial mediat-ion
	SCR-ECS	.807 (*t*=39.7)				.0203	
	ECS-SCS	.302 (*t*=5.98)				.0506	
	SCS-SCR	.615 (*t*=12.6)	.244 (*z*=5.9)	.859 (*t*=66.78)	.284	.0490	
H19 (ECS mediates the relationship between SCR and ENS)	SCR-ENS (without mediation)	.8567 (*t*=57.5)					Partial mediat-ion
	SCR-ECS	.807 (*t*=39.9)				.0202	
	ECS-ENS	.310 (*t*=4.6)				.0671	
	SCR-ENS	.579 (*t*=9.1)	.25 (*z*=4.59)	.829 (*t*=54.12)	.302	.0633	
H20 (ECS mediates the relationship between SCR and OPS)	SCR-OPS (without mediation)	.869 (*t*=59.95)					Partial mediat-ion
	SCR-ECS	.807 (*t*=39.3)				.0206	
	ECS-OPS	.363 (*t*=6.6)				.0547	
	SCR-OPS	.530 (*t*=9.9)	.293 (*z*=6.54)	.823 (*t*=60.93)	.356	.0530	
H21 (SCS mediates the	ECS-OPS (without mediation)	.79 (*t*=35.14)					Partial mediat-

relationship between ECS and OPS)	ECS-SCS	.799 (*t*=42.1)				.0190	ion
	SCS-OPS	.664 (*t*=15.8)				.0420	
	ECS-OPS	.261 (*t*=5.9)	.531 (*z*=14.8)	.792 (*t*=35.25)	.67	.0437	

Note: VAF=variance accounted for=indirect effect/total effect

Table 6.25 (see page 199) and Figures 6.10-6.15 (see page 200) analyse the mediation effects in the model. The criteria for mediation analysis, as suggested by Baron and Kenny (1986), were examined as follows: firstly, the relationship between the predictor and the mediator; secondly, the relationship between the mediator and the criterion variables; and finally, the link between the predictor and the criterion variable in the absence of the mediator's influence were investigated.

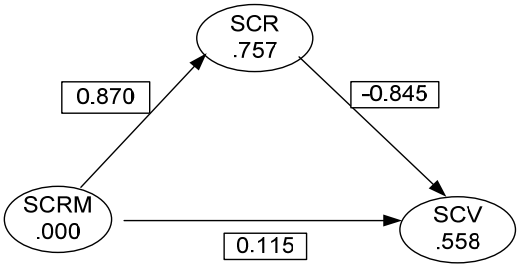


Figure 6.10: Mediation role of SCR between SCRM and SCV (*H16*)

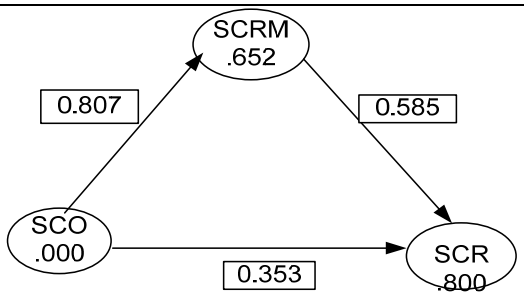


Figure 6.11: Mediation role of SCRM between SCO and SCR (*H17)*

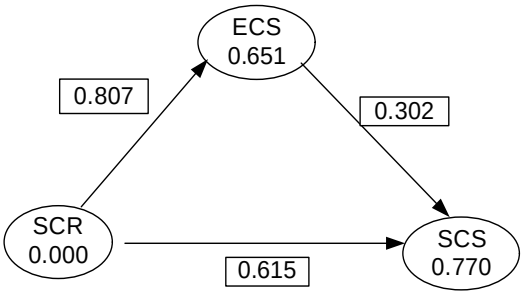


Figure 6.12: Mediation role of ECS between SCR and SCS (*H18)*

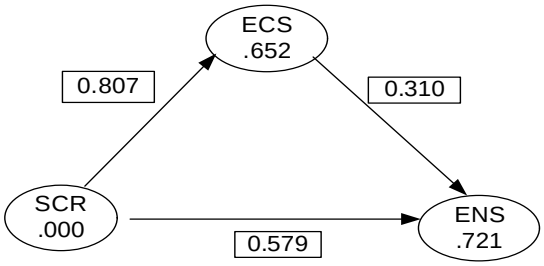


Figure 6.13: Mediation role of ECS between SCR and ENS (*H19)*

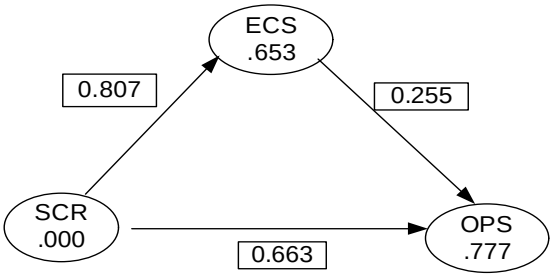


Figure: 6.14: Mediation role of ECS between SCR and OPS (*H20)*

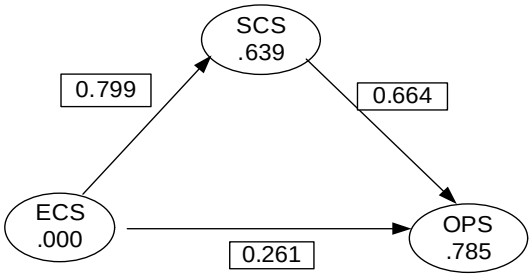


Figure: 6.15: Mediation role of SCS between ECS and OPS (*H21)*

SCR as mediator between SCRM and SCV

Table 6.25 shows that the relationship between the predictor (SCRM) and the mediator (SCR) as well as the relationship between the mediator (SCR) and the criterion variables (SCV) are significant. The link between the predictor (SCRM) and the criterion variable (SCV) in the absence of the mediator's influence is also significant. Finally, the indirect effect for the SCRM-SCV link is significant (Baron and Kenny 1986) as the Sobel test result (Sobel 1982) is satisfied (z-value > 1.65 at $p < 0.10$). Therefore, there are statistical grounds to accept hypothesis *H16*.

SCRM as mediator between SCO and SCR

Table 6.25 shows that the relationship between the predictor (SCO) and the mediator (SCRM) as well as the relationship between the mediator (SCRM) and the criterion variables (SCR) are significant. The link between the predictor (SCO) and the criterion variable (SCR) in the absence of the mediator's influence is also significant. Finally, the indirect effect for the SCO-SCR link is significant (Baron and Kenny 1986) as the Sobel test result (Sobel 1982) is satisfied (z-value > 1.65 at $p < 0.10$). Therefore, there are statistical grounds to accept hypothesis *H17* partially.

ECS as mediator between SCR and SCS

Table 6.25 shows that the relationship between the predictor (SCR) and the mediator (ECS) as well as the relationship between the mediator (ECS) and the criterion variables (SCS) are significant. The link between the predictor (SCR) and the criterion variable (SCS) in the absence of the mediator's influence is also significant. Finally, the indirect effect for the SCR-SCS link is significant (Baron and Kenny 1986) as the Sobel test result (Sobel 1982) is satisfied (z-value > 1.65 at $p < 0.10$). Therefore, there are statistical grounds to accept hypothesis *H18* partially.

ECS as mediator between SCR and ENS

Table 6.25 shows that the relationship between the predictor (SCR) and the mediator (ECS) as well as the relationship between the mediator (ECS) and the criterion variables (ENS) are significant. The link between the predictor (SCR) and the criterion variable (ENS) in the absence of the mediator's influence is also significant. Finally, the indirect effect for the SCR-ENS link is significant (Baron and Kenny 1986) as the Sobel test result (Sobel 1982) is satisfied (z-value > 1.65 at $p < 0.10$). Therefore, there are statistical grounds to accept hypothesis *H19* partially.

ECS as mediator between SCR and OPS

Table 6.25 shows that the relationship between the predictor (SCR) and the mediator (ECS) as well as the relationship between the mediator (ECS) and the criterion variables (OPS) are significant. The link between the predictor (SCR) and the criterion variable (OPS) in the absence of the mediator's influence is also significant. Finally, the indirect effect for the SCR-OPS link is significant (Baron and Kenny 1986) as the Sobel test result (Sobel 1982) is satisfied (z-value > 1.65 at $p < 0.10$). Therefore, there are statistical grounds to accept hypothesis *H20* partially.

SCS as mediator between ECS and OPS

Table 6.25 shows that the relationship between the predictor (ECS) and the mediator (SCS) as well as the relationship between the mediator (SCS) and the criterion variables (OPS) are significant. The link between the predictor (ECS) and the criterion variable (OPS) in the absence of the mediator's influence is also significant. Finally, the indirect effect for the ECS-OPS link is significant (Baron and Kenny 1986) as the Sobel test result (Sobel 1982) is satisfied (z-value > 1.65 at $p < 0.10$). Therefore, there are statistical grounds to accept hypothesis *H21* partially.

6.4.4 Assessing the impact of control variables

The impact of control variables such as size, experience (EXP) and supply chain entity (SCENT) was evaluated by estimating the R^2, path coefficients and t-values corresponding to the link between control variables and supply chain resilience (SCR) as well as sustainability components (SCS, ENS, OPS and ECS). The effects of control variables only on supply chain resilience were evaluated first (Table 6.26 on page 204) and then the effect was tested on both resilience and sustainability factors (Table 6.27 on page 204). In both cases, the impact was considered on three conditions: i) the impact of control variables was considered separately based on SIZE (see row 1 in Table 6.26 and 6.27), EXP (see row 2 in Table 6.26 and 6.27)and SCENT (see row 3 in Table 6.26 and 6.27); ii) the impact was considered pair-wise (SIZE-EXP or EXP-SCENT or SIZE-SCENT) (see row 4, 5, and 6 in Table 6.26 and 6.27); and iii) the impact of control variables (SIZE-EXP-SCENT) (see row 7 in Table 6.26 and 6.27) was considered altogether. Analysing the impact of control variables under different conditions helps to thoroughly explore the significance of control variables' impact. It also helps to extract the dynamic relationships of control variables.

The impact of control variables only on SCR

When the impact of control variables on SCR was examined (see Table 6.26 on page 204), it appeared that the impact of EXP and SCENT was significant in all conditions, that is, conditions i), ii) and iii) as mentioned above. The impact of size was insignificant in condition i) but significant in case of condition ii) and iii). This inferred that size does not have significant influence on resilience while the dynamism of size experience and supply chain entity has a significant influence on the resilience capability of organizations and their supply chains.

The impact of control variables both on SCR and sustainability factors

When the impact of control variables both on SCR and sustainability components was considered, it was revealed that the impact of SIZE was significant: on SCR in condition ii) (simultaneous impact of SIZE-EXP) and iii) (simultaneous impact of SIZE-EXP-SCENT); on SCS in condition iii); significant on ENS in condition ii) (simultaneous impact of SIZE-SCENT) and iii); and not significant on OPS and ECS in all three conditions because of negative path coffecient.

The impact of EXP was found significant on SCR in all three conditions; significant on SCS in condition i) and iii); significant on ENS only in condition iii); insignificant on OPS in all three conditions; and significant on ECS in all conditions except condition i).

The impact of SCENT was found to be significant on SCR in all three conditions; significant on SCS only in condition iii); significant on ENS in all three conditions; significant on OPS in all three conditions; and insignificant on ECS in all conditions.

Table 6.26: Impact of control variables on SCR

			Control variables on SCR																		
Size	EXP	SCENT	SCR				SCS				ENS				OPS				ECS			
			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value		
				Size	EXP	SCENT		Size	EXP	SCENT		Size	EXP	SCENT								
*	-	-	0.854	.023 *t*=.67			0.754				0.703				0.77				0.64			
-	*	-	0.855		.06 *t*=2.8		0.754				0.703				0.77				0.64			
-	-	*	0.856			.12 *t*=3.6	0.754				0.703				0.77				0.64			
*	*	-	0.855	.04 *t*=2.1	.06 *t*=2.5		0.754				0.703				0.77				0.64			
-	*	*	0.861		.08 *t*=3.5	.13 *t*=4.8	0.754				0.703				0.77				0.64			
*	-	*	0.861	.02 *t*=1		.11 *t*=4.1	0.754				0.703				0.77				0.64			
*	*	*	0.854	.041 *t*=2.2	.08 *t*=3.3	.12 *t*=4.4	0.751				0.704				0.79				0.65			

Table 6.27: Impact of control variables on SCR and sustainability

Control variables on both SCR and sustainability factors																						
Size	EXP	SCENT	SCR				SCS				ENS				OPS				ECS			
			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value			R^2	Path loading & *t*-value		
				Size	EXP	SCENT		Size	EXP	SCENT		Size	EXP	SCENT		Size	EXP	SCENT		Size	EXP	SCENT
*	-	-	.854	.023 *t*=.65			0.754	.03 *t*=1.2			0.703	.035 *t*=1.3			.776	-.06 *t*=2.5			.643	-.066 *t*=.24		
-	*	-	.855		.06 *t*=2.7		0.755		.26 *t*=5.5		0.703		.004 *t*=.14		.77		.01 *t*=.5		.643		.072 *t*=.07	
-	-	*	.856			.12 *t*=3.5	0.759			.04 *t*=1.4	0.710			.07 *t*=1.9	.776			.07 *t*=2.3	.640			.04 *t*=1.03
*	*	-	.855	.04 *t*=2.1	.06 *t*=2.4	-	0.746	.03 *t*=1.3	.03 *t*=1.2	-	0.703	.02 *t*=1.2	.01 *t*=.27	-	.776	-.06 *t*=2.5	-.02 *t*=.73	-	.647	-.06 *t*=.25	-.07 *t*=2.2	-
-	*	*	.861	-	.08 *t*=3.5	.095 *t*=4.8	0.752	-	.04 *t*=1.4	.05 *t*=1.6	0.712	-	.01 *t*=.5	.07 *t*=2	.776	-	-.003 *t*=.01	.07 *t*=2.3	.643	-	-.08 *t*=2.5	-.05 *t*=1.5
*	-	*	.861	.02 *t*=1	-	.11 *t*=3.8	0.759	.04 *t*=1.6	-	.06 *t*=1.5	0.711	.05 *t*=1.9	-	.08 *t*=2.3	.779	-.06 *t*=1.9	-	.05 *t*=1.9	.643	-.06 *t*=.3	-	-.04 *t*=1.12
*	*	*	.854	.043 *t*=2.3	.06 *t*=3.1	.093 *t*=4.4	0.778	.018 *t*=1.7	.06 *t*=1.9	.089 *t*=2.1	0.730	.03 *t*=1.66	.041 *t*=1.76	.11 *t*=2.5	.802	-.064 *t*=1.9	-.007 *t*=.32	.06 *t*=1.67	.658	-.07 *t*=.62	-.08 *t*=2.6	-.06 *t*=1.6

6.4.5 Goodness-of-Fit (GoF)

This study estimated the Goodness-of-Fit (GoF) index to measure the overall fitness of the proposed model. Average variance extracted (AVE) or communality and R^2 values of the endogenous constructs are needed to calculate the GoF index for PLS path modelling (Wetzels, Odekerken-Schroder, and Van Oppen 2009). Table 6.28 shows the AVE and R^2 values for the endogenous constructs.

Table 6.28: AVE and R^2 values for endogenous constructs

Constructs	AVE	R2
SCR	0.8907	0.854
SCV	0.5059	0.558
SCRM	0.7557	0.652
SCS	0.7516	0.778
ENS	0.7273	0.730
OPS	0.7675	0.802
ECS	0.7538	0.658

The geometric means for AVE =

$$\sqrt[7]{0.8907 \times 0.5059 \times 0.7557 \times 0.7516 \times 0.7273 \times 0.7675 \times 0.7538}$$

$$= 0.6765$$

The geometric means for R^2 =

$$\sqrt[7]{0.854 \times 0.558 \times 0.652 \times 0.778 \times 0.730 \times 0.802 \times 0.658}$$

$$= 0.712$$

Therefore GoF= $\sqrt{AVE \times R^2}$ = $\sqrt{0.6765 \times 0.712}$ = 0.694

The GoF yielded in this study was 0.694: this is large according to the set measure suggested by Wetzels, Odekerken-Schroder and Van Oppen (2009). Therefore, the fit index for this model was considered good enough.

6.5 STATISTICAL POWER ANALYSIS

This study used G*Power 3.1.2 (Faul et al. 2009) to obtain the statistical power of the model. The result of the power analysis is shown on Figure 6.16 where it is revealed that the overall power of the model is 95.2 and the *t*-value is 1.663. Statistical power in this study is more than the required power (80%) suggested by Cohen (1988). Therefore, the study has adequate confidence in the hypothesized relationships in the model. It was also revealed that the power of the overall model increased with the increased number of sample sizes. If the sample size is 110, the power is more than

95% which indicates that the sample size in this study is adequate to validate the model.

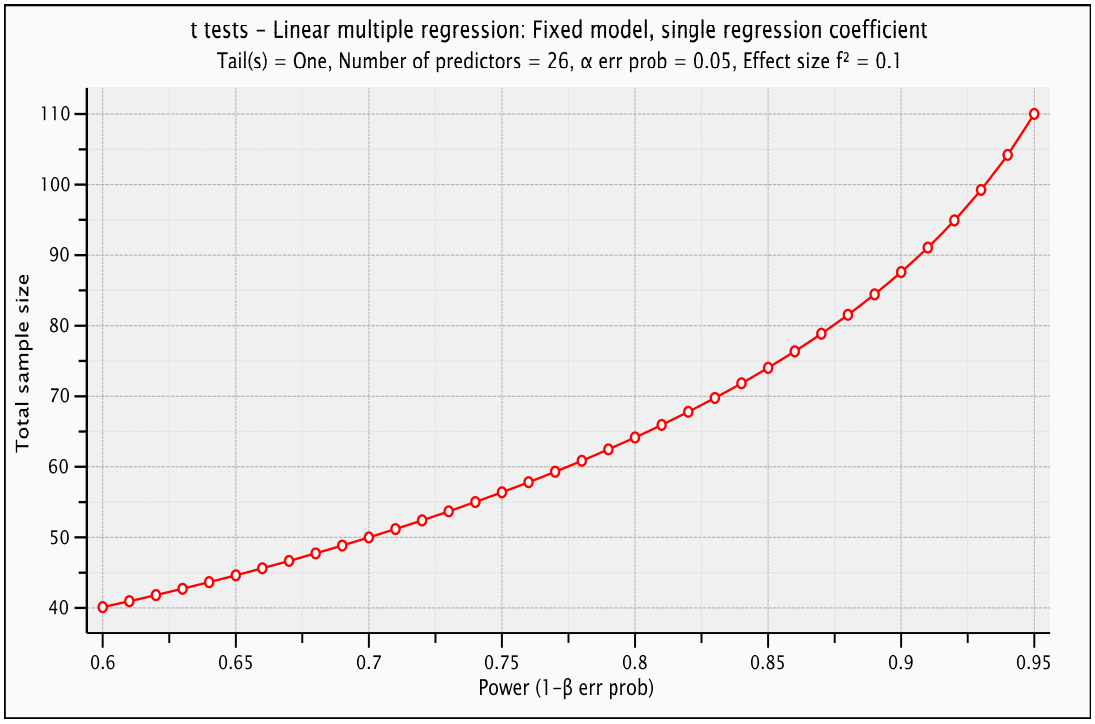


Figure 6.16: Statistical power of model

6.6 SUMMARY

This chapter presented the results of the quantitative analysis of the survey conducted on the apparel manufacturers and their suppliers in Bangladesh to explore the dimensions and the relationships among supply chain vulnerability, resilience and sustainability. To analyse the proposed model, 296 usable responses in total were collected. The component-based PLS technique, and in particular SmartPLS, was used for analysing the data in this study. The PLS technique was considered owing to the nature of the data (reflective as well as formative items), the smaller sample size, and the nature of the study (exploratory study). Data analyses were performed in two phases: assessment of the measurement model and assessment of the structural model. In assessing the measurement model, convergent validity and discriminant validity were performed. Convergent validity was affirmed by examining item loadings of the reflective indicators, as well as weights and multi-collinearity tests for the formative items. Reflective items having item loadings less than 0.7 were discarded. In addition, composite reliability and AVE (average variance extracted) were examined. Discriminant validity was ensured through: (i) examining the square root of AVE to the inter-construct correlations, and (ii) developing and analysing an item loading matrix.

For assessing the structural model: (i) the R^2 (amount of variance explained) value for each predicted variable; (ii) the path coefficient (β); and (iii) the significance of the *t*-values were examined. The nomological validity and predictive validity of the focal multidimensional constructs were also examined. Data analysis revealed that R^2 values for all endogenous constructs were above 0.5. Moreover, the important endogenous construct: supply chain resilience (SCR) could explain 84.63% of the variance in the supply chain sustainability and resilience model. The adequacy of the multidimensional constructs SCV and SCR was also proven as the constructs confirmed the nomological and predictive validity as suggested by previous studies.

CHAPTER 7

DISCUSSION AND IMPLICATIONS

7.1 INTRODUCTION

The aim of this chapter is to discuss the empirical findings of the previous chapter in terms of theoretical relevance, methodological precision and practical significance. The empirical findings are discussed consistent with the hypothesised relationships among different constructs in the model as well as the objectives of the research. Based on the two research questions and the associated research objectives, this study attempted to uncover some valuable findings and test a number of hypotheses which had not been addressed earlier in the domain of supply chain risk management particularly, in the context of the apparel industry of Bangladesh. The specific contribution of this study was the empirical validation of the supply chain sustainability and resilience model and testing the relationship between supply chain vulnerability, resilience and sustainability by using PLS-based SEM (Ringle, Sarstedt, and Straub 2012; Chin 2010). The findings of the study are discussed below through the lenses of statistical evidence, and existing theories and practices.

This chapter is structured as follows: The next section describes the hypotheses related to the research model then the impact of control variables are discussed followed by the discussion of the findings in the light of the research objectives. Finally, the chapter is concluded with a brief summary.

7.2 FINDINGS IN THE LIGHT OF HYPOTHESES

7.2.1 Hypothesis H1: Supply chain resilience (SCR) negatively impacts on Supply chain vulnerability (SCV)

This study investigates the relationship between SCR and SCV which is aligned with the reseach objective 3. The findings of the analysis revealed that there is significant statistical evidence to support a negative relationship between supply chain resilience and supply chain vulnerability. The study outcome reports the association between SCR and SCV (β=-0.843 and *t*=11.905) and proves the theoretical relationship that SCR is indispensable for mitigating supply chain vulnerabilities. It specifies that an increase in supply chain resilience will decrease the severity of supply chain vulnerability which is consistent with the literature with reference to Christopher and Peck (2004), Sheffi

and Rice (2005), Jüttner and Maklan (2011) and others. Thus, the findings of this study accentuate the importance of supply chain resilience as a critical decision-making variable in order to reduce the impact of supply chain vulnerability by developing relevant capability, designing a proper supply chain network, creating readiness and exhibiting adequate response and recovery effort.

The field study results also support the role of supply chain resilience to reduce the impact of vulnerabilities in the apparel supply chain of Bangladesh. This finding is supported by practice as well. It is observed that the proactive apparel manufacturers are expanding markets to different parts of the world rather than depending only on US and EU markets to reduce the risk from specific markets. They keep alternative suppliers to avoid supply risk and choose alternative transport such as air shipment to maintain lead time. It is also observed that the apparel manufacturers conduct readiness training and inspections such as fire drills to achieve disaster preparedness which is also a requirement of buyers, the government and the BGMEA. Apart from these activities, the apparel manufacturers and their supply chain members develop the capability to maintain flexibility, responsiveness and efficiency which helps them to overcome vulnerabilities. Therefore, it is imperative that the apparel supply chain partners, who are struggling with disruptions, develop proactive capabilities to overcome and to reduce the impact of vulnerabilities.

7.2.2 The relationships associated with SCR and its antecedent factors

This study sought to identify and investigate the role of antecedent factors of supply chain resilience which corresponds to the research objective 4. Consistent with previous studies and the field study outcomes, this study posits supply chain orientation, supply chain risk management, learning and development as well as supportive environmental factors as antecedent factors of supply chain resilience. To investigate the relationship between supply chain resilience and its antecedent factors, hypotheses *H2, H3, H4, H5, H6* and *H7* have been developed. The outcome of hypotheses test results are discussed below:

Hypothesis H2: Supply chain orientation (SCO) positively impacts on and supply chain resilience (SCR).

From the results of the analysis, it was affirmed that there is a positive relationship between supply chain resilience and supply chain orientation. The study's results also report the association between SCO and SCR (β=0.184 and *t*=4.449) which proves that SCO is important for supply chain resilience. It also postulates that without supply

chain orientation, supply chain resilience cannot be ensured. More specifically, enhancement of supply chain orientation in the form of top management support, and improving trust, cooperation and commitment among supply chain partners leads to sharing and reduction of risk arising from supply chain vulnerabilities. This finding is supported by Kleindorfer and Saad (2005), Jüttner (2005) and Jüttner and Maklan (2011). Thus, the findings of this study emphasise the importance of supply chain orientation (SCO) in terms of top management support as well as trust, cooperation and commitment among the supply chain partners as a prerequisite for overcoming supply chain vulnerabilities and for developing supply chain resilience.

The field study results also prove that supply chain orientation is an important enabler for developing supply chain resilience and for reducing vulnerabilities existing in the apparel supply chain of Bangladesh. Results from the field study revealed that the apparel supply chain members had a good relationship with each other based on trust, cooperation and adherence to commitment. When the apparel manufacturers face any unavoidable disruptions, the manufacturers inform the buyers about the disruptions and possible consequence of the disruptions. In that case, the trust and cooperation among the buyers, manufacturers and suppliers help to share the risk among the supply chain partners. Therefore, companies need to place more emphasis on supply chain orientation by improving trust, cooperation and commitment, and by building long-term value-based relationships with supply chain partners to overcome supply chain vulnerabilities.

Hypothesis H3: Learning and development (L&D) positively influences on supply chain resilience (SCR).

The hypothesized relationship between learning and development (L&D) and supply chain resilience is supported by the findings of the analysis. The coefficient of association between L&D and SCR (β=0.437) and the corresponding *t*-value (*t*=5.639) imply that there is a significant positive relationship between L&D and SCR. It also stipulates the positive role of L&D on SCR which suggests that L&D helps to achieve and enhance SCR. In other words, an increase in L&D in terms of an increase in training, opportunity for improvement, research and development (R&D), and learning from past experience enables a firm and its supply chain to increase adaptive capacity, reduce risk and increase resilience. This finding is also supported by the studies of Berkes (2007), Ritchie and Brindley (2007), Manuj and Mentzer (2008) and Comfort (1994). Thus, the findings of this study emphasise the importance of learning and development as an enabler of supply chain resilience.

The field study results also affirm that learning and development are a prerequisite for enhancing supply chain resilience and for reducing vulnerabilities existing in the apparel supply chain of Bangladesh. It was found that previous experience and learning from vulnerabilities help supply chain members to be aware about risk and to take corrective actions. For example, apparel manufacturers and their suppliers have learnt from the previous industrial accidents (fire, building collapse, and others): as a result, some of them have already taken preventive measures to avoid such accidents. It was also found that the apparel manufacturers and their association, the BGMEA, arrange skill development training programs as they have realized the importance of learning and development for being competitive and resilient. From the findings, it can be asserted that the apparel supply chain managers should concentrate on developing a learning culture and development initiatives in their organizations to be more resilient in future.

Hypothesis H4: Supportive environmental factors positively influences on supply chain resilience.

The findings of this study corroborated that there is a positive relationship between supply chain resilience and supportive environmental factors. The study result also documented the association between SF and SCR (β=0.053 and *t*=2.203) which proves that SF is one of the antecedents for developing supply chain resilience. It suggests that the enrichment of supportive environmental factors in the form of government support, factor endowment, international trade support and institutional facilitating services help to create a strong fortification against vulnerabilities. This finding is supported by previous studies (Narrod et al. 2009; Rich and Narrod 2005; Roth et al. 2008; Manuj and Mentzer 2008). Thus, the findings of this study reiterate the importance of supportive environmental factors to improve supply chain resilience to overcome supply chain vulnerabilities.

The field study results also support the view that supportive environmental factors help supply chains to be more resilient and to reduce the impact of vulnerabilities in the context of the apparel supply chain of Bangladesh. Most of the participants emphasised the positive role of a supportive international trade environment and support from the government of their home country and other facilitating factors for gaining a competitive edge in the market. This finding is supported by practical observations as well. It was found that the Government of Bangladesh provides different supports such as a duty drawback facility, cash incentives and others (Haider 2006) which help the apparel supply chain members to be more competitive in the

international markets. However, political instability and bureaucratic processes are deterrents to the supply chain functions (Nuruzzaman, Chowdhury, and Quaddus 2013). In this case, the government should play an active role to keep a favourable political environment and to reduce long bureaucratic processes. It was also found that the apparel supply chain members have a Generalized System of Preferences (GSP) facility and duty-free access in different markets of the world (Haider 2007) which help them to be more competitive and resistant to the vulnerabilities arising out of intensive competition. Along with these supports, the BGMEA is also playing a supportive role by arranging exhibitions and trade fairs, training programs, awareness programs, lobbying with government, and other activities. If the government and the trade bodies extend more support to the apparel manufacturers and suppliers, the industry will perform better.

Hypothesis H5: Supply chain risk management (SCRM) positively influences on supply chain resilience (SCR).

It is proved that there is a positive relationship between supply chain risk management and supply chain resilience. The coefficient of association between SCRM and SCR (β=0.293) and the corresponding *t*-value (*t*=6.5736) imply that there is a significant positive relationship between SCRM and SCR. It also specifies that concentration on SCRM is a precondition for developing SCR, which suggests that SCRM helps to enhance SCR. In other words, an increase in SCRM in terms of an increase in risk sharing initiatives, risk reducing efforts, knowledge about risk and consideration of risk in decision making enables the firms and their supply chains to increase the resilience capability of the supply chains (Jüttner and Maklan 2011; Sheffi and Rice 2005; Rao and Goldsby 2009). It is also argued that risk management initiatives such as acquiring knowledge about supply chain risks help to create necessary preparedness in the supply chain which in turn helps the supply chains to be resilient (Manuj and Mentzer 2008).

The field study results also confirmed that SCRM is an antecedent for enhancing supply chain resilience and for reducing vulnerabilities existing in the apparel supply chain of Bangladesh. The field study participants placed emphasis on risk sharing initiatives with supply chain members, for example, joint production planning, partial shipment and partial payment options. They also expressed their awareness about risk consequences in decision making. In practice, it was found that the apparel supply chain members consider risk in decision making: for example, if possible, they try to source raw material from a local source to avoid the risk of delay in international

sourcing. The supply chain members also collect information to increase knowledge about risk in national and international markets. For example, the fabric manufacturers predicted the crisis in the cotton supply when a massive flood in Pakistan affected the cotton production: as a result, they planned alternative sources of supply. These risk management initiatives enable the supply chain to be resilient to uncertainties. Therefore, the apparel supply chain managers should take risk management initiatives and develop a risk management culture to handle the risks existing in the industry.

Hypothesis H6: Supply chain orientation (SCO) positively influences on Supply chain risk management (SCRM).

The findings of this study supported that there is a positive relationship between supply chain orientation and supply chain risk management. The study's results documented a significant association between SCO and SCRM (β=0.807 and *t*=40.7114) which provides evidence in favour of the relationship between SCO and SCRM. It can be interpreted that more supply chain orientation results in increased supply chain risk management effort. More specifically, supply chain orientation activities such as building trust, cooperation and commitment, and top management support for supply chain initiatives are favourable to supply chains' risk management and mitigation as supported by previous studies (Jüttner 2005; Min and Mentzer 2004; Faisal, Banwet, and Shankar 2006; Kleindorfer and Saad 2005).

The field study results also echo the necessity of SCO for SCRM initiatives in the context of the apparel supply chain of Bangladesh. The participants emphasised the positive role of supply chain orientation for risk management initiatives among the supply chain partners. In practical terms, it was found that mutual trust, cooperation and commitment among the supply chain members help them to share risks and reduce risks arising from fluctuation of raw material price and currency rate, and delay in shipment. Therefore, the apparel supply chain managers should enhance the efforts towards supply chain orientation in order to manage risk prudently.

Hypothesis H7: **S**upply chain risk management (SCRM) negatively influences on supply chain vulnerability (SCV).

The findings of this study reject the hypothesis regarding a negative relationship between supply chain risk management and supply chain vulnerability as the coefficient of association between SCRM and SCV is positive (β=0.114). From this finding, it can be interpreted that supply chain risk management efforts do not have implications in reducing SCV. The literature (Jüttner and Maklan 2011; Pettit, Fiksel,

and Croxton 2010; Ellegaard 2008) support the view that SCRM initiatives such as risk sharing and risk management knowledge help to achieve readiness in the event of disruptions to reduce the probability of occurrences of risk and to reduce the impact of risk. The findings of this study do not conform to the hypothesized relationship between SCRM and SCV. However, it was evidenced that the direct relationship between SCRM and SCV is positive and significant when the link between SCRM and SCV is tested separately (see Table 6.25 on page 199). On the other hand, when the whole model is run together, the relationship becomes irrelevant as the mediating variable (SCR) has a suppressor effect on the direct relationship (Hensler 2009) between SCRM and SCV. Moreover, SCR explains most of the variances with SCV. The mediation test also proves that there is a full mediation of SCR, in the relationship between SCRM and SCV.

Hypothesis H16**:** SCR mediates the relationship between SCRM and SCV.

The findings of the study investigated and confirmed the mediating role of SCR between SCRM-SCR and SCR-SCV. The findings affirmed that without any mediation, the direct effect between SCRM and SCV is significant (t=19.13). It also affirmed that the indirect effect of SCR on SCV is significant (z=9.16, p=.01) and explained about 119% (VAF= 1.19) of the total effect between SCRM and SCV (see Table 6.25 on page 199 and Figure 6.10 on page 200). In addition, it is observed that the direct effect between SCRM and SCV becomes insignificant (t=1.16) when the mediation effect is considered. Therefore, a full mediating role of SCR was found between the links SCRM-SCR and SCR-SCV with reference to Baron and Kenney (1986). This type of indirect relationship between SCRM and SCV via SCR is also supported by the literature with reference to Jüttner and Maklan (2011).

Hypothesis H17: SCRM mediates the relationship between SCO and SCR.

The findings of the study investigated and confirmed the mediating role of SCRM between SCO-SCRM and SCRM-SCR. The findings affirmed that without any mediation, the direct effect between SCO and SCR is significant (t=43.91, p=.01). It is also affirmed that the indirect effect of SCO on SCR is significant (z=11.4, p=.01) and explained about 57.2% of the total effect between SCO and SCR (see Table 6.25 on page 199, Figure 6.11 on Page 200). In addition, it is observed that the direct effect between SCO and SCR is significant (t=7.1) when the mediation effect is considered. Therefore, a partial mediating role of SCRM was found between the links SCO-SCRM and SCRM-SCR with reference to Baron and Kenney (1986).

7.2.3 The relationships associated with SCR and sustainability

This study attempted to investigate the relationships between supply chain resilience and supply chain sustainability components, namely: social sustainability, environmental sustainability, economic sustainability and operational sustainability. It also assessed the interrelationships among the sustainability components. The associations among the variables have been examined with respect to testing hypotheses *H8, H9, H10, H11, H12, H13, H14* and *H15* which fulfil the research objective 5. The outcome of hypotheses test results are discussed below:

Hypothesis H8: Supply chain resilience (SCR) positively influences on social sustainability (SCS).

The findings of this study revealed that there is significant statistical proof to support a positive relationship between supply chain resilience and supply chain sustainability. The analysis of findings extracts a significant association between SCR and the outcome construct SCS (β=0.574, *t*=13.4). It proves that SCR helps to achieve social sustainability in the supply chain. More specifically, it contends that an increase in supply chain resilience will enhance supply chain sustainability and reduce the risks arising from non-compliance of social sustainability issues. Previous studies also support the need for proactive actions towards social issues such as responsible treatment of workers, customers and the environment to reduce risk arising from social issues (Seeger 1997; Hearit 1997). Such resilient approaches can ensure social sustainability in the supply chain (Fiksel 2006). Therefore, the finding of this study is relevant with reference to the previous studies.

The field study result also supported the association between supply chain resilience and social sustainability in the supply chain in the context of the apparel supply chain of Bangladesh. This finding was reinforced by the practical operation of the apparel supply chain. It was observed that the apparel manufacturers who take a proactive and resilient approach in terms of providing better wages and benefits, taking precautions for health and safety issues, and addressing other social sustainability factors do not have the significant problems of labour unrest, dissatisfaction, turnover and other related risks. It was also evidenced that buyers, the government and other relevant stakeholders focus attention on the compliance of social issues to avoid risks associated with those issues. The findings infer that apparel supply chain managers should take proactive actions to reduce the chances of risks arising from social sustainability issues and to improve social sustainability performance.

Hypothesis H9: Supply chain resilience (SCR) positively influences on environmental sustainability (ENS).

It was evidenced from the findings of this study that there is a positive relationship between supply chain resilience and environmental sustainability. The coefficient of association between SCR and ENS (β=0.535) and the corresponding *t*-value (*t*=12.1594) infer that there is a significant positive relationship between SCRM and SCR. It also identifies that SCR has an impact on achieving environmental sustainability. In other words, an increase in SCR by developing supply chain capability in terms of efficiency development, waste management and controlling defects helps to achieve competitiveness as well as reducing environmental impact. In a similar fashion, selecting environmentally responsible suppliers, taking a proactive approach and having the readiness to avoid risk arising from environmental issues enable the firms and their supply chains to achieve environmental sustainability (Foerstl et al. 2010).

The field study results also affirmed that SCR has an influence on achieving the environmental sustainability of the supply chain. The field study participants emphasised taking proactive approaches towards the environmental sustainability requirements of the buyers to avoid risk arising from non-compliance of environmental issues. It was found that the apparel manufacturers and their suppliers are aware about environmental issues and are gradually implementing environment-friendly practices such as waste recycling, effluent treatment planning, adaption of efficient technology and others which help them to be more competitive in the market as well as to be more environmentally sustainable. The findings also infer that proactive actions towards environmental issues help to reduce risk arising from environmental issues and to improve environmental sustainability performance. Therefore, the supply chain managers need to develop capabilities to enhance environmental sustainability performance and to gain a competitive edge in the market.

Hypothesis H10: Supply chain resilience (SCR) positively influences on economic sustainability (ECS).

The findings of this study produced substantial evidence to accept the hypothesized relationship between supply chain resilience and economic sustainability. It revealed that there is a significant association between SCR and ECS (β=0.815, *t*=5.0781). This implies that SCR has a significant positive role to achieve economic sustainability in the supply chain. It can be explained that supply chain resilience plays an important role to reduce financial/economic vulnerabilities arising from competition, currency

fluctuation, price fluctuation etc. which is also supported by Pettit, Croxton and Fiksel (2013) and others. Thus, resilience capability helps to enhance economic sustainability which is reflected by meeting expected lead time, quality standard and specification.

The field study results also supported the association between supply chain resilience and economic sustainability in the supply chain. The field study participants emphasised resilience capabilities such as flexibility, efficiency and financial strength to obtain competitiveness and to overcome economic crisis in the supply chain. In practice, it was found that the ability to produce at a cheaper cost, having flexible payment and delivery options, and the efficiency of employees helped the supply chain members to run their business and hold their market position even at times of global economic crisis. It was evident that strong relationships as well as satisfaction of the buyers help the apparel manufacturers to share risk arising from raw material price fluctuation and currency fluctuation. Therefore, the apparel manufacturers and their suppliers should develop resilience capabilities to ensure economic sustainability in the chain.

Hypothesis H11: Supply chain resilience (SCR) positively influences on operational sustainability (OPS).

The findings of this study supported the hypothesis that there is a positive relationship between supply chain resilience and operational sustainability. The study's results reported a significant association between SCR and the outcome construct OPS (β=0.181 and t=5.0781) which provides evidence in favour of the relationship between SCR and operational sustainability of the supply chain. It can be interpreted that supply chains that emphasise risk management activities and resilience development can mitigate operational problems arising from utility supply disruptions, poor quality, supply problem, logistical disruptions, IT system failure and others (Pettit, Croxton, and Fiksel 2013; Blos et al. 2009). Thus, resilient supply chains are able to obtain operational sustainability in terms of meeting expected lead time, quality standard and technical specifications.

This finding was also consistent with the field study results in which it was affirmed that SCR has an impact on operational sustainability. It was observed that the apparel supply chain is exposed to operational disruptions such as utility shortage, machinery and IT system failure, and switching and absenteeism of employees. If supply chains do not have resilience towards these operational disruptions, smooth production cannot be ensured. If production operation is not smooth, it is not possible to finish production and delivery at the due time. Furthermore, the quality of products and specifications

cannot be maintained according to expectations. Therefore, it can be deduced from the field study, survey findings and the industry practice that supply chain resilience is required to achieve operational sustainability in the supply chain.

Hypothesis H12: Economic sustainability (ECS) positively influences social sustainability (SCS).

The survey findings produced significant evidence regarding the positive relationship between economic sustainability and social sustainability in the supply chain. It appeared that the coefficient of association between ECS and SCS (β=0.319) and the corresponding *t*-value (*t*=12.1594) are significant thus implying that economic sustainability leads to social sustainability of the supply chain. More specifically, it can be argued that progress towards ECS in terms of achieving the sales target, keeping the cost of production lower and ensuring more profitability and sales growth opens the door for a contribution to society through employment generation, human development and other social goods. Previous studies (Doane and MacGillivray 2001; Quaddus and Siddique 2001; Zadek, Simon, and Tuppen 2000; and others) have also drawn a similar conclusion that without achieving economic sustainability, social sustainability cannot be ensured.

The field study findings also drew a similar conclusion that social sustainability depends on economic sustainability. Most participants indicated that they need good profitability to be able to spend for social issues. In practice, it was evident that financially weak companies cannot provide good wages, facilities and benefits while economically stable and larger firms can provide better wages, benefits and ensure health and safety issues. It was also found that economically sick companies often cannot provide wages to workers in due time which in turn creates unrest among the workers. Therefore, sufficient sales and profitability are important to ensure regular pay to the workers and to maintain other social goods. It also posits the importance of improving the efficiency of operation to reduce cost and to increase economic performance.

Hypothesis H13: Economic sustainability (ECS) positively influences environmental sustainability (ENS).

The findings of this study contended that there is significant statistical proof in favour of the positive relationship between the economic sustainability and environmental sustainability of a supply chain. The analysis of findings extracted a significant association between ECS and ENS (β=0.324, *t*=4.728). It proves that ensuring ECS is

essential for obtaining environmental sustainability in the supply chain. It postulates that progress towards economic sustainability in terms of enough sales volume, lower cost of production, more profitability and sales growth creates opportunities for investment in environmental compliance issues. This relationship is consistent with the findings of previous studies (Roseland 2000; Quaddus and Siddique 2001; Doane and MacGillivray 2001; Zadek, Simon, and Tuppen 2000)

The field study results also supported the association between economic sustainability and environmental sustainability. The participants emphasised their economic factors and indicated that it was not possible for them to concentrate on environmental issues without ensuring economic stability. They also sought economic incentives for developing environmental factors such as pollution control, recycling of waste, effluent treatment and others. In practical terms, it was evident that economically sustainable and larger companies have options for environment-friendly production and processing while most of the small companies have not made attempts towards addressing environmental issues. It was also observed that some branded buyers provide economic incentives and premium price to the companies with environmental consciousness. Buyers also evaluate and inspect the manufacturers' plants from time to time to ensure that the have complied with environmental factors. Therefore, the research findings imply that stakeholders, and specifically the buyers, should set the price of products in a way that helps to cover the cost of environmental quality development.

Hypothesis H14: Economic sustainability (ECS) positively influences operational sustainability (OPS).

It was verified from the findings of this study that there is a positive relationship between economic sustainability and operational sustainability of the supply chain as the coefficient of association between ECS and OPS (β=0.198) and the corresponding t value (*t*=3.1113) are significant. It can be inferred that growth in ECS factors creates the scope for operational development by installing efficient and updated technologies, attracting skilled employees, improving quality standard and others. This finding is also consistent with the previous studies (Blackburn and Rosen 1993; de Brito, Carbone, and Blanquart 2008).

The relationship between economic sustainability and operational sustainability is also reinforced by the field study results. It was found that field study participants placed emphasis on economic strength to implement operational sustainability factors. According to them, operational improvements are not possible without investment in

new technology, human development and other operational excellence factors. In practice, it was observed that high-growth companies routinely replace less efficient and old machinery: they also invest in training and development as well as paying good wages to skilled workers to minimise operational disruptions and to ensure that the operations shall continue smoothly. The other companies should set the benchmark and follow the industry leader in this regard.

Hypothesis H15: Social sustainability (SCS) positively influences on operational sustainability (OPS).

The findings of this study accepted the hypothesis regarding a positive relationship between social sustainability and operational sustainability as there is statistical evidence in favour of the hypothesized relationship. It was revealed that the coefficient of association between SCS and OPS is significant (β=0.533 and *t*=6.2372). From this finding, it can be interpreted that social sustainability issues have substantial implications on achieving operational sustainability in the supply chain. The literature supports that activities such as training, good compensation and advancement opportunities are related to organizational effectiveness such as quality, customer satisfaction, productivity, reduced absenteeism and other operational improvements (Delaney and Huselid 1996; Huselid 1995; Katz, Kochan, and Weber 1985). On the other hand, adversarial labour relation practices have a negative impact on the operations (Huselid 1995). This study also statistically proved similar findings.

The positive relationship between social sustainability and operational sustainability was also iterated by the field study participants. In practice, it was found that operational disruptions often occur in factories that do not have good working conditions and employee satisfaction. As a result, those companies often fail to finish production in time. They also face quality-related problems and sometimes buyers reject the shipment owing to non-conformance of quality. On the contrary, companies with a good working environment and positive social factors have less operational disruptions. They also achieve recognition, for example, awards, certification, etc. from the buyers due to their good performance in social sustainability factors. Therefore, companies that are lagging behind in social sustainability performance should take initiatives for improving social sustainability issues to reduce operational disruptions and to affirm operational sustainability in the long run.

Hypothesis H18: ECS mediates the relationship between SCR and SCS.

The findings of the study investigated and confirmed the mediating role of ECS between SCR-ECS and ECS-SCS. The findings affirmed that without any mediation, the direct effect between SCS and SCR is significant (t=73.1, p=.01). It was also affirmed that the indirect effect of SCS on SCR is significant (z=5.9, p=.01) and that it explained about 28.4% of the total effect between SCS and SCR (see Table 6.25 on page 199). In addition, it was observed that the direct effect between SCS and SCR is significant (t=12.6, p=.01) when the mediation effect is considered. Therefore, a partial mediating role of ECS was found between the SCR-ECS and ECS-SCS link, with reference to Baron and Kenney (1986).

Hypothesis H19: ECS mediates the relationship between SCR and ENS.

The findings of the study investigated and confirmed the mediating role of ECS between SCR-ECS and ECS-ENS. The findings affirmed that without any mediation, the direct effect between SCR and ENS is significant (t=57.5, p=.01). It was also affirmed that the indirect effect of SCR on ENS is significant (z=4.59, p=.01) and that it explained about 30.2% of the total effect between SCR and ENS (see Table 6.25 on page 199). In addition, it was observed that the direct effect between SCR and ENS is significant (t=9.1, p=.01) when the mediation effect is considered. Therefore, a partial mediating role of ECS was found between the SCR-ECS and ECS-ENS link, with reference to Baron and Kenney (1986).

Hypothesis H20: ECS mediates the relationship between SCR and OPS.

The findings of the study investigated and confirmed the mediating role of ECS between SCR-ECS and ECS-OPS. The findings affirmed that without any mediation, the direct effect between SCR and OPS is significant (t=59.95, p=.01). It was also affirmed that the indirect effect of SCR on OPS is significant (z=6.54, p=.01) and that it explained about 35.6% of the total effect between SCR and OPS (see Table 6.25 on page 199). In addition, it was observed that the direct effect between SCR and OPS is significant (t=9.1, p=.01) when the mediation effect is considered. Therefore, a partial mediating role of ECS was found between the SCR-ECS and ECS-OPS link, with reference to Baron and Kenney (1986).

Hypothesis H21: SCS mediates the relationship between ECS and OPS.

The findings of the study investigated and confirmed the mediating role of SCS between ECS-SCS and SCS-OPS. The findings affirmed that without any mediation, the direct

effect between ECS and OPS is significant (t=35.14, p=.01). It was also affirmed that the indirect effect of ECS on OPS is significant (z=14.8, p=.01) and that it explained about 67% of the total effect between ECS and OPS (see Table 6.25 on page 199). In addition, it was observed that the direct effect between ECS and OPS is significant (t=5.9, p=.01) when the mediation effect is considered. Therefore, a partial mediating role of ECS was found between the ECS-SCS and SCS-OPS link, with reference to Baron and Kenney (1986).

7.3 IMPACT OF CONTROL VARIABLES

The findings of the study examined the impact of control variables on the two major endogeneous constructs. Firstly, it examined the effects of control variables only on supply chain resilience, and the effects of control variables were then considered on both resilience and sustainability factors. In both cases, the impact was considered on three conditions: i) the impact of control variables was considered separately based on SIZE (size), EXP (experience) and SCENT (supply chain entity); ii) the impact was considered pair-wise (SIZE-EXP or EXP-SCENT or SIZE-SCENT); and iii) the impact of control variables (SIZE-EXP-SCENT) was considered altogether. Tables 6.26 and 6.27 (page 204) show the detailed information about the impact of control variables.

Firstly, the impact of control variables was tested on SCR (see Table 6.26, page 204). It was found that the impact of SIZE was not significant (β=.023, t=.67) in condition i) but it was significant (β=.04, t=2.1) in condition ii) when a simultaneous impact of SIZE and EXP was controlled and in condition iii) when simultaneous impact of SIZE-EXP-SCENT was controlled for ((β=.041, t=2.2). However, the impact of EXP and SCENT was found to be significant in all three conditions.

Secondly, the impact of control variables was tested on both SCR and sustainability factors (see Table 6.27, page 204). It was found that the impact of SIZE was significant: on SCR in condition ii) (simultaneous impact of SIZE-EXP) and iii) (simultaneous impact of SIZE-EXP-SCENT); on SCS in condition iii); significant on ENS in condition ii) (simultaneous impact of SIZE-SCENT) and iii); and not significant on OPS and ECS in all three conditions because of negative path coffecient.

The impact of EXP was found significant on SCR in all three conditions; significant on SCS in condition i) and iii); significant on ENS only in condition iii); insignificant on OPS in all three conditions; and significant on ECS in all conditions except condition i).

The impact of SCENT was found significant on SCR in all three conditions; significant on SCS only in condition iii); significant on ENS in all three conditions; significant on OPS in all three conditions; and insignificant on ECS in all conditions.

Finally, it appears that size does not always significantly contribute to resilience: rather, experience and supply chain entity are important variables influencing the resilience of apparel supply chain in Bangladesh. Further, the impact of size is not significant on operational and economic sustainability. The experience of the supply chain members has influence on resilience and social sustainability while it does not have substantial influence on other sustainability factors. Similarly, type of supply chain entity has significant influence on resilience, environmental sustainability and operational sustainability.

7.4 FINDINGS IN THE LIGHT OF RESEARCH OBJECTIVES

This section discusses findings in the light of research objectives. Research objective-1, addresses identification and measurement of the dimensions of supply chain vulnerability (SCV) while research objective-2, corresponds to identification and measurement of the dimensions of supply chain resilience (SCR). Research objective-3, examines the relationships between supply chain resilience and supply chain vulnerability in the context of the apparel industry of Bangladesh. Then, research objective-4, addresses the relationships associated with SCR and its antecedent factors in the context of the apparel industry of Bangladesh. Followed by this, research objective-5, investigates the relationship between SCR and sustainability in the context of the apparel industry of Bangladesh. It is worh mentioning that in section 7.2, under the sub-sections 7.2.1; 7.2.2 and 7.2.3, the hypothesised relationships in the model are discussed which address the research objectives 3, 4 and 5 respectively. Therefore, in this section research objective 1 and 2 are discussed in detail.

7.4.1 Research Objective 1: To identify and to measure the dimensions of SCV

In conjunction with Research objective 1, this study attempted to develop the multidimensional and hierarchical measurement construct "supply chain vulnerability". Based on theoretical conceptualization and the field study findings, the hierarchical construct SCV was operationalized as the formative lower-order and formative higher-order mode. A two-stage approach (Ringle, Sarstedt, and Straub 2012; Wetzels, Odekerken-Schroder, and Van Oppen 2009; Becker, Klein, and Wetzels

2012) was used in estimating the higher-order construct as it is effective for developing a complex but parsimonious model.

The study posited that supply chain vulnerability (SCV) is a second-order hierarchical construct which is comprised of six first-order dimensions (i.e. hazard vulnerability, strategic vulnerability, operational vulnerability, financial vulnerability, infrastructural vulnerability and demand–supply vulnerability). The findings affirmed that infrastructural vulnerability has the highest absolute importance (.4406) with respect to supply chain vulnerability, followed by strategic vulnerability (.3818) and operational vulnerability (.3667) (see Table 6.19 on page 192). In the following sections, the associations between SCV and its dimensions are discussed with empirical and theoretical insights.

Hazard vulnerability

The empirical findings (Table 6.19 on page 192) confirmed that the absolute importance of hazard vulnerability (HV) is 24.78% which is significant (t=1.72, p=*.10*) in forming the construct SCV. In the supply chain vulnerability literature, a number of studies (e.g. Pettit, Croxton, and Fiksel 2013; Blos et al. 2009; and others) contend that hazard vulnerability is one of the dimensions of supply chain vulnerability. Therefore, this study's results are consistent with the findings of previous studies in supply chain risk management literature. From the findings, it can be deduced that HV, which is comprised of natural disaster, accidental damage, political instability and labour unrest, is one of the important components of SCV. The findings of the study have also provided strong evidence regarding the importance of the formative measurement items of the dimension: hazard vulnerability. It was revealed that all the items are significant either based on their weight or loading (see Table 6.17 on page 191) to form the construct HV with reference to Hair, Ringle and Sarstedt (2011). In addition, following the guidelines of assessing a formative measurement construct (Hair, Ringle, and Sarstedt 2011), it was evident that the multi-collinearity problem does not exist among the items of the dimension: HV as the VIF values for all items are below 5 (see Table 6.18 on page 192). Therefore, the measurement of hazard vulnerability is valid in terms of all the formative items used for its measurement.

Strategic vulnerability

The empirical findings (Table 6.19 on page 192) confirmed that the absolute importance of strategic vulnerability (SV) is 38.18% which was significant (t=2.4, p=*.10*) in forming the construct SCV. In the supply chain vulnerability (SCV) literature, a

number of studies emphasised the impact of strategic vulnerability on the supply chain in terms of: increased competition (Haider 2007; Schoenherr, Rao Tummala, and Harrison 2008; Blos et al. 2009); non-compliance of social and environmental factors (Islam and Deegan 2008); relationships with buyer and supplier (Pettit, Croxton, and Fiksel 2013; Blos et al. 2009); and integration and real-time information (Gaudenzi and Borghesi 2006). Therefore, this study's results are consistent with the findings of previous studies in the supply chain risk management literature. From the findings, it can be deduced that SV is one of the important components of SCV. The findings of the study also provided strong evidence regarding the importance of the formative measurement items under the dimension: strategic vulnerability. It was revealed that all the items are significant either based on their weight or loading (see Table 6.17 on page 191) to form the construct SV, with reference to Hair, Ringle and Sarstedt (2011). Moreover, following the guidelines of assessing a formative measurement construct (Hair, Ringle, and Sarstedt 2011), it was evident that the multi-collinearity problem does not exist among the items of the dimension SV as the VIF values for all items are below 5 (see Table 6.18 on page 192). Therefore, the measurement of strategic vulnerability is valid in terms of all formative items used for its measurement.

Financial vulnerability

The empirical findings (Table 6.19 on page 192) confirmed that the absolute importance of strategic vulnerability is 27.28% which is significant (t=1.73, p=.10) in forming the construct SCV. In the supply chain vulnerability literature, a number of studies (Pettit, Croxton, and Fiksel 2013; Blos et al. 2009; Peck 2005; Blackhurst, Scheibe, and Johnson 2008; Manuj and Mentzer 2008; and others) emphasised the impact of financial vulnerability (FV) on the supply chain in terms of: currency fluctuation, economic recession, raw material price fluctuation, funds availability and bankruptcy. Therefore, this study's results are consistent with the findings of previous studies in the supply chain risk management literature. From the findings, it can be deduced that FV is one of the important components of SCV. The findings of the study also provided strong evidence regarding the importance of the formative measurement items of the dimension: financial vulnerability. It was revealed that all the items are significant either based on their weight or loading (see Table 6.17 on page 191) to form the construct FV, with reference to Hair, Ringle and Sarstedt (2011). Furthermore, with reference to the guidelines of assessing a formative measurement construct (Hair, Ringle, and Sarstedt 2011), it was evident that the multi-collinearity problem does not exist among the items of the dimension FV as the VIF values for all items are below 5

(see Table 6.18 on page 192). Therefore, the measurement of financial vulnerability is valid in terms of all formative items used for its measurement.

Operational vulnerability

The empirical findings (Table 6.19 on page 192) confirmed that the absolute importance of strategic vulnerability is 36.67% which is significant (*t*=2.17, p=.10) in forming the construct SCV. In the supply chain vulnerability literature, a number of studies (Pettit, Croxton, and Fiksel 2013; Blos et al. 2009; Wu, Blackhurst and Chidambaram 2006) emphasised the impact of operational vulnerability (OV) on the supply chain in terms of: shortage of skilled workers; switching and absenteeism of workers; production planning and inventory management; failure of IT system and machinery; disruption in utility supply; product quality defects; and illiteracy of workers and supervisors. Therefore, this study's results are consistent with the findings of previous studies in the supply chain risk management literature. From the findings, it can be deduced that OV is one of the important components of SCV. The findings of the study also provided strong evidence regarding the importance of the formative measurement items of the dimension: operational vulnerability. It was revealed that all the items are significant either based on their weight or loading (see Table 6.17 on page 191) to form the construct OV, with reference to Hair, Ringle and Sarstedt (2011). In addition, following the guidelines of assessing a formative measurement construct (Hair, Ringle, and Sarstedt 2011), it was evident that the multi-collinearity problem does not exist among the measurement items of OV as the VIF values for all items are below 5 (see Table 6.18 on page 192). Therefore, the measurement of operational vulnerability is valid in terms of all formative items used for its measurement.

Infrastructural vulnerability

The empirical findings (Table 6.19 on page 192) confirmed that the absolute importance of infrastructural vulnerability (IV) is 44.06% which is significant (*t*=3.25, *p=.10*) in forming the construct SCV. In the literature, a number of studies (Colicchia, Dallaria, and Melacini 2010; Blackhurst, Scheibe, and Johnson 2008; Pettit, Croxton, and Fiksel 2013) emphasised the impact of infrastructural vulnerability on the supply chain in terms of: delay in customs clearance and documentation; inefficiency in port management; and delay in land transportation. Therefore, this study's results are consistent with the findings of previous studies in the supply chain risk management literature. From the findings, it can be deduced that IV, which is comprised of delay in

custom clearance, inefficiency in port, delay in transportation, is one of the important components of SCV. The findings of the study also provided strong evidence regarding the importance of the formative measurement items of the dimension: infrastructural vulnerability. It was revealed that all the items are significant either based on their weight or loading (see Table 6.17 on page 191) to form the construct IV, with reference to Hair, Ringle and Sarstedt (2011). Following the guidelines of assessing a formative measurement construct (Hair, Ringle, and Sarstedt 2011), it was evident that the multi-collinearity problem does not exist among the items of the dimension IV as the VIF values for all items are below 5 (see Table 6.18 on page 192). Therefore, the measurement of infrastructural vulnerability is valid in terms of all formative items used for its measurement.

Demand–supply vulnerability

The empirical findings (Table 6.19 on page 192) confirmed that the absolute importance of strategic vulnerability is 10.14% which is not significant (t= 0.63, p=.10). However, demand–supply vulnerability (DSV) is significant in terms of its loading with SCV. Therefore, with reference to Hair, Ringle and Sarstedt (2011), DSV has relevance in forming the construct SCV. In the supply chain vulnerability literature, a number of studies (Pettit, Croxton, and Fiksel 2013; Blackhurst, Scheibe, and Johnson 2008; Ponomarov and Holcomb 2009) emphasised the impact of demand–supply vulnerability on the supply chain in terms of: suppliers' disruptions; dependence on imported material; non-conformity of material; buyers' disruptions; and demand fluctuation. Therefore, this study's results are consistent with the findings of previous studies in the supply chain risk management literature. From the findings, it can be deduced that DSV is one of the important components of SCV. The findings of the study also provided strong evidence regarding the importance of the formative measurement items of the dimension: demand–supply vulnerability. It was revealed that all the items are significant either based on their weight or loading (see Table 6.17 on page 191) to form the construct DSV, with reference to Hair, Ringle and Sarstedt (2011). Following the guidelines of assessing a formative measurement construct (Hair, Ringle, and Sarstedt 2011), it was evident that the multi-collinearity problem does not exist among the items of the dimension DSV as the VIF values for all items are below 5 (see Table 6.18 on page 192). Therefore, the measurement of demand–supply vulnerability is valid in terms of all formative items used for its measurement.

Nomological validity of the construct SCV

The nomological validity of the multidimensional construct SCV was tested by examining the impact of (direct effect) of the antecedent construct: supply chain risk management (SCRM) on the dimensions of SCV (Edwards 2001; MacKenzie, Podsakoff, and Podsakoff 2011). The results showed that the direct effect of the antecedent construct (SCRM) on the formative dimensions of SCV is nearly same (see Table 6.22 on page 196) for all dimensions except in the case of infrastructural vulnerability. However, based on theoretical relevance and field study support, this research retains infrastructural vulnerability as one of the dimensions of supply chain vulnerability. Therefore, based on the adequacy of the multidimensional structure suggested by Mackenzie (2012) and Edwards (2001), it can be inferred that the dimensions of the multidimensional construct SCV are valid.

7.4.2 Research Objective 2: To determine and to measure the dimensions of SCR

Corresponding to Research objective 2, this study endeavoured to develop and validate the multidimensional and hierarchical construct: supply chain resilience. Theoretical conceptualization and field study findings supported the operationalization of the construct SCR as the reflective lower-order and reflective higher-order mode. As mentioned, this study used the two-stage approach (Ringle, Sarstedt, and Straub 2012; Becker, Klein, and Wetzels 2012) in estimating the higher-order constructs; therefore, the same approach is also followed to measure and to validate the dimensions of SCR with adequate measurement and structural properties.

Previous studies contend that SCR is a multidimensional construct (Erol, Sauser, and Mansouri 2010; Pettit, Croxton, and Fiksel 2013; Christopher and Peck 2004). This study also affirms that SCR is a higher-order construct which is adequately reflected by the lower-order dimensions: supply chain capability (CAP), supply chain design (SCD), supply chain readiness (RED) and supply chain response–recovery (RR). The findings corroborated that supply chain response-recovery (R^2=.910) had the highest reflection of supply chain resilience, followed by supply chain readiness (R^2=.898), supply chain capability (R^2=.896) and supply chain design (R^2=.839) (see Figure 6.8 on page 194). In the following sections, the relationship between supply chain resilience and its dimensions are discussed with their empirical and theoretical insights.

Supply chain capability

The empirical findings confirmed the role of supply chain capability as a significant dimension of supply chain resilience to mitigate the vulnerabilities arising from supply chain disruptions which is consistent with previous studies on supply chain resilience (Christopher and Peck 2004; Pettit, Fiksel, and Croxton 2013; Erol, Sauser, and Mansouri 2010). An assessment of the association indicates that SCR had a significant association with the dimension: supply chain capability (β=0.947, *t*=54.92) and it explains 89.6% of overall variance (R^2) in supply chain resilience (see Figures 6.7 and 6.8 on page 194): thus, incorporating supply chain capability as an important dimension of SCR is logical and empirically valid. This finding also highlights that a significant portion of the multidimensional construct: supply chain resilience is explained by supply chain capability in terms of supply chain flexibility, redundancy, integration, efficiency, market strength and financial strength.

Supply chain design

The empirical findings confirmed the role of supply chain design in terms of: alternative sourcing, transportation, market and production facility, and backward linkage as a significant dimension of supply chain resilience which is consistent with previous studies (Craighead et al. 2007; Pettit, Croxton, and Fiksel 2013). An assessment of the association indicates that SCR had a significant association with the dimension: supply chain design (β=0.916, *t*=33.28) and it explains 83.9% of overall variance (R^2) in supply chain resilience (see Figures 6.7 and 6.8 on page 194). Thus, incorporating supply chain design as an important dimension of SCR is logical and empirically valid. This finding also highlights that a significant portion of the multidimensional construct: supply chain resilience is explained by supply chain design in terms of alternative suppliers, alternative market, alternative transportation, alternative production facilities and backward linkages.

Supply chain readiness

The empirical findings confirmed the relevance of supply chain readiness as a significant dimension of supply chain resilience which is consistent with the findings of Sheffi and Rice (2005) and Ponomarov and Holcomb (2009) that supply chain readiness is essential to overcome the vulnerabilities in due time. An assessment of the association indicates that SCR had a significant association with the dimension: supply chain readiness (β=0.948, *t*=59.14) and it explains 89.6% of overall variance (R^2) in supply chain resilience (see Figures 6.7 and 6.8 on page 194). Thus, incorporating

supply chain readiness as an important dimension of SCR is logical and empirically valid. This finding also highlights that a significant portion of the multidimensional construct: supply chain resilience is explained by supply chain readiness in terms of readiness training, readiness resources, forecasting and security.

Supply chain response and recovery

The empirical findings confirmed the relevance of supply chain response and recovery as a significant dimension of supply chain resilience which is consistent with the findings of Sheffi and Rice (2005) and Ponomarov and Holcomb (2009) that supply chain response and recovery are essential to overcome the vulnerabilities in due time. An assessment of the association indicates that SCR had a significant association with the dimension: supply chain response and recovery (β=0.954, *t*=58.65) and it explains 91% of overall variance (R^2) in supply chain resilience (see Figures 6.7 and 6.8 on page 194). Thus, incorporating supply chain response and recovery as a dimension of SCR is logical and empirically valid. It further highlights that a significant portion of the multidimensional construct: supply chain resilience is explained by supply chain response and recovery in terms of quick response, quick recovery, loss absorption, reduction of impact and cost of recovery.

It is noteworthy that the construct: supply chain capability, one of the dimensions of supply chain resilience, itself is a hierarchical and multidimensional construct. The dimensions of supply chain capability are supply chain flexibility, redundancy, integration, efficiency, market strength and financial strength. As this study used the two-stage approach at the lower-order level, the items under each dimension of supply chain capability have been replaced by a latent variable score/construct score. In this regard, the association between the construct score and the higher-order construct: supply chain capability (Table 6.22 page 196) indicate that each construct score has a very high loading with a significant *t*-value. This finding reveals that the dimensions of supply chain flexibility, redundancy, integration, efficiency, market strength and financial strength significantly reflect the construct: supply chain capability.

From the above discussion, it can be concluded that the multidimensional construct: supply chain resilience had a strong association with its dimensions: supply chain capability (β=0.947, *t*=54.92); supply chain design (β=0.916, *t*=33.28); supply chain readiness (β=0.948, *t*=59.14); and supply chain response–recovery (β=0.954, *t*=58.65) which explained 89.6%, 83.9%, 89.8% and 91% of overall variance on SCR, respectively (see Figures 6.6 and 6.7 on page 194). Therefore, incorporating supply

chain capability, supply chain design, supply chain readiness, and supply chain response and recovery as dimensions of SCR is logical and empirically valid.

Nomological and predictive validity of the construct SCR

An assessment of the nomological and predictive validity of the higher-order multidimensional construct: SCR was conducted by examining its relationship with outcome constructs: SCS, ENS, ECS and OPS (Akter, D'Ambra, and Ray 2013; MacKenzie, Podsakoff, and Podsakoff 2011). The results yielded standardized beta coefficients of 0.65, 0.626, 0.8277 and 0.357, respectively, from supply chain resilience to social sustainability; supply chain resilience to environmental sustainability; supply chain resilience to economic sustainability; and supply chain resilience to operational sustainability (see Table 6.20 on page 195). All of these path coefficients were significant at $p < 0.001$, which proved *H8, H9, H10* and *H11*. In addition, this study obtained R^2 (the coefficient of determination) of 0.778 for social sustainability, 0.73 for environmental sustainability, 0.658 for economic sustainability and 0.802 for operational sustainability (see Figure 6.8 on page 194), which were significantly large (> 0.30) according to the measure of explained variance defined for R^2 (Straub, Boudreau, and Gefen 2004). These results confirmed the impact of supply chain resilience on the social, environmental, economic and operational sustainability of the supply chain, thereby ensuring nomological validity (Akter, D'Ambra, and Ray 2013) for the higher-order construct: supply chain resilience.

In addition, this study also evaluated the adequacy of the multidimensional structure of SCR as suggested by Edwards (2001) to validate the dimensions of SCR. The study revealed that the indirect effects of the antecedent construct (SCRM) on the sub-dimensions of SCR: CAP, SCD, RED and RR are substantially larger than the direct effects of SCRM on these sub-dimensions (see Table 6.22 on page 196). Therefore, it can be inferred that the dimensions of the multidimensional construct SCR are valid.

This study also used Stone–Geisser's Q^2 to test predictive validity of the higher-order multidimensional construct: SCR. Using the cross-validated redundancy approach, this study obtained a Q^2 value of 0.538 for social sustainability, 0.5246 for environmental sustainability, 0.356 for economic sustainability and 0.604 for operational sustainability (see Table 6.23 on page 197). To ensure high predictive validity, Stone–Geisser's Q^2 should exceed zero (Chin 2010: Fornell and Larcker 1982). Therefore, the results of this study exhibited the predictive validity of the higher-order supply chain resilience measurement.

7.5 SUMMARY

This chapter has provided a discussion of the findings based on the PLS analysis, as presented in Chapter 6. The interpretations of the findings have been carried out to support the research objectives and the related hypotheses. It was found that supply chain vulnerability consists of the dimensions: hazard, strategic, financial, operational, infrastructural and demand–supply vulnerability. Furthermore, supply chain resilience is attributed to by the dimensions: supply chain capability, supply chain design, supply chain readiness and supply chain response and recovery. It was also found that supply chain resilience is essential to mitigate supply chain vulnerability and to ensure long-term sustainability (social, environmental, economic and operational) of organizations and their supply chains. In addition, it was proven that supply chain resilience is also influenced by supply chain orientation, supportive environmental factors, and learning and development as well as supply chain risk management initiatives.

CHAPTER 8

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

8.1 INTRODUCTION

The focus of this mixed method research was to examine the hypothesized relationships in the model: supply chain sustainability and resilience. More specifically, it examined the relationships between supply chain resilience, vulnerability and the components of supply chain sustainability in the context of the apparel supply chain in Bangladesh. It also aimed at identifying and measuring the dimensions of supply chain resilience and supply chain vulnerability. The concluding chapter begins by providing a summary of the research. This overview of the research process and findings is followed by the significance of the theoretical and practical contributions. In addition, the limitations of the study are discussed, and finally, several avenues for future research are detailed.

8.2 SUMMARY OF RESEARCH

Maintaining an effective supply chain has become challenging and difficult as supply chains are facing overwhelming complexities and unexpected disruptions such as delay during transportation, port stoppages, frequent occurrence of natural disasters, weak communication, supply shortages, demand volatility, quality problem, operational issues, terrorism, etc. (Colicchia et al. 2010; Kleindorfer and Saad 2005; Blackhurst et al. 2008; Mitro and Alpaslan 2003). Similarly, the apparel supply chain of Bangladesh is also exposed to a number of challenges (Islam, Bagum, and Choudhury 2012; Ahmed 2009; Dowlah 1999) which are threatening the sustainability of the industry. Therefore, supply chain resilience is essential for mitigating the vulnerabilities of the apparel industry in Bangladesh because failure to develop resilience in the right time may be a cause of huge financial loss for a company and for the whole supply chain (Pettit, Croxton, and Fiksel 2013). The existing literature on supply chain resilience (Christopher and Peck 2004; Ponomarov and Holcomb 2009; Jüttner and Maklan 2011; Pettit, Croxton, and Fiksel 2013; and others) lacks an empirically validated model that can address supply chain vulnerability. With this backdrop, the present study aimed to develop a model of supply chain sustainability and resilience by reviewing the literature on supply chain vulnerability, resilience and supply chain sustainability. To ensure the theoretical foundation of the conceptual model, the constructs and their

hypothesized relationships were justified in the light of the resource-based view (RBV) and stakeholder theory. Finally, the constructs and variables of the initial research model, developed from the comprehensive literature review, were contextualised and validated by a qualitative field study.

The qualitative field study was conducted by interviewing 15 supply chain decision makers of apparel manufacturing companies and accessory manufacturing companies (suppliers) in Bangladesh. Using a semi-structured interview protocol, the data collected from the field study were analysed through the content analysis approach. From the findings of content analysis, a field study model was developed (as discussed in Chapter 4). Then, based on the comparison of the conceptual model and the field study model, a comprehensive and final research model was developed. This final research model was subject to empirical validation by the quantitative research approach in accordance with the mixed methods research approach adopted in this study.

The final research model consisted of the dimensions of supply chain resilience: supply chain capability, supply chain design, supply chain readiness and supply chain response and recovery; the antecedent constructs of supply chain resilience: supply chain orientation, supportive environmental factors, learning and development, and supply chain risk management; and outcome constructs of supply chain resilience, that is, supply chain sustainability which is reflected by social, environmental, economic and operational sustainability. The final research model also includes the dimensions of supply chain vulnerability: hazard, strategic, financial, operational, infrastructural and demand–supply vulnerability. The measurements of the factors used in this study were mostly sourced from the theories as well as from previous studies. These measures were used for questionnaire development (as described in Chapter 5) in the quantitative analysis phase. The developed questionnaire was pre-tested and refined. Then, following the pilot study, the final survey data were collected and in total 296 usable survey responses were obtained. The collected data were analysed by using partial least squares (PLS)-based structural equation modelling (SEM) technique (see Chapter 6). The PLS analysis was performed to assess the measurement model and the structural model. In the assessment of the measurement model, items with low reliability were dropped from the model. The refined model ensured the acceptable level of item reliability, convergent validity and discriminant validity. The structural model was then assessed.

The assessment of the structural model revealed that the construct: supply chain resilience can explain 84.63% of the variance and that the construct: supply chain vulnerability can explain 56.5 % of the variance. The results of the hypotheses testing showed that, with one exception, all hypotheses were found to be statistically significant (see Table 6.20 on page 195). It was also found that all mediating hypotheses were supported. It was also evident that the model confirmed the nomological and predictive validity with respect to the focal construct: supply chain resilience. The results have both managerial and research implications. The following section presents the significant contributions of this study.

8.3 CONTRIBUTIONS

8.3.1 Theoretical contribution

The research model developed for this study gives rise to significance in several theoretical areas. One of the major contributions is that this research provides a better understanding of supply chain resilience and vulnerability by testing and validating the measurement properties. It also explains the relationships between supply chain resilience and other constructs in the model: supply chain vulnerability and the antecedent constructs of resilience as well as the outcome constructs. Significant research gaps have been identified by the extensive literature search on supply chain resilience, vulnerability and supply chain sustainability. Building on previous research, and filling the gaps in the existing literature, this research offers new and valuable insights by developing a research model: furthermore, the developed model was contextualised through a qualitative field study. The final research model thus developed addresses the resilience capabilities required to mitigate the existing vulnerabilities of the apparel supply chain in Bangladesh and to ensure sustainability of the supply chain. Therefore, the study contributes to the body of knowledge as there is no previous research model that integrates supply chain sustainability and resilience to combat supply chain vulnerability in the context of the apparel supply chain, particularly the apparel supply chain of Bangladesh.

This study empirically validates the measurement of the multidimensional and hierarchical construct: supply chain resilience. An empirically validated measurement for the multidimensional supply chain resilience construct has not yet been developed. Therefore, this study enriches the literature of supply chain risk management and resilience.

In the literature, there is a conceptual debate on the antecedents and measurement constructs of supply chain resilience. This study identifies and separates the measurement constructs and the antecedent constructs of supply chain resilience. Besides the existing literature, based on the field study outcomes, this research explores some important constructs such as infrastructural vulnerability as a dimension of supply chain vulnerability; supply chain readiness as a dimension of supply chain resilience; and supportive environmental factors as an antecedent construct for supply chain resilience. These constructs were validated based on empirical evidence and literature support from the relevant studies.

Despite the wide range of studies on supply chain vulnerability, empirically validated measurements for supply chain vulnerability are really rare. This study identifies the vulnerabilities of the apparel supply chain in Bangladesh and develops an empirically validated measure for the multidimensional construct: supply chain vulnerability.

There are conceptual studies indicating that supply chain resilience is a precondition for supply chain sustainability (e.g. Fiksel 2006; Ponomarov and Holcomb 2009) but an empirical study to validate the link between the two has not yet been conducted. This study finds that there is a positive relationship between supply chain resilience and social, environmental, economic and operational sustainability which is a unique contribution.

In addition, this study explores a number of relationships among the constructs of the supply chain sustainability and resilience model, for example, the relationship between economic to social, environmental and operational sustainability as well as social to operational sustainability. Although these relationships are prevalent in the field of sustainable development, they are completely new in the supply chain literature. Apart from these relationships, this study also identifies and tests that supply chain resilience mediates the relationship between supply chain risk management and supply chain vulnerability. Similarly, it tests the mediation role of SCRM between SCO and SCR. To the best of the researcher's knowledge, these mediation relationships have not yet been empirically tested.

Finally, the comprehensive research model was unique in the sense that it integrates two core theories: the resource-based view (RBV) and stakeholder theory to identify the relevant factors and their relationships in the supply chain sustainability and resilience model. To explain the outcome perspective of supply chain resilience, this study integrated stakeholder theory with the resource-based view (RBV) and

established the link between supply chain sustainability and resilience. Therefore, this study extends the outcome perspective of the resource-based view (RBV) in the context of the apparel supply chain in Bangladesh and contributes significantly to the existing literature.

8.3.2 Practical contribution

From a managerial standpoint, it is essential to understand the factors that influence the continuity of business and the supply chain by minimising the negative effects of supply chain disruptions. For supply chains that are frequently disrupted by numerous uncertain events, particularly the apparel supply chain members in Bangladesh, this study presents a better understanding of the vulnerabilities and their mitigation approaches. The apparel supply chain managers will also gain an indication in order to equip themselves with relevant factors needed for developing supply chain resilience such as supply chain capability, design factors and required readiness, response and recovery initiatives for mitigating the supply chain vulnerabilities. More specifically, the supply chain decision makers can also make use of the model to refine their thinking about supply chain capability requirements in terms of required flexibility, integration, redundancy, efficiency development, increasing market and financial strength.

In terms of supply chain design factors, this model will assist the supply chain managers to make decisions regarding single sourcing versus multiple sourcing, and suggest to them strategies such as alternative distribution, diversification of markets and keeping alternative production facilities to provide options during a crisis. The supply chain managers may also use the model to develop the factors needed for improving readiness, response and recovery ability once their system is disrupted or exposed to disruption. For example, the decision makers may place emphasis on readiness training, improving the security system, forecasting, quick response to any disruption and increasing disruption tolerance/absorption capacity.

From the model, the decision makers will gain valuable insights about the facilitating factors for improving supply chain resilience. The antecedent factors in the model such as supply chain orientation, supportive environmental factors, learning and development, and supply chain risk management are significant input for supply chain managers to develop resilience capability. More specifically, the model shows that supply chain managers need to improve trust, cooperation and commitment among the supply chain members, and place emphasis on training, development and research as

well as undertaking risk management initiatives to create an effective repertoire of responses to the challenges of the external environment and to improve the resilience of their supply chain. The model also suggests that mere supply chain risk management initiatives are not enough to mitigate the existing vulnerabilities: rather, supply chain managers need to be proactive and resilient to mitigate the vulnerabilities.

The model also reinforces to supply chain managers that supply chains need to develop resilience capability to achieve social, environmental, economic and operational sustainability. Furthermore, it guides the supply chain managers toward improving social sustainability factors to ensure operational sustainability of their organizations and supply chain.

This study considers Bangladesh as a case, particularly the apparel industry of Bangladesh; however, the study's implications are significant for other countries in a similar institutional context.

8.3.3 Implications for Government and relevant bodies

Relevant government authorities as well as other agencies may find valuable inputs from the results of this study and prepare their strategy and policy to improve the resilience capability of the apparel industry for long-term sustainability.

The study finds that to mitigate the apparel supply chain vulnerability and to enhance resilience, supply chain capability development is very important. As the contribution of the apparel industry is huge in the economy of Bangladesh government may facilitate the industry in developing capabilities to mitigate the vulnerabilities. For example, this research shows that the Government of Bangladesh may take the initiative of infrastructure development to reduce the vulnerabilities from poor transportation, port system management and utility disruptions. Such initiative for infrastructure development will help the apparel supply chain members to reduce the vulnerability arising from the delay in procurement and distribution of products. The government may also work toward ensuring stable political conditions and industry supportive policies to motivate the backward linkage firms. As the study finds that instable political condition is one of the major vulnerabilities for the apparel industry, harmony among the political parties and congenial government policy will support the industry to a greater extent in reducing political instability. Government may also provide incentives and extend its support to the development of backward linkage industry. More private investment will be attracted if government can set effective policies and packages for backward linkage development in the apparel industry.

Dependence on imported material is one of the salient demand-supply vulnerabilites, as a result, development in backward linkage industry will help in increasing more domestic supply. Such initiative will play a major role in reducing supply side vulnerability.

Similarly, the study will also help the trade bodies such as the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) and Bangladesh Textile Mills Associations (BTMEA) to play an active role in improving the resilience and sustainability of the industry. For example, it may help them to be more vigilant about organizing training and workshops for improving disaster preparedness skills, disaster response and recovery ability, increasing awareness related to sustainability, etc.

This study also has substantial implication for the government and relevant bodies with respect to sustainability issues of the apparel supply chain. Government and other relevant bodies such as BGMEA and NGOs may work to ensure fair wages, health and safety issues of the workers, fire safety training, eliminating child labour and force labour and establishing human rights for the workers.

Similarly, Government and other relevant bodies may also assist in improving the environmental sustainability issues through supervising and monitoring the water, soil and air pollution. Government may assist the apparel manufacturers to provide platforms for collaboration regarding recycling, to establish central effluent treatment plant (ETP) in industrial jones that can be used by smaller companies, to increase chemical testing capability etc. Such initiatives of government and the relevant bodies will help the apparel manufacturers to comply with the sustainability requirements of the buyers and to reduce the reputation risk which will eventually help in ensuring sustainability of apparel supply chain.

8.4 LIMITATIONS

All research methods and designs have their own flaws and limitations (McGrath 1982). This research also has some limitations several of which are worth noting.

Firstly, this research adopts a cross-sectional design. One major limitation of a cross-sectional study design in this research is that investigation of the phenomenon of supply chain resilience is limited to a point-in-time assessment. However, supply chain disruption cannot be assessed without considering the effects of various supply chain disruptions for a longer time. Longitudinal research designs, on the other hand, could capture the dynamic nature of the phenomenon of interest and capture the effects of

various supply chain disruptions on resilience and performance outcomes in the long run. Thus, a longitudinal focus is recommended for future studies.

Secondly, the unit of analysis is the apparel manufacturers and their suppliers (the accessory producers) while the buyers or customers are not considered as the buyers are not associated with manufacturing and the physical flow of goods. This study on resilience is mainly operational in nature; therefore, only the entities involved with the manufacturing operation are included. However, it would have been more comprehensive if all entities in the supply chain, that is, suppliers, manufacturers and buyers could be included.

Thirdly, this research was conducted within the specific industry and in one country. Although supply chain resilience by its nature is context-specific, replication in other contexts would increase confidence in the research model.

Fourthly, the latent variables: SCO and SCRM were measured by four items although these are rigorous concepts. These constructs were originally conceptualized that way and the scales were properly validated. However, future research might benefit from a more comprehensive way to operationalize SCO and SCRM capturing additional items.

8.5 FUTURE RESEARCH DIRECTIONS

This research generates a number of opportunities for further research which can be summarised as follows:

This study adopted a qualitative study to contextualise the conceptual model developed from the literature and then validated the research model by applying a quantitative tool. By using the principles of methodological triangulation, further research may be initiated to apply the validated model at the firm level through the case study approach.

To address the methodological limitations of cross-sectional research, a longitudinal study could be conducted to analyse the factors influencing and influenced by supply chain resilience.

As the unit of analysis in the model is limited to apparel manufacturers and the accessory suppliers, furure research may be conducted by incorporating all the members in the supply chain network.

This research was conducted on the apparel industry of Bangladesh. Future research may be conducted under different contextual conditions, such as incorporating firms

from other industries or another country's context or in the context of dyadic buyer–supplier relationships.

As the overall research model consists of a large number of constructs, for the parsimony of the model, the concepts of supply chain orientation and supply chain risk management were measured by very carefully selected limited number of items. The relationship between supply chain resilience, supply chain orientation and supply chain risk management needs to be investigated further in the future research.

This study address the dynamic relationships between supply chain resilience, vulnerability and sustainability in the context of manufacturing industry while future research can be initiated to investigate the dynamic relationships between supply chain resilience, vulnerability and sustainability in the context of service industry.

This study identifies and investigates supply chain sustainability as an outcome construct of supply chain resilience or in other words, it investigates supply chain resilience as an antecedent construct of supply chain sustainability. Future research may be conducted to investigate other antecedent factors of supply chain sustainability such as supply chain governance, supply chain social capital. Previous literature posits supply chain social capital as the antecedent factor of supply chain resilience while supply chain resilience is an antecedent of supply chain sustainability. Thus, the mediating role of supply chain resilience in the relationship between supply chain social capital and supply chain sustainability is worth investigating.

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Appendices

Appendix A: Interview guide for field study

Semi-structured questionnaire for the qualitative part

The aim of the research is to develop a model of supply chain sustainability and resilience for apparel industry of Bangladesh. In this regard the objective of this interview is to understand the present status of economic, social and environmental sustainability factors of apparel supply chain of Bangladesh. Along with this it also aims at exploring supply chain disruptions/vulnerabilities and capabilities for mitigating the disruptions to formulate a resilient-sustainable supply chain management framework.

Introductory Questions

Your name.....

Your present position, duties and responsibilities.....

Total number of employees in your organization……

Semi structured questions

Supply chain resilience:

Resilience is the capability of a system to get back to original position once it is disrupted (Christopher, 2004) while supply chain resilience is also referred as the ability of a supply chain to reduce the probability of disruptions, to reduce the consequences of those disruptions, and to reduce the time to recover normal performance (Falasca et al. 2008).

(Above definition will be explained verbally to the participant)

1. What are the different supply chain members of your organization and how they are related to your organization's supply chain in terms of flow of good and information?
   (Please sketch a diagram to present the apparel supply chain of Bangladesh)

2. Do you think the supply chain of your organization is disrupted by different uncertain events and vulnerabilities?

3. If yes, what are those disruptions and vulnerabilities?

   (Example: Natural hazard, transportation disruption, production/processing disruption, supply/procurement disruption, customer disruptions and others.)

4. What is your perception about supply chain resilience?

5. Is resilience important for your organization? Why?

6. How will you measure resilience of your organization corresponding to the vulnerabilities?

Probing if necessary

i. The capabilities of your organization (e.g. flexibility, efficiency, financial strength, supply chain network strength, quick response and recovery ability etc.) to reduce supply chain vulnerabilities.

7. How will you improve resilience of your organization and supply chain?

Probing if necessary

i. Relationship with supply chain members, concentration of management towards risk mitigation issues, training, development and innovation, consideration of risk in decision making)

Supply chain Sustainability: Supply chain sustainability refers the management of material, information and capital flows and cooperation among all entities in the chain for achieving the economic, environmental and social goals while satisfying the requirements of customer and stakeholder (Seuring and Muller 2008).

8. What is your understanding about sustainability and how it is applied to the supply chain of your organization?

Probing if necessary

i. What social factors (e.g. *health and safety, fair wages, training and development)* do you usually think important for apparel supply chain sustainability?

ii. What environmental factors (pollutant treatment, emission control, environmental hazard free product) do you usually think important for apparel supply chain sustainability?

iii. What economic factors (cost, competition, productivity, profitability) do you usually think important for apparel supply chain sustainability?

9. Do you think supply chain resilience is essential for apparel supply chain sustainability? Why or why not?

Appendix B: Survey questionnaire

Questionnaire

Dear Survey Respondent

Thank you for agreeing to complete this questionnaire. Your participation in this research is voluntary. The confidentiality and anonymity of the respondents will be respected and protected. I will ensure and guarantee that none of the respondents that cooperate in the research will be identified or be capable of identification in the writing up of the research for academic publication. Any data presented will be aggregated as I am interested in general trends, not in a particular individual or organization.

The questionnaire attempts to find out the **predominant factors that influence the supply chain resilience and sustainability of apparel industry in Bangladesh.** Your assistance in completing this questionnaire would be valuable not only to me but would also make an important contribution to our knowledge about achieving supply chain sustainability and resilience in the apparel supply chain of Bangladesh. I will value your honest response to the questionnaire and your kind participation is greatly appreciated.

This study has been approved by the Curtin University Human Research Ethics Committee. If needed, verification of approval can be obtained by writing to the Curtin University Human Research Ethics Committee, c/o - Office of Research & Development, Curtin University of Technology, GPO Box U1987, Perth 6845, or telephone +618-92662784. If you would like further information about the study, please feel free to contact me. My contact details are provided below. Alternatively, you can contact my supervisor Professor Mohammed Quaddus on +618-92662862 or by e-mail: m.quaddus@curtin.edu.au

Consent to participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities.

This survey is divided into four sections. Please make sure that you have completed all the items listed in these sections.

Thank you very much for taking your time and effort to complete this survey.

Yours sincerely,
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Supply Chain Sustainability and Resilience: The Case of Apparel Industry in Bangladesh

Section 1: Some information about you and your organisation

Some necessary information about you and your organisation will be collected in this section of the questionnaire. The background information will be used for statistical purposes only.

Please tick ☐ the most appropriate answer:

Name----------

Nominate your current position----------

Type of operation

☐Apparel manufacturer ☐Apparel accessory producer

Number of employees working in your organisation

☐Less than 1000 employees ☐1000 – 2000 employees
☐+2000 – 3000 employees ☐+3000 – 4000 employees ☐ More than 4000 employees

Number of years since the company established

☐ Less than 5 years ☐+15 to 20 years ☐+5 to 10 years ☐+20 to 25 years
☐+10 to 15 years ☐ other (please specify) _____

Please indicate the annual sales (in BDT/USD) of your organisation ----------

Section 2: Questionnaire about supply chain vulnerability

Resilience refers to the capacity of a system to get back to original position if the system is disrupted by something. **Listed below are the statements that reflect the supply chain resilience in terms of capacity, vulnerability, supply chain network structure, and supply chain readiness, response & recovery.** Please read each statement carefully, then indicate the extent of impact due to different vulnerabilities by checking the appropriate number on a scale of 1	**Extremely low**	**Very low**	**Low**	**High**	**Very high**	**Extremely high**
	1	**2**	**3**	**4**	**5**	**6**
2.1 Impact of natural disaster (e.g. flood, cyclone, earthquake, etc.) on our supply chain is	1	2	3	4	5	6
2.2 Impact of fire and other accidental damage on our supply chain is	1	2	3	4	5	6
2.3 Impact of labour unrest and dissatisfaction on our supply chain is	1	2	3	4	5	6
2.4 Impact of political instability on our supply chain is	1	2	3	4	5	6
2.5 Impact of increased competition on our supply chain is	1	2	3	4	5	6
2.6 Impact of non-compliance of social and environmental factors on our supply chain is	1	2	3	4	5	6
2.7 Impact of problem of relation with buyer and supplier (e.g. switching of buyer) on our supply chain is	1	2	3	4	5	6
2.8 Impact of problem of integration and real-time information on our supply chain is	1	2	3	4	5	6

2.9 Impact of plant location problem (far from port or lack of infrastructural facilities, loading and unloading for shipment of products) on our supply chain is	1	2	3	4	5	6
2.10 Impact of currency fluctuation on our supply chain is	1	2	3	4	5	6
2.11 Impact of economic recession on our supply chain is	1	2	3	4	5	6
2.12 Impact of raw material price fluctuation on our supply chain is	1	2	3	4	5	6
2.13 Impact of high bank interest and fund shortage on our supply chain is	1	2	3	4	5	6
2.14 Impact of bankruptcy or credit default of supply chain members on our supply chain is	1	2	3	4	5	6
2.15 Impact of lack of skilled worker and productivity on our supply chain is	1	2	3	4	5	6
2.16 Impact of switching and absenteeism of workers on our supply chain is	1	2	3	4	5	6
2.17 Impact of fault in production planning and inventory management on our supply chain is	1	2	3	4	5	6
2.18 Impact of IT system failure on our supply chain is	1	2	3	4	5	6
2.19 Impact of disruption in utility supply on our supply chain is	1	2	3	4	5	6
2.20 Impact of product quality defects (e.g. rejection of shipment) on our supply chain is	1	2	3	4	5	6
2.21 Impact of illiteracy of workers supervisors on our supply chain is	1	2	3	4	5	6
2.22 Impact of delay in custom clearance on our supply chain is	1	2	3	4	5	6
2.23 Impact of delay for congestion and inefficiency in port on our supply chain	1	2	3	4	5	6
2.24 Impact of poor land transportation infrastructure on our supply chain is	1	2	3	4	5	6
2.25 Impact of suppliers' disruption and delay on our supply chain is not	1	2	3	4	5	6
2.26 Impact of dependence on imported material and poor backward linkage on	1	2	3	4	5	6
2.27 Impact of fault in material supplied by supplier on our supply chain is	1	2	3	4	5	6
2.28 Impact of buyer disruption and Opportunism on our supply chain is	1	2	3	4	5	6
2.29 Impact of demand fluctuation/uncertainty on our supply chain is	1	2	3	4	5	6

Section 3-A: Questionnaire about supply chain resilience

Listed below are the statements that reflect the different aspects of apparel supply chain capability. Please read each statement carefully, then indicate the extent **to which you disagree or agree** by checking the appropriate number on a scale of 1 (Strongly Disagree) to 6 (Strongly agree).	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly**
3.1 We have enough flexibility in production (e.g. Flexible production schedule to meet delivery date, can handle large to small order)	1	2	3	4	5	6
3.2 We are efficient to customize products as per buyers' requirement (any design, size, colour etc.)	1	2	3	4	5	6
3.3 Our workers are skilled to handle different tasks and product lines.	1	2	3	4	5	6
3.4 we have enough flexibility in contract with SC members (e.g. partial order, partial shipment, partial payment)	1	2	3	4	5	6
3.5 We are cost effective in logistics and supply chain functions (e.g. sourcing, producing, and distribution).	1	2	3	4	5	6
3.6 We are very quick to respond to additional order or sudden demand of our buyers	1	2	3	4	5	6
3.7 We are able to introduce and supply new product for different types of customer group (men, women, and kids items, shorts, undergarments etc.)	1	2	3	4	5	6
3.8 We maintain adequate alternative and reserve capacity (e.g. logistical and transportation facilities, assets, labour)	1	2	3	4	5	6
3.9 We keep required stock for raw material.	1	2	3	4	5	6
3.10 We have effective backup energy/utility source	1	2	3	4	5	6

3.11 Information sharing with our supply chain partners is satisfactory	1	2	3	4	5	6
3.12 We have communication and information flow between different functional areas to facilitate supply chain functions.	1	2	3	4	5	6
3.13 We have collaborative planning with supply chain partners (for product designing and improvement, forecasting about demand etc.)	1	2	3	4	5	6
3.14 We have ICT supported planning (production, material sourcing, inventory)	1	2	3	4	5	6
3.15 We reduce waste by efficient use of resources (controlling misuse of resource, using efficient technology, reducing energy consumption, and recycling or selling of waste to recyclers)	1	2	3	4	5	6
3.16 We try to increase efficiency and satisfaction of employees by different initiatives (training, better working environment and pay)	1	2	3	4	5	6
3.17 We have low defects and rejection rate because of strict quality control (checking sewing quality, checking health and environment hazardous chemicals and ingredients)	1	2	3	4	5	6
3.18 Our buyers and suppliers are satisfied with us	1	2	3	4	5	6
3.19 We are preferred supplier as we meet their requirements regarding social, environmental, and operational issues.	1	2	3	4	5	6
3.20 We have strong relationship with our buyers, suppliers, employees and other stakeholders	1	2	3	4	5	6
3.21 We have enough fund to recover from crisis (capacity of investment and huge credit bearing ability)	1	2	3	4	5	6
3.22 We have consistent profit and low risk of loss	1	2	3	4	5	6
3.23 We have insurance for all of our resources and employees	1	2	3	4	5	6

Section 3-B: Questionnaire about supply chain resilience

3.24 we have alternative suppliers and sourcing options	1	2	3	4	5	6
3.25 To overcome problem of sourcing and distribution we easily arrange alternative shipping and rerouting arrangement (shipping by sea, air, air-sea,	1	2	3	4	5	6
3.26 We have market/customer in different region (ex: USA, Europe, Japan, Canada, Australia etc.)	1	2	3	4	5	6
3.27 We have production in different locations (ex: Chittagong, Dhaka, or outside the country)	1	2	3	4	5	6
3.28 We have our own accessory plant to supply material to our company (Ex: Cartoon, poly, washing, dying etc)	1	2	3	4	5	6
3.29 We have better readiness training and inspection to overcome disruptions (checking electrical and fire equipment, fire drilling, safety training, having	1	2	3	4	5	6
3.30 We do not have enough resources and accessibility to resources regarding mitigation of disruptions/disaster	1	2	3	4	5	6
3.31 We properly collect and analyse early warning signals/information (signals regarding political instability, labour unrest, market condition)	1	2	3	4	5	6
3.32 To prepare our self against disruptions we have adequate forecasting and anticipation	1	2	3	4	5	6
3.33 We have adequate safety and security system	1	2	3	4	5	6
3.34 We respond quickly (in short time) to uncertainties (demand and supply uncertainty, disaster, operational failure)	1	2	3	4	5	6
3.35 We can recover quickly from highly vulnerable and highly probable disruptions	1	2	3	4	5	6
3.36 We can absorb huge loss	1	2	3	4	5	6
3.37 We can reduce the impact of loss	1	2	3	4	5	6
3.38We can recover at low cost	1	2	3	4	5	6

Section 4: Questionnaire about antecedents of supply chain resilience

4.1 We have higher level of trust with the supply chain members.	1	2	3	4	5	6
4.2 Level of commitment with our supply chain members is high.	1	2	3	4	5	6
4.3 We have enough cooperation with the supply chain members to overcome vulnerabilities	1	2	3	4	5	6
4.4 Top management is actively engaged in in supply chain decision making	1	2	3	4	5	6
4.5 Government provides us enough support (e.g. tax incentive, financial supports and others)	1	2	3	4	5	6
4.6 We have adequate factor endowment (raw material, labour and others) to compete with other countries producers	1	2	3	4	5	6
4.7 We have favourable international trade environment (e.g. GSP facility, duty free access)	1	2	3	4	5	6
4.8 Our trade body and institutions (BGMEA, EPB) support us sufficiently	1	2	3	4	5	6
4.9 Training and counselling system in our organization is high	1	2	3	4	5	6
4.10 We provide enough opportunities for development of employees (e.g. job rotation, career development opportunity)	1	2	3	4	5	6
4.11 We have Research & development for improvement of product, process and efficiency	1	2	3	4	5	6
4.12 We use learning from past experience to improve us and to mitigate disruptions	1	2	3	4	5	6
4.13 We have high level of risk sharing activities with supply chain members (ex. Partial shipment, outsourcing from nominated source) compared to the	1	2	3	4	5	6
4.14 We cannot always take enough effort to reduce disruption (ex. Redundant capacity, skills and resources)	1	2	3	4	5	6
4.15 Our effort to know about risk is high (ex. Identifying risk sources, monitoring, evaluating supplier, forecasting)	1	2	3	4	5	6
4.16 We consider risk in decision making.	1	2	3	4	5	6

Section 5: Questionnaire about apparel supply chain sustainability

Listed below are the statements that reflect the social, environmental, economic and operational aspects of apparel supply chain sustainability. Please read each statement carefully, then indicate the extent **to which you disagree or agree** by checking the appropriate number on a scale of 1 (Strongly Disagree) to 6 (Strongly agree). **Please circle the most appropriate answer.**	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Somewhat Agree**	**Agree**	**Strongly Agree**
	1	**2**	**3**	**4**	**5**	**6**
5.1 Our company provides standard wages and overtime payments	1	2	3	4	5	6
5.2 Our company provides required benefits to the employees (e.g. leave benefit, medical benefit, child care facility, transportation etc)	1	2	3	4	5	6
5.3 We take adequate precautions for hazard and safety of the employees (fire safety, building safety, personal protective equipment)	1	2	3	4	5	6
5.4 We take adequate measures for health and sanitation of the employees (e.g. pure drinking water, cleanliness, adequate toilet).	1	2	3	4	5	6
5.5 We are strict about child labour issue	1	2	3	4	5	6
5.6 We do not force to work and do not harass workers	1	2	3	4	5	6

5.7 We monitoring the social compliance factors of our suppliers	1	2	3	4	5	6
5.8 Our employees are satisfied with us	1	2	3	4	5	6
5.10 We adequate measures to control water pollution (e.g. Effluent treatment plant-ETP, maintaining proper sewerage system)	1	2	3	4	5	6
5.11 We take adequate measures to control air pollution	1	2	3	4	5	6
5.12 We take adequate measures to control soil pollution (dumping wastes in land and everywhere)	1	2	3	4	5	6
5.13 We recycle the wastes of our plant or sell the wastes to recyclers	1	2	3	4	5	6
5.14 We control the use of hazardous materials and chemical in our products (e.g. lead, azo, amo or other banned chemical)	1	2	3	4	5	6
5.15 We have environmental certification and audit (either by buyers or government or other organizations)	1	2	3	4	5	6
5.16 We do not fulfil the criteria regarding environmental legislation of the country	1	2	3	4	5	6
5.17 We evaluate and monitor the environmental performance of our suppliers	1	2	3	4	5	6
5.18 We have adequate sales and business volume	1	2	3	4	5	6
5.19 We can produce at low cost.	1	2	3	4	5	6
5.20 We can make required profit	1	2	3	4	5	6
5.21 We have enough sales growth	1	2	3	4	5	6
5.22 We can meet the lead time set by our buyers.	1	2	3	4	5	6
5.23 We meet high quality standard	1	2	3	4	5	6
5.24 We can meet different specifications of the buyers properly (design, size, colour, quality etc).	1	2	3	4	5	6
5.25 We use efficient and updated machinery and technology	1	2	3	4	5	6