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COLLEGE OF BUSINESS AND ECONOMICS

THE ROLE OF SUPPLY CHAIN RESILIENCE IN SUPPLY CHAIN RECONFIGURATION: EVIDENCE FROM QATAR

BY

MARYAM SAAD B A AL-NAIMI

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COMMITTEE PAGE

The members of the Committee approve the Dissertation of
Maryam Saad B A Al-Naimi defended on 29/09/2020.

Professor Mohd. Nishat Faisal

Name
Thesis/Dissertation Supervisor

Professor Rana Sobh

Name
Committee Member

Professor Belaid Aouni

Name
Committee Member

Dr. Abdalkareem S.S. Eyalawwad

Name
Committee Member

Approved:

Professor Adam Mohamed Fadlalla, Dean, College of Business and Economics

ABSTRACT

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Title: The Role of Supply Chain Resilience in Supply Chain Reconfiguration: Evidence from Qatar

Supervisor of Dissertation: Faisal, Mohd. Nishat

Supply chain resilience has emerged as a key attribute in wake of increased risk susceptibilities due to globalized operations. This dissertation aims to understand the role of supply chain resilience and reconfiguration in context of economic-political risk. A systematic mapping review was conducted to identify the gaps in contemporary literature on supply chain resilience and reconfiguration. Based on literature review, a model utilizing Interpretive Structural Modeling (ISM) is proposed to understand the relationships among the enablers of supply chain resilience to effectively mitigate the economic-political risk.

The results of ISM model were utilized to propose a model, which empirically investigated the impact of supply chain resilience on supply chain reconfiguration considering the impact of key antecedents of supply chain resilience. Descriptive statistics, hypothesis testing and partial least squares modeling using data from the selected organizations in Qatar provided useful information about the recovery of supply chains following an economic-political risk event of blockade in Qatar. Risk management culture, agility, and collaboration significantly support supply chain resilience, which assist in supply chain reconfiguration.

In this research, supply chain reconfiguration emerged as a key variable determining

the ability of supply chains to adjust in the wake of risk events or in a dynamic business environment. To focus resources towards building supply chain reconfiguration capabilities a multi-criteria decision framework integrating Analytic Network Process (ANP) and Balanced Scorecard to prioritize the variables associated with supply chain reconfiguration was proposed in the research.

The findings reported in the thesis improves the understanding of supply chain resilience and reconfiguration in a developing economy. It proposes models and framework to understand resilience and reconfiguration variables that would enable businesses to develop resilient supply chains to effectively mitigate risks and improve continuity of operations.

Keywords: Supply Chain Resilience, Supply Chain Reconfiguration, Systematic Mapping Study, Questionnaire survey, PLS modeling, Interpretive Structural Modelling, Qatar, Economic-Political Risk, Analytic Network Process, Multi-criteria Decision-making Model, Balanced Scorecard

DEDICATION

I dedicate my dissertation to my parents who have been there always for me. Their support, value, and upbringing that has held me is what has make me who I am now

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First and foremost, praises and thanks to Allah, the Almighty, for his showers of blessings throughout my research work to enable me to complete it successfully.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

In June 2017, Qatar experienced a disruption of supply chains after the imposition of a blockade by four other countries (the United Arab Emirates [UAE], Saudi Arabia, Bahrain, and Egypt). The blockade closed the land borders between Qatar and Saudi Arabia, along with national airspace and territorial waters. The major reason for this blockade is linked to the economics and politics of the region (BBC, 2017). This is similar to US-imposed tariffs on China in 2018 and reciprocal action by China leading to a significant rise in uncertainty and the search for new suppliers by many firms (Yu et al., 2019). The blockade in Qatar had a huge impact on supply chains, because the majority of products in Qatar were imported, and imports were mainly routed through the blockading countries. Qatari companies were forced to change their suppliers and redesign their supply chains to meet the needs of residents. The country is also due to host the Football World Cup in 2022, which has led to a number of infrastructure projects and increased demand on construction supply chains. The disruption of supply chains during the blockade led to delays and material shortages in these projects, including many in the final delivery stage.

Managers have always had to deal with a wide variety of supply chain risks. Sáenz et al. (2018) identified three categories of external risks to supply chains: hazards (such as fire, floods, hurricanes, earthquakes, or tsunamis), market forces (such as sudden changes in demand, price collapse, or competition), and economic or social forces (for example, recession, labour instability, political events, or currency devaluation). This study explored the role of supply chain resilience in mitigating risk, using economic-political (econo-

political) risk as an example. Econo-political risk is an external risk that significantly influences the performance of supply chains (Walters, 2006). It lowers order capabilities and negatively influences supply chain resilience (Altay and Ramirez, 2010; Bode et al., 2011). It is affected by many factors outside the control of organizations, so cannot be entirely eliminated. Organizations therefore need strategies in place to deal effectively with disruptions to their supply chains resulting from econo-political issues.

There is increasing interest in supply chain resilience, but it remains a new and relatively unexplored topic (Cardoso et al., 2015). Studies have suggested that it requires a move away from traditional approaches to mitigating risks (Ali et al., 2017a), particularly to deal with the complexities of global supply chains (Pettit et al., 2013). There are several definitions of supply chain resilience. One of the most commonly-used is from Christopher and Peck (2004), who defined it as "the ability of a system to return to its original state, within an acceptable period of time, after being disturbed" (Akkermans and Wassenhove, 2018; Brandon-Jones et al., 2014; Cheng and Lu, 2017; Spiegler et al., 2012). Resilience is therefore an important property of supply chains, enabling them to handle risks effectively. However, studies have largely considered resilience to disruptions that affect a relatively small part of the overall supply network (Cardoso et al., 2015). Few, if any, studies have examined different types of enablers of supply chain resilience to econo-political risks, or their interrelationships.

Supply chain disruption is one of the most significant risks in supply networks. Disruptive events like the Japan earthquake of 2011 or the Icelandic volcanic eruption in 2010 have emphasized its importance (Esmaeili-Najafabadi et al., 2019). Resilient supply

chains can adapt to both positive and negative environmental influences. They can also anticipate and minimize the negative effects of disruptions (López and Ishizaka, 2019). Resilience also has broader implications than supply chain risk control (Brusset and Teller, 2017). It affects supply chains' ability to survive, adapt and grow in changed business environments. Organizations should therefore prioritize supply chain resilience because it has a significant direct effect on financial performance (Yu et al., 2019). Resilience can even be a source of sustainable competitive advantage (Rajesh, 2019), and has a positive effect on customer satisfaction (Govindan et al., 2015).

The current study will cover the gap in the area of supply chain resilience and reconfiguration in recover the supply chain disruption by exploring the relationship between supply chain resilience and reconfiguration under economic-political risk. This study will be the first of which we are aware to use a systematic mapping review methodology in supply chain resilience and reconfiguration. This review deals mainly with the accuracy of supply chain resilience enablers and supply chain reconfiguration characteristics, linking these with other issues of supply chain resilience and reconfiguration such as research sources, research type, geographical area, and methodology. The study also empirically examine how supply chain resilience separately and jointly influence the supply chain reconfiguration. Moreover, this study aims to identify the factors and sub-factors important in improve the understanding of supply chain resilience under economic-political risks. This is necessary because it has a major influence on the successful recover of the disruption within supply chain. Finally, the study will propose a multi-criteria decision model to prioritize supply chain reconfiguration variables by evaluating a case of retail sector supply chain.

1.2 Supply chain resilience

When problems occur with the supply chain, managers have to make difficult decisions about resilience and reconfiguration. Companies will usually have an agreed policy in place to recover from issues, either by mitigating risks or through supply chain resilience. It is usually considered important to maintain normal supply chain operations, so companies may decide to reconfigure supply chains to allow this. Resilience in supply chains can also be a way to avoid supply chain risk. This has therefore become an important area of research, as well as a practical issue in supply chain risk management (Ponomarov and Holcomb, 2009; Datta, 2017). Supply chains and organizations need to build resilience to enable the supply chain to anticipate, adapt, respond and recover quickly from unpredictable events (Ponomarov and Holcomb, 2009; Jüttner and Maklan, 2011).

Supply chain resilience should help to alleviate a number of problems. These include:

- Organizational risk, which sometimes causes a loss of labor through strikes and production uncertainties (e.g. process quality), and IT system uncertainties (e.g. machine breakdown) (Jüttner, et al., 2003);
- Network risk, because of difficulties created by supply risk, demand risk, and information risk (Christopher and Peck, 2004; Wagner and Bode, 2008); and
- Environmental risk, which may affect physical, social, political, legal, operational, economic, and cognitive environments (Bogataj and Bogataj, 2007).

Generally, the environmental risk from unpredictable and rare events such as natural disasters, bankruptcy, fire, transportation, and terrorism, arises from the supply chain–

environment interaction, and is often quite damaging (Jüttner, et al., 2003; Chopra and Sodhi, 2004; Tang, 2006; Trkman and McCormack, 2009).

Resilience enablers are designed to alleviate some of these challenges. They therefore need to include features such as ability to anticipate, monitor, respond, and learn (Blackhurst et al., 2011; Jüttner and Maklan, 2011; Ambulkar et al., 2015; Ali, et al., 2017b). However, there is insufficient information about which enablers have these functions or are suitable for use in an uncertain business environment. A few studies have examined some of the existing enablers, such as Soni et al. (2014), who provided a set of supply chain resilience enablers, classified by the level of resilience and scope of improvement.

1.3 Supply chain reconfiguration

Failure of one entity in a supply chain can lead to a number of entities closing down, or even a shutdown of the whole supply chain. The dynamics of supply chain reconfiguration therefore help organizations to return to equilibrium (Holmstrom et al., 2017; Wilhelm, et al., 2013). Supply chain reconfiguration has been examined at both strategic and operational level, and as an ongoing process, rather than a single event (Kaminsky et al., 2004; Storer et al., 2014; Varsei et al., 2014; Vidal and Goetschalckx, 1997). It enables supply chains to survive, return to normality or move to a new status from which they can operate. Supply chain reconfiguration results from the strategic goal to determine the required number, location and capabilities of manufacturing plants and distribution centers, the best set of suppliers and the effective flow of material throughout the supply chain (Vidal and Goetschalckx, 1997; Kaminsky et al., 2004; Varsei et al., 2014). Operationally, it is defined

as reshaping of resources by businesses and staff into new operational competencies (Storer et al., 2014).

Researchers on supply chain reconfiguration have mainly focused on developing reconfiguration strategies (Guo et al., 2018). These have included reconfiguring the supply chain to improve the overall system through providing agility (Lu et al., 2001), reconfiguring supply chain flexibility (Komoto et al., 2005), solving supplier selection problems (Osman and Demirli, 2010), and improving the level of integration in all aspects of the supply chain, such as inventory allocation and manufacturing processes (Kristianto et al., 2012). These studies provide valuable models on the manufacturing supply chain system, as well as methods for supply chain reconfiguration. However, few, if any, studies have developed an effective model to investigate the characteristics of supply chain reconfiguration. It is therefore unclear how firms reconfigure their supply chain, and studies are needed to further our understanding of the process of supply chain reconfiguration. Knowledge gathered in narrow functional disciplines also needs to be consolidated to advance knowledge of supply chain risk, resilience, and reconfiguration and create a coherent knowledge framework.

1.4 The Qatar blockade

In the last two decades, boosted by high petroleum prices, Qatar has emerged as one of the world's richest countries (World Bank Group, 2019). This led to major investments in human development projects like Education City and Hamad Medical City. However, there was a high dependence on imports for the majority of goods consumed in the country, including food. Food production in Qatar is low because of the high aridity, poor soil and

low rainfall. After winning the bid to host the 2022 Football World Cup, there is also a huge demand for construction materials for major infrastructure projects including roads, light rail transportation, a new port, stadiums, and other sporting facilities. The majority of imported goods were routed through the UAE and Saudi Arabia, with a good percentage of dairy, poultry and vegetables being produced in Saudi Arabia. The Qatari government encouraged buying from businesses in other Gulf Cooperation Council (GCC) countries as a way of expressing Arab solidarity. However, the econo-political blockade imposed by Saudi Arabia, UAE, Bahrain and Egypt on June 5, 2017 on air, sea, and land traffic meant that Qatari companies had to reconfigure their supply chains to maintain continuity of operations. This led to new sources of supplies being found in countries like Turkey, India, Kuwait, Iran, Oman, and Lebanon, creating new routes and updating logistical capabilities.

1.5 Research problem

The main objective of this study was to examine the effects of supply chain resilience on mitigating risk of disruption. It also aimed to determine how supply chain resilience contributes to supply chain reconfiguration. The blockade imposed on Qatar is a type of econo-political risk and led to restructuring of supply chains in the country. Previous studies have mainly focused on the impact of supply chain resilience on mitigating risk (Brusset and Teller, 2017; Beheshtian et al., 2018; Behzadi et al., 2017; Chowdhury and Quaddus, 2016; Chowdhury and Quaddus, 2017; Cheng and Lu, 2017; Datta, 2017; Jüttner and Maklan, 2011; Hohenstein et al., 2015; Khan et al., 2012; Liu and Lee, 2018; Liu, et al., 2018; Mandal et al., 2016; Pettit et al., 2013; Ponomarov and Holcomb, 2009; Scholten and Schider, 2015;

Soni et al., 2014; Spiegler et al., 2012; Treiblmaier, 2018; Tukamuhabwa et al., 2017; Wieland and Wallenburg, 2013). However, they did not specify the type of risk to be mitigated through supply chain resilience (Ambulkar et al., 2015). There is a growing body of literature on the impact of supply chain resilience on supply chain reconfiguration (Blackhurst et al., 2005; Wilhelm, et al., 2013; Holmström et al., 2017). Rapid variations in types of disruption mean that the tools of the past might not be valid for mitigating current supply chain disruptions. Examining the role of supply chain resilience in mitigating the risks that led to reconfiguration of supply chains will add valuable insight into supply chains. This thesis therefore attempted to examine the impact of supply chain resilience on reconfiguration. The context of the study is Qatar because this provides an opportunity to understand the relationship under one particular type of risk, the blockade. The responses used for analysis were all from Qatari organizations. This research therefore contributes to knowledge in the area of supply chain resilience and reconfiguration. In particular, it identified the characteristics of supply chain reconfiguration and the effect of supply chain resilience in mitigating one particular econo-political risk. The findings also have significant practical applications that can be used by organizations and practitioners wishing to mitigate risks to supply chains.

1.6 Objectives of the study

The major objectives of this research are:

1. To gain an insight into supply chain management in Qatar, with a focus on resilience and reconfiguration.

2. To test the validity of some hypotheses related to (a) risk management culture, agility, collaboration, and integration in supply chain resilience, and (b) reconfiguration in supply chains.
3. To develop a systematic mapping review for supply chain resilience and reconfiguration studies, covering type of research, methodology, definition, supply chain resilience enablers, and supply chain reconfiguration characteristics.
4. To examine the relationship between supply chain resilience, enabled by risk management culture, agility, collaboration, and integration, with supply chain reconfiguration. The model was tested under conditions of a particular econo-political risk in Qatar.
5. To develop a framework to understand the relationships among the enablers of resilience in a supply chain.
6. To develop a framework to select the best approach to reconfiguration of supply chains.
7. To develop a framework to model and evaluate the characteristics of supply chain reconfiguration by integrating ANP-BSC.

1.7 Significance of the study

Building a resilient supply chain is important in developing a supply chain management strategy that reduces the impact of disruptions and enables the supply chain to return quickly to normal or better (Sheffi and Rice, 2005). Previous scholars have noted the significance of research on building supply chain resilience (e.g. Beheshtian et al., 2018;

Chowdhury and Quaddus, 2016; Johnson et al., 2013; Jüttner and Maklan, 2011; Mandal et al., 2016; Scholten and Schneider, 2015). However, none of the previous studies on supply chain resilience have attempted to develop an integrated framework of supply chain resilience covering proactive and reactive capabilities and links to supply chain reconfiguration. One exception is the empirical paper by Ambulkar et al. (2015), which proposed an integrated framework for firm resilience and supply chain disruption orientation based on resource reconfiguration and risk management resources infrastructure. Ambulkar et al. (2015) also developed a measurement scale to examine the impact of supply chain disruption orientation, resource reconfiguration, and risk management infrastructure on firm resilience. They noted that supply chain resilience is a budding field of research and has been a matter of increasing interest among researchers since Rice and Caniato (2003) called attention to the importance of building secure and resilient supply networks. Various empirical studies have proposed supply chain resilience frameworks to help practitioners to reduce the impact of disruptions and enable organizations and supply chains to recover quickly from disruptions (Ambulkar et al., 2015; Chowdhury and Quaddus, 2016; Chowdhury and Quaddus, 2017; Jütter and Maklan, 2011; Liu et al., 2018; Scholten and Schider, 2015; Wieland and Wallenburg, 2013). However, thus far, no article, whether empirical or review, has exclusively looked at supply chain resilience with supply chain reconfiguration. The potential contributions of this thesis are therefore:

1. It provides insights on supply chain resilience and reconfiguration and how to build on previous studies to enrich our understanding in this area.

2. The systematic mapping review of supply chain resilience and reconfiguration will help academics and managers understand the interconnectedness of building resilience enablers into supply chains. The review also indicates the main characteristics used to reconfigure supply chains.
3. The study is among the earliest attempting to address issues of supply chain reconfiguration and explore the role of resilience in supply chain recovery from disruptions, especially how it contributes to restructuring the supply chain.
4. As far as can be ascertained, the proposed framework is the only analytical platform that models specified enablers of supply chain resilience with supply chain reconfiguration, and projects recovery from an econo-political risk.
5. The study will help in testing the positive influence of supply chain resilience and reconfiguration.
6. The findings provide practical guidance on the benefit of supply chain resilience, reinforcing the importance of agility, collaboration, and risk management culture in improving ability to recover from supply chain disruption and reconfigure the supply chain when it is needed.
7. The interpretive structural model proposed in this study helps to identify the relationships among resilience enablers.
8. The model also enhances understanding of the linkages between one particular form of risk, econo-political risk, and resilience enablers.
9. Most previous studies have been in developed economies. This study therefore extends the supply chain resilience literature to a new setting to discover whether

enablers in one setting, developed economies, are also effective in another, developing economies (Soni et al., 2014).

10. The use of the Analytic Network Process (ANP) allows managers to select the best alternative decision for reconfiguring the supply chain.
11. The integration of the balanced scorecard (BSC) to ANP provides important insights into the evaluation of the alternative decisions on reconfiguring the supply chain.

1.8 Research methodology

There are many possible methods for data collection and analysis, and researchers have to choose the approach and emphasis that will best answer their research problem (Churchill and Iacobucci, 2005). The two main approaches to data collection are quantitative and qualitative. A combination of these two approaches is often used to overcome the inherent limitations of each (Brewer and Hunter, 1989). Using mixed methods in data collection can also lead to more valid results (Jick, 1979). This study therefore used a mixed-methods or a multi-method field study approach incorporating both qualitative and quantitative methods. The methods were tailored to address the specific issues arising at each phase of the research process. The data collection process included two distinct phases. The first (the systematic mapping review, discussed in Chapter 2) was qualitative, and addressed domain-level issues. This enabled the development of a new construct. The second phase was quantitative and centered on the development and subsequent testing of the survey instrument, the ISM model, and the ANP-BSC model. A brief discussion of the methodological choices is given below.

The tools used in this research are:

1. Systematic mapping review, used to map and categorize existing literature on supply chain resilience and reconfiguration.
2. Questionnaire-based survey, to gain broad insights into supply chain resilience and reconfiguration in selected Qatari organizations.
3. Interpretive structural modeling (ISM) to establish relationships among the enablers of supply chain resilience. It was also used to find the key variables affecting resilience, to enable organizations to focus on these in particular.
4. Analytical network process (ANP), to solve multi-criteria decision-making problems. It was used to select the best alternative to reconfigure supply chains. It provides an opportunity to simultaneously consider the impact of criteria and sub-criteria, and also their interrelationships to select the best alternative course of action.
5. Balanced scorecard (BSC), as a tool to look beyond financial performance and also assess non-financial business performance after reconfiguration of the supply chain.

1.9 Scope of the study

The study attempted to target organizations in Qatar to explore the role of supply chain resilience in supply chain reconfiguration. The study was carried out in five phases.

Phase (1): A meticulous review of the available literature to identify the various determinants of supply chain resilience and reconfiguration. The review methodology, systematic mapping, helped in designing the research models for the study. The literature review identified four main resilience enablers (risk management culture, agility,

collaboration, and integration) associated with econo-political risk. To measure these resilience enablers, scales were adopted from previous studies and modified to fit the level of understanding in organizations. A pilot study was conducted to confirm the unidimensionality of the scales and to remove any errors.

Phase (2): Identifying the relationships between supply chain resilience enablers under conditions of econo-political risk. Interpretive structural modeling (ISM) was used to understand the complex relationships among the resilience enablers related to the econo-political risk. To measure these enablers, an ISM model was developed and modified, drawing on expert advice.

Phase (3): Validation of the research scale and model building. The study started with the exploration and confirmation of constructs using statistical tools. Data were collected from a sample of private sector organizations in various sectors in Qatar. The rationale for selecting private sector organizations was that they tend to be more environmentally-aware and readily accept new and innovative ideas. A measurement model and structural model were applied to the data. The proposed research model and hypotheses were tested using partial least squares-structural equation modeling (PLS-SEM). The demographic characteristics of the sample were examined using SPSS.

Phase (4): A multi-criteria decision-making model, based on the analytic network process (ANP), was developed to use pairwise comparisons to measure the weights of the characteristics of supply chain reconfiguration, then rank the best alternative decisions. The balanced scorecard (BSC) was integrated with ANP to evaluate the supply chain reconfiguration performance.

Phase (5): Preparing a summary of the research with a detailed discussion of the key findings. Research implications for academics and managers were outlined. A list of limitations and directions for future research were set out.

1.10 Thesis structure

An extensive literature review was undertaken to identify the gaps in the literature on supply chain resilience and reconfiguration. A secondary empirical study was also conducted to provide an overview of the current state of supply chain resilience and reconfiguration. A questionnaire was developed drawing on the systematic mapping review and discussion with experts in supply chains. This was used in a survey on supply chain resilience and reconfiguration in selected private sector organizations in Qatar. The resilience enablers selected for this purpose were risk management culture, agility, integration and collaboration. The survey was followed by developing an ISM-based framework for supply chain resilience under conditions of econo-political risk.

To understand the relationships among the enablers of supply chain resilience, the study proposed a hierarchy-based framework using ISM. This framework helps to expose the relative importance of the variables in supply chain resilience under conditions of one particular econo-political risk. It also helps to identify the most important variables related to resilience, which may require more attention from supply chain professionals. There may be many approaches to mitigating risk, so an ANP-BSC-based framework was proposed to select the best alternative approach to supply chain reconfiguration under this particular econo-political risk. Supply chains are affected by a number of factors, including the flows

of information and products, financial support, value, and risk. The quantification of various risks that could affect the supply chain, and the evaluation of the reconfiguration options were analyzed using the analytic network process and the balanced scorecard.

The structure of this thesis is outlined in Figure 1.1

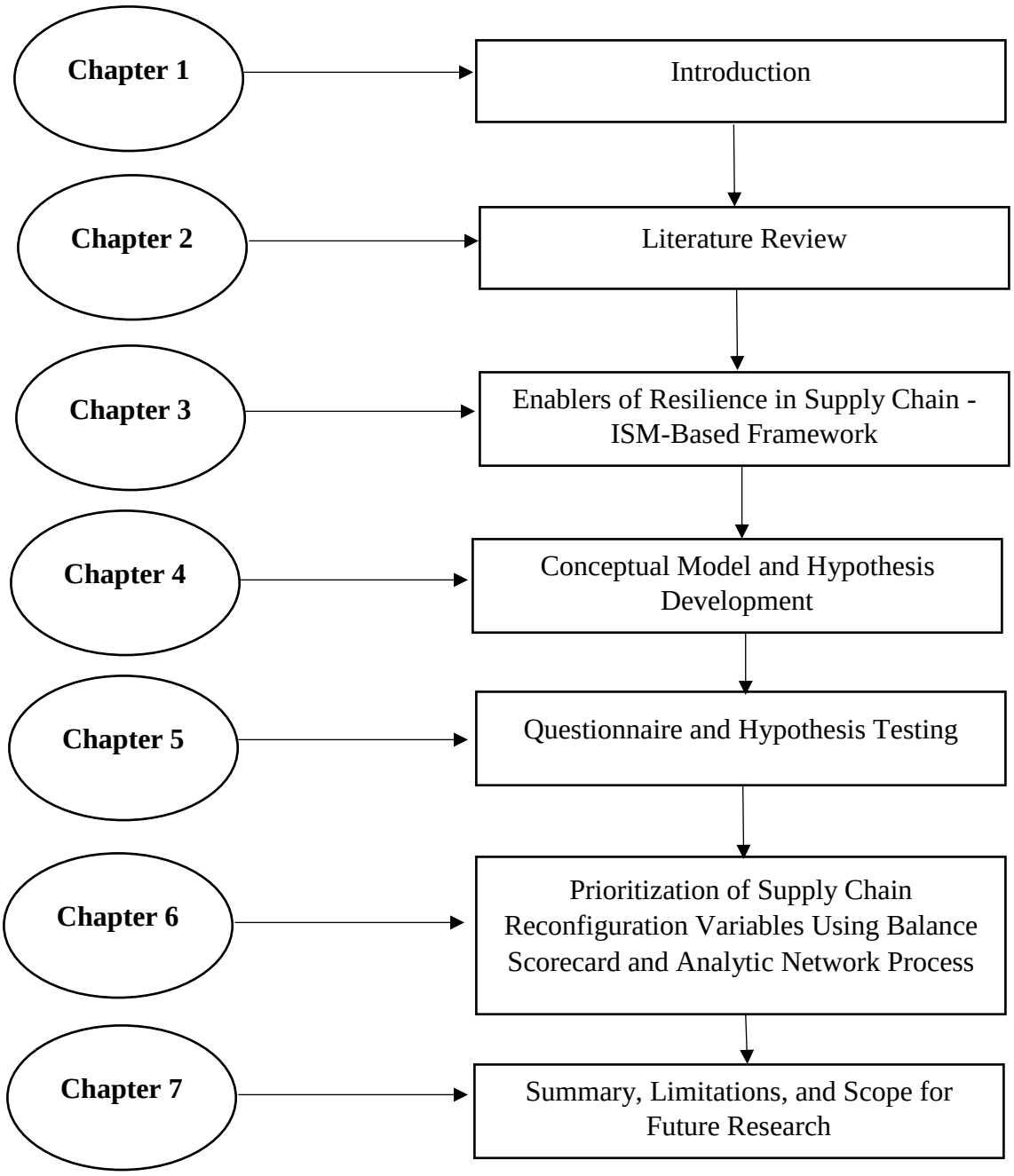

Figure 1.1. Thesis outline

Chapter 1 contains an introduction to supply chain management. It introduces issues related to supply chain resilience, supply chain reconfiguration, and the Qatar blockade. It also discusses the reasons for the research, and sets out its objectives. Finally, it provides an outline of the structure of the dissertation.

Chapter 2 contains a review of the literature on supply chain resilience, supply chain reconfiguration. It also discusses the issues related to the theories behind the proposed model of supply chain resilience and reconfiguration. This literature review enabled identification of the gaps in knowledge of this area. These gaps were the major drivers for this research. This chapter also includes information about selection of the research location, the type of research, research methods, definition, resilience enablers, and reconfiguration characteristics.

Chapter 3 identifies enablers of supply chain resilience, drawing on the literature review and survey. It explains how these variables were modeled using ISM to provide a framework for the effective deployment of management strategies for supply chain resilience. It also sets out their further categorization as independent, dependent, linkage, and autonomous variables on the basis of their driving and dependence power. Finally, it discusses the results and their managerial implications.

Chapter 4 starts with a discussion of the need for this study. It outlines the research objectives and discusses the rationale behind the selection of the study variables. It also provides details about hypothesis formation and the rationale behind the proposed relationships, and sets out the proposed model for this and the research questions. It also discusses the ethical considerations in the study.

Chapter 5 deals with the survey methodology used to validate the research model and hypotheses. It provides a justification for the survey methodology and formulation of hypotheses, and covers the development and administration of the questionnaire. It explains that a sample size of 314 was selected, and that 253 usable responses were received, a response rate of 80.57%. The chapter also details the analysis and findings of data from the questionnaire. These included descriptive statistics and the results of PLS path modeling. Both measurement and structural models are discussed in detail along with the result of the SEM, to test the proposed relationships between the variables and test the study model.

Chapter 6 sets out the hybrid analytical framework combining ANP and BSC. The chapter explains that this could be used by top managers to prioritize supply chain reconfiguration variables, and discusses these alternatives. The chapter shows that many related criteria, sub-criteria, determinants and dimensions can affect selection of the best approach.

Chapter 7 summarizes the research. It outlines the main findings, and sets out the implications for academics and managers. It concludes by setting out the study limitations and the scope for future research.

1.11 Conclusion

This chapter has introduced the ideas of supply chain resilience and reconfiguration, and explained about the blockade of Qatar. These are the prime focus and context for this study. The chapter has also set out the research problem, objectives, scope, significance and potential contributions, with a brief description of the research methodology, and an outline

of the thesis structure. The next chapter examines the literature in this field, using systematic mapping review techniques.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The management and operations research literature is currently experiencing considerable development in the fields of supply chain resilience and reconfiguration. However, there has been little attention paid to the relationship between these two (Ambulkar et al., 2015).

The aim of this chapter is to discuss what is known about the relationship between supply chain resilience and reconfiguration. The first part briefly introduces supply chain resilience and reconfiguration theories and highlights the role of different resilience enablers in mitigating supply chain risk. It concludes by noting that the resource-based view is the most often-cited theory in this area, especially for examining dynamic capabilities in supply chain resilience.

The second part discusses the main research streams in this area. It grounds the thesis in a clear literature review methodology, that of a systematic mapping review (Petersen et al., 2008). The section concludes by justifying the importance of supply chain resilience and reconfiguration in mitigating risk and recovering from disruptions. Finally, the chapter sets out the overall research objectives of the thesis.

2.2 Theoretical background

Many years ago, researchers started to recognize the importance of organizational capability and resources for firm performance. Organizational capability plays an important role in inter-organizational competition (Chen et al., 2014). It has been defined as a firm's

overall ability to coordinate its complex human and other resources effectively to achieve higher firm performance (Barney, 1991). The resource-based view of the firm and its subsets, resource-based theory, core competencies, and dynamic capability, have emerged as major theoretical pillars in supply chain management and other management fields (Halldorsson et al., 2007). In particular, the dynamic capability view focuses on exploiting and developing internal and external firm-specific competences to address environmental changes (Teece et al., 1997).

Barney (1991) linked firms' resources with sustainable competitive advantage. He suggested that there were four important indicators of the ability of a firm's resources to produce a sustainable competitive advantage. These were value, rareness, immutability, and sustainability. Newbert (2007) described this 'resource-based view' (RBV) as one of the most widely-accepted views of strategic management. He found that the RBV had been evolving over time, and that there were large numbers of empirical studies supporting it. Lockett et al. (2009) also examined the theoretical and empirical work on the RBV. They suggested that future research should examine the causes of firm heterogeneity rather than its consequences. They also called for more focus on the neglected theoretical issues of resource functionality, and asserted the importance of developing the RBV alongside other theories to explain strategic behavior. Finally, they suggested that scholars should reflect on the methodological approaches to empirical research using the RBV.

The RBV has made a considerable contribution to ideas on the dynamic capabilities of supply chain resilience (Golgeci and Ponomarove, 2013; Brandon-Jones et al., 2014; Brusset and Teller, 2017; Chowdhury and Quaddus, 2017; Liu and Lee, 2018; Liu et al.,

2018; Dubey et al., 2019a; Hendry et al., 2019). Dynamic supply chain resilience capabilities (i.e. re-engineering, collaboration, agility, and risk management culture) reinforce firms, and support their readiness to respond to and recover rapidly from disruptions (López and Ishizaka, 2017). Dynamic capabilities can enhance the sustainability of supply chains by allowing firms to integrate, create, and reconfigure resources in a dynamic business environment (Bag et al., 2019). Hendry et al. (2019) compared the three areas of dynamic capabilities (sense, seize and transform) with areas of supply chain resilience (prepare, respond and recover) and found similarities between the two (see Figure 2.1). They argued that the sensing and scanning activities of a firm, used to recognize opportunities and threats, are similar to the preparation phases of supply chain resilience. Seizing is the response phase of supply chain resilience, when firms respond to sensed opportunities and threats in the supply chain. Finally, reconfiguration of the supply chain or activities is similar to the transformation capability, which firms may use before, during, or after a threat to the supply chain. They suggested that transformation could therefore allow firms to avoid supply chain disruptions.

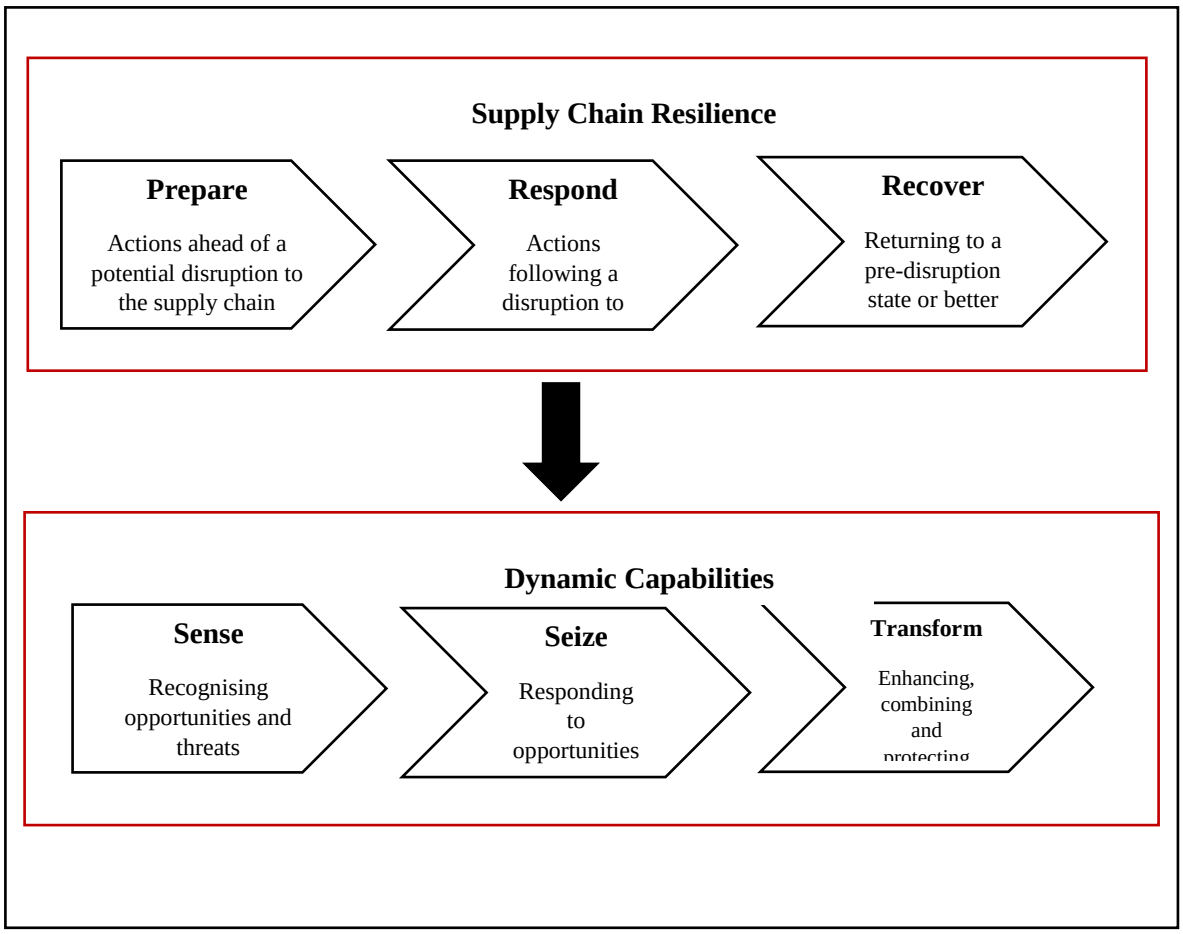

Figure 2.1. The link between supply chain resilience and dynamic capabilities (Hendry et al., 2019)

Previous studies have shown that integration can be also a source of resources to help firms respond to environmental changes and disruptions (Hohenstein et al., 2015; Ponomarove and Holcomb, 2009). Some studies have used the RBV to examine the factors that affect the organization's abilities to improve supply chain resilience (Brandon-Jones et al., 2014; Liu and Lee, 2018). They found that factors such as information-sharing and connectivity could be seen as complementary resources that lead to visibility (Brandon-Jones et al., 2014). However, supply chain resilience itself can also be seen as a type of

organizational resource that helps organizations to cope with environmental change and deliver sustainable development that improves both performance and customer satisfaction (Liu et al., 2018; Ponomarove and Holcomb, 2009). RBV can also be used to consider the benefits gained through dynamic and operational capabilities (Cheng and Lu, 2017). Supply chain members may innovate to achieve a competitive advantage by bundling valuable, rare, inimitable, and non-substitutable resources to create capabilities (Cheng and Lu, 2017; Golgeci and Ponomarove, 2013). Organizations and supply chains can therefore also improve resilience by acquiring, developing, and combining their resources and capabilities to respond to environmental changes and improve firm performance (Chowdury and Quaddus, 2017).

Recent studies have used other theories to examine supply chain resilience, such as the information processing theory (Jain et al., 2017; Dubey et al., 2019b), social exchange theory (Bhattacharjya, 2018; Jain et al., 2017), high reliability theory (Chowdury and Quaddus, 2016; Jain et al., 2017), normal accident theory (Chowdury and Quaddus, 2016), ontology-based view (Singh et al., 2019), multilevel theory (Adobor, 2019), and standards inventory theory (Liu et al., 2016). The information processing theory explains that organizational design, structure, and capabilities require certain information to be processed (Dubey et al., 2019b). It has been argued that sharing relevant information across the supply chain can reduce the bullwhip effect—the idea that as customer demand changes, larger variations in stock levels develop further up the supply chain—and increase the accuracy of information-sharing and supply chain visibility (Jain et al., 2017). Some researchers have suggested that social exchange theory between partners has an effect, because of

international networks in supply chains. They argued that a deeper understanding of the underlying dynamics could improve relationships and enhance trust between partners (Jain et al., 2017; Bhattacharjya, 2018).

Chowdury and Quaddus (2016) used two organizational theories, normal accident theory and high reliability theory, to discuss the effects of accidents of any kinds on organizational operations. They argued that firms must develop a complex awareness of risk to reduce unexpected disruptions, and increase reliability to avoid high-level supply chain vulnerability (Chowdury and Quaddus, 2016; Jain et al., 2017). Resilience enablers, such as agility, adoptive capabilities, and a risk management culture, could therefore influence a firm's operations and enable managers to plan for multiple contingencies (Jain et al., 2017).

As far as can be ascertained, only one theory has been used to discuss supply chain reconfiguration, transaction cost theory. This was used to consider reallocation of activities when redesigning the supply chain (Kindel et al., 2012). There is therefore a lack of theoretical background on supply chain reconfiguration.

Drawing on the literature, a theoretical framework was developed to investigate the theories used in supply chain resilience and reconfiguration studies (Figure 2.2).

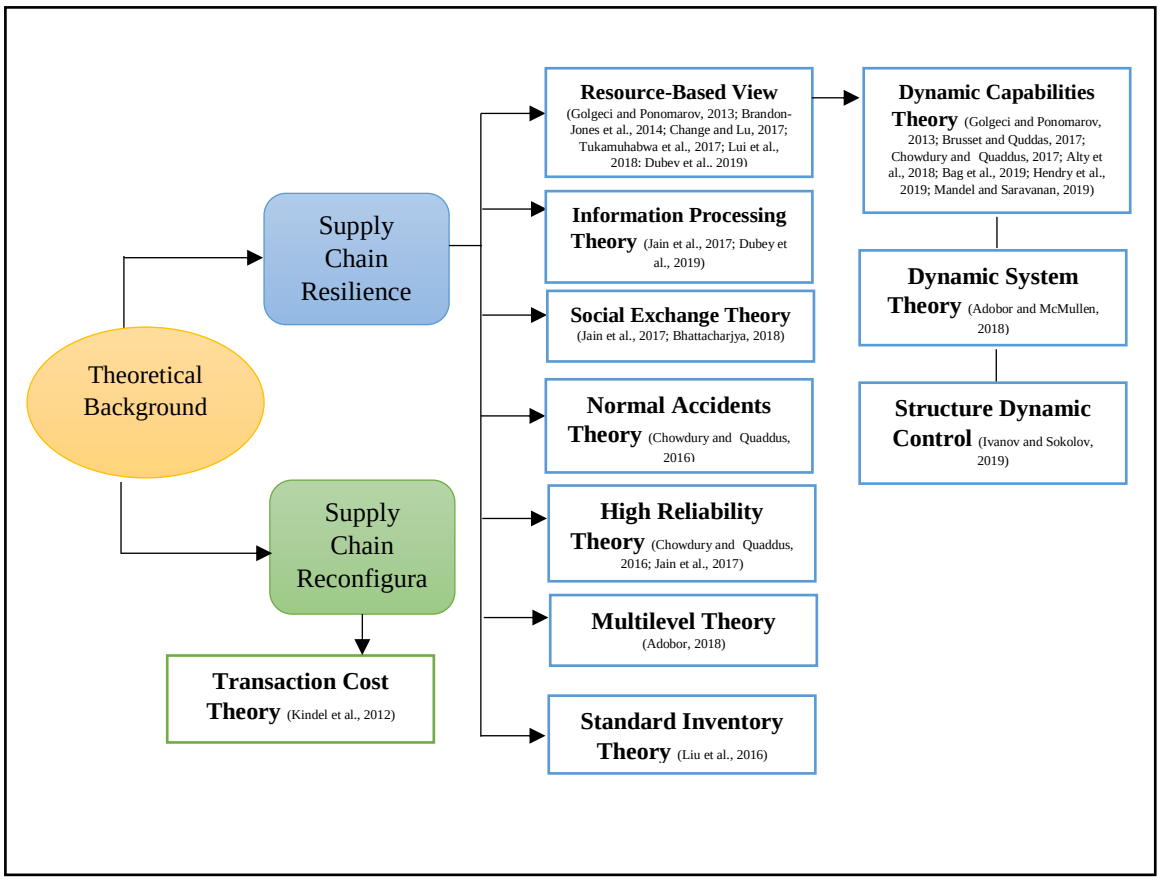

Figure 2.2. Theoretical framework for supply chain resilience and reconfiguration

2.4 Supply chain resilience

Resilience was initially seen as an ecological issue, related to domains and stability in natural systems and ecological processes, with random events, and heterogeneity of temporal and spatial scales (Folke, 2006; Holling, 1973). It was therefore viewed as persistence of relationships within a system and the system's ability to absorb changes and return to equilibrium after disturbance (Holling, 1973). A definition of resilience has now received general agreement among the majority of management scholars. In particular, it is clear that the concept has a multidisciplinary and multidimensional nature (Chowdhury and

Quaddus, 2016; Hohenstein et al., 2015; Kamalahmadi and Parast, 2016; Thome et al., 2016; Tukamuhabwa et al., 2015). As thinking on resilience has matured, many social scientists have started to consider its role in management domains including economics, strategic management, and operations management (Annarelli and Nonino, 2016). However, there are distinct differences between each of those domains, and operational resilience serves as a link between supply chain resilience and responsiveness to risks and disruptions (Annarelli and Nonino, 2016; Kamalahmadi and Parast, 2016).

Research on supply chain resilience is divided into two main areas, based on its timing. Pre- disruption resilience covers capabilities such as flexibility, visibility, velocity, collaboration, disaster readiness, and agility ahead of any disruption (e.g. Beheshtian et al., 2018; Chowdhury and Quaddus, 2016; Johnson et al., 2013; Jüttner and Maklan, 2011; Mandal et al., 2016; Scholten and Schneider, 2015). Post-disruption resilience is the capability to overcome issues and events after they have happened, including recovery time, cost, and response effort (e.g. Beheshtian et al., 2018; Chowdhury and Quaddus, 2016; Lam and Bai, 2016; Liu et al., 2018; Pournader et al., 2016; Treiblmaier, 2018). Studies using both perspectives have found a significant relationship between supply chain resilience and firm performance. Some researchers have also suggested that it is important to consider competitive advantage alongside dynamic capabilities for resilience to guarantee the continuity of firms and supply chain operations (Brusset and Teller, 2017; Chowdhury and Quaddus, 2017; Soni et al., 2014). There is huge focus on the relationships between supply chain resilience, firm performance and competitive advantage, but little is known about how

supply chain resilience is associated with supply chain reconfiguration (Ambulkar et al., 2015).

Supply chain management strategies are usually categorized into two: creating robustness and creating resilience. The main aim of a robust supply chain is to resist disturbances, and maintain the original structure. A resilient supply chain, by contrast, aims to return quickly to its original state or a desirable new state after being disrupted (Behzadi et al., 2017; Christopher and Peck, 2004). Supply chain resilience strategies can be classified into two main areas: proactive and reactive (Ali et al., 2017a; Tukamuhabwa et al., 2017). Proactive strategies mainly focus on pre-disruption activities, such as planning and preparing (Ambulkar et al., 2015; Ponomarove and Holcomb, 2009). Reactive strategies focus on post-disruption activities, and assuring recovery (Urciuoli et al., 2014). Both types of strategies are explicitly discussed in the supply chain resilience literature. Many researchers have linked them with supply chain resilience enablers, such as collaboration and flexibility (Hohenstein et al., 2015; Tukamuhabwa et al., 2017).

2.5 Supply chain reconfiguration

Reconfiguration is defined as "the activities in which firms engage when adding, redeveloping, recombining, or divesting resources or business unit" (Karim and Capron, 2016 p.1). Supply chain reconfiguration can have both strategic and operational aspects. Strategic aspects include the activities required to determine the correct number, location and capabilities of manufacturing plants and distribution centers, the set of suppliers to select and the effective flow of material throughout the supply chain (Kaminsky et al., 2004; Varsei

et al., 2014; Vidal and Goetschalckx, 1997). Operational supply chain reconfiguration is the reshaping of resources by businesses into new operational competencies (Storer et al., 2014).

A dramatic change in business paradigm will occur when the supply chain is restructured (Roh et al., 2014). However, dynamic reconfiguration of the supply chain is needed to cope with changes in demand and cost structure over time, because of variations in economic factors and the evolution of the business environment (Wilhelm et al., 2013). An increasing number of firms, both national or multinational, face the problem of reconfiguring their supply chain network (Lambiase et al., 2015). Multiple case studies suggest that changing supply chains is non-linear and requires re-planning and learning throughout the change effort to build the capacity and capability for change (Van Hoek et al., 2010). There are two important parameters affecting the reconfiguration of any supply chain. Financial capability is the money available to invest in the reconfiguration. Second, technology selection is the decisions about which technology to use, including, for example, decision support systems and direct digital manufacturing, which may depend on activity location (Lambiase et al., 2013).

A limited amount of research has been carried out on changes in logistics and supply chains. However, reconfiguration of supply chain management is considered to fall into the same two categories as reconfiguration in general management. First, it may occur with restructuring, as often happens to address natural risks and crises (Kinkel, 2012; Osman and Demirli, 2010; Ross, 2000). Second, it may occur without restructuring, which often happens when the product is redesigned, or inventory allocations are considered (Dev et al., 2014; Mondragon et al., 2018; Wei and Wang, 2010).

In 1993, a multiple stages framework was developed for reconfiguring European logistics systems (O'Laughline et al., 1993). It was based on visioning, strategic analysis, and planning and management of the process. It has been argued that the visioning stage is the most critical (Van Hoek et al., 2010). It has three key enablers, top management support, the use of a total supply chain perspective, and the use of a structured planning process for making the case and preparing for the change (Van Hoek et al., 2010). Ross et al. (1998) modified this framework by offering a six-step methodology for reconfiguration of an existing supply chain network. Their methodology allows integration of the decision makers' input throughout the process. This approach was successfully used for a decision support system for distribution of petroleum products. Reconfiguration of an existing supply chain network has also been studied from a strategic perspective, considering the importance of supply chain synchronization and postponement strategies (Van Hoek, 1998, 1999). Supply chain synchronization enhances coordination among existing members and leads to better responses to changes in demand and product designs (Osman and Demirli, 2012). Postponement strategies are used to reduce the inventories of finished goods in anticipation of future orders (Van Hoek, 2001). These two types of strategies are therefore important in reconfiguration of supply chain networks.

A number of researchers have investigated the role of operations in supply chain reconfiguration. Many of these have discussed direct digital manufacturing, or the use of additive manufacturing technologies to manufacture end-use components (Holmström et al., 2017). Linked with supply chain reconfiguration, direct digital manufacturing-based dynamic supply chain reconfiguration is a new operational practice that allows process

contextualization (Holmström et al., 2017). Finally, many previous studies described supply chain innovation linked to reconfiguration (Ageron et al., 2013). They argued that innovation could also rely on logistics network reconfiguration to increase collaborative relationships between supply chain partners (Ageron et al., 2013). Continuous innovation in computer technologies, product design and other areas have made the use of modeling to support decision-making very common in supply chain management.

There are three main supply chain reconfiguration mechanisms, decision support systems, postponement strategies and supply chain synchronization.

2.5.1 Decision support systems

Decision support systems are defined as "computer technology solutions that can be used to support complex decision-making and problem solving" (Shim et al., 2002 P.1). The classic design of decision support system contains three components for databased management capability: access to internal and external data, information and knowledge; power modeling functions; and simple user interface design that enables interactive reporting, queries, and graphical functions (Shim et al., 2002). Many firms need to change their supply chain very rapidly, which requires a huge amount of data (Beraldi et al., 2011). The use of efficient and effective decision support systems can assist the complex decision-making process and improve the quality and effectiveness of solutions (Beraldi et al., 2011).

Decision support systems have evolved significantly in supply chain reconfiguration. They have been integrated into supply chain reconfiguration to improve demand planning (Kirkwood et al., 2005), inventory allocation and assembly planning (Kristianto et al., 2012),

timing and extent of inventory replenishment (Borade and Sweeney, 2015), and global competition and customer expectations (Guner et al., 2016) in both manufacturing and product design. Hammami and Frein (2014) developed a profit-maximization optimization model that was specific to the redesign of global supply chains when integrating transfer pricing. Their model supported four main decisions: location and reallocation of activities, capacity planning, selection of external suppliers, and transfer pricing. Two of those decisions, location and reallocation activities and capacity planning, have been extensively examined in other studies using different models. Decisions about location and reallocation of activities are used to determine whether sites must be closed or opened, for example for inventory allocation (Borade and Sweeney, 2015; Hammami and Frein, 2014; Kristianto et al., 2012; Wu et al., 2013). Capacity planning has been used for demand planning, assembly planning (Kristianto et al., 2012), enterprise resource planning (Dev et al., 2016), production and replenishment planning (Borade and Sweeney, 2015), supplier planning capability (Kirkwood et al., 2005), and maintenance planning (Guner et al., 2016). Recent global crises, such as the diplomatic crisis in Qatar, have further emphasized the need to complement human expertise and experience with decision-making support provided by advanced systems integrating decision models and algorithms (Beraldi et al., 2011).

2.5.2 Postponement strategies

Postponement is an organizational concept defined as a delay in the final process and manufacturing activities until the customer order has been received. There are three principles of postponement: form, time, and place (Van Hoek, 1998, 1999). Form

postponement is a delay in the form and function of the product in the chain until the customer order is received. Time and place postponements are delays in the forward movement of goods and the position of inventories in centralized manufacturing or distribution operations. Van Hoek (2001) compared traditional and postponement approaches to operations, considering uncertainties, volume, variety, lead times, and supply chain approach. Postponement reduced risk of volume and variety mix by delaying finalization of products, and enabling batches of one (i.e. job shop for customization and flow shop elsewhere), customization and flexibility. It also increased accuracy of response, and reduced complexity in operations (Van Hoek, 2001). Its implementation requires reconfiguration of supply chain management across companies and borders (Guericke et al., 2012; Kisperska-Moron and Swierczek, 2011; Oh et al., 2013; Saghiri and Barner, 2016; Van Hoek, 1998, 1999, 2001; Weskamp et al., 2018). Recent studies have considered a different three types of postponement: design, order, and manufacturing. Those deal with product quality and design, frequency of delivery, and the specification of purchase items (Saghiri and Barner, 2016).

2.5.3 Supply chain synchronization

Postponement strategies may affect the synchronization of the supply chain when there are multiple suppliers. Coordination between the different members of the chain is an important step in supply chain management, as the materials move from one supplier to the next (Khouja, 2003). The production lead time (Takahashi et al. 2005), cycle time for production or transportation (Khouja, 2003; Vegara et al., 2002), and the timing point of supply or demand (Wang et al., 2004) are the three main objectives of supply chain

synchronization (Jung and Lee, 2010). The focus of these objectives is to reduce the delivery time from suppliers and to get products to buyers. Implementation of an effective synchronization plan is therefore one of the most important ways to improve the performance of a supply chain (Jung and Lee, 2010).

2.6 Systematic Mapping Review of Supply Chain Resilience and Reconfiguration

Systematic mapping reviews (also called scoping reviews) have their origins in the fields of health and engineering and have been developed through the Cochrane Collaboration (Sheldon and Chalmers, 1994; Hemsly-Brown and Oplatka, 2015; Petersen et al., 2015). Systematic mapping reviews aim to map the key concepts underpinning a research area by categorizing existing literature on a particular topic then identifying future avenues for work (Arksey and O'Malley, 2005; Petersen et al., 2015). They therefore focus on the structure of the research area rather than gathering and synthesizing evidence like systematic literature reviews (Petersen et al., 2015). Some features of this approach have been implemented in social sciences (Tranfield et al., 2003) and human resource management (Arias, et al., 2018). However, as far as it has been possible to ascertain, no previous studies have carried out a systematic mapping review in supply chain management.

2.6.1 Systematic Mapping Review Process

This study carried out a systematic mapping review using the process proposed by Petersen et al. (2008) (see Figure 2.3).

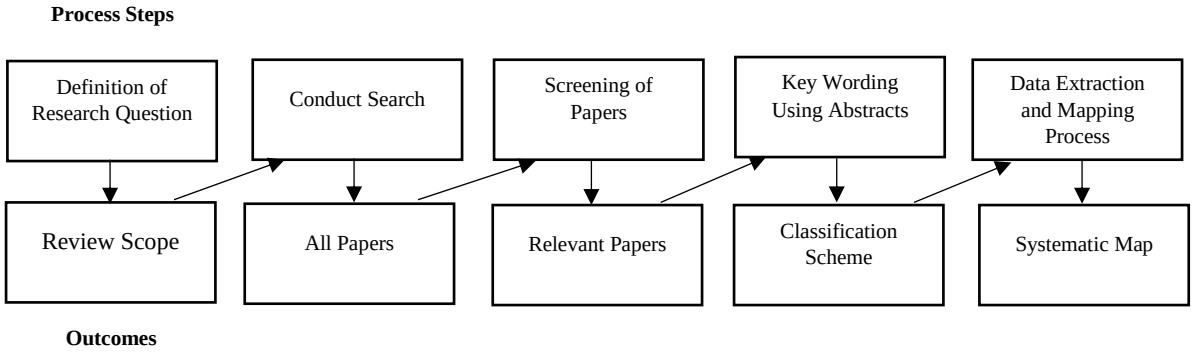

Figure 2.3. Systematic mapping study process (Petersen et al., 2008)

The study aimed to explore the literature on supply chain resilience. It therefore identified six mapping questions (MQs) and the main motivation behind each (see Table 1). The MQs followed the procedure introduced by Kitchenham and Charters (2007), using a structure of population, intervention, comparison, outcome, and context (PICOC). Table 2 shows this structure and the broad areas covered. This paper did not compare any interventions, because of the methodology used. The mapping questions were considered against the results of selected studies that aimed to address or examine supply chain resilience.

Table 2.1. Systematic Mapping Review Questions

	Mapping Question	Main Motivation
MQ1	Which sources include papers on supply chain resilience and how many sources include supply chain resilience papers?	To identify the list of relevant studies on supply chain resilience
MQ2	Which geographical areas have reported approaches to supply chain resilience?	To identify the international clusters of knowledge and to determine the specific research groups focusing on supply chain resilience.

MQ3	What research types have been used in supply chain resilience studies?	To identify research types and changes in use over time in the supply chain resilience literature.
MQ4	Which types of methodologies are most frequently used to validate supply chain resilience approaches and models? Are real-life data involved?	To identify the different types of methodology used to validate models and approaches in supply chain resilience studies.
MQ5	Which of the reported enablers are used most frequently for supply chain resilience? Have the various enablers of supply chain resilience received the same amount of research attention?	To identify the enablers used for supply chain resilience and to classify the enablers by level of research attention.
MQ6	How have supply chain reconfiguration characteristics been tackled in the supply chain management literature?	To explore the characteristics of supply chain reconfiguration.

Table 2.2. Structure of questions for systemic mapping review

Criteria	**Description**
Population	Studies that describe how supply chain resilience is built into supply chains.
Intervention	Studies that focus on the approaches (methods, strategies, techniques, tools, enablers, capabilities, and components) that are used to build supply chain resilience.
Comparison	N/A
Outcome	Studies that focus on the effectiveness of supply chain resilience measures.
Context	Studies that examine the enablers used to evaluate supply chain resilience.

2.6.2 Search Strategy

Accurate selection of supply chain resilience studies requires transparent search and analysis processes. The search strategy consisted of three steps: search terms, literature resources, and search process (Peters et al., 2015).

2.6.2.1 Search Terms

The search terms were developed in three steps:

1. The main terms associated with the mapping questions were identified, including “supply chain”, “supply chain resilience”, “resilience”, “enablers”, “approaches”, “capabilities”, “supply chain reconfiguration”, “reconfiguration”, and “characteristics”.
2. Alternative spellings and synonyms of the main terms were identified, including “resilient”, “resiliency”, “enabler”, “capability”, “component”, “SCRES”, and “reconfigure”
3. The Boolean Operators “OR”, “AND” and “NOT” were used to join synonymous terms and exclude any non-related terms to retrieve relevant records. Example searches included (“supply chain” AND “resilience”), (“supply chain resilience” OR “resilience”), (“supply chain resilience” NOT “organizational resilience”), (“supply chain” AND “resilience” OR “resilient” OR “resiliency”), (“supply chain resilience” AND “enabler” OR “component” OR “capability”), and (“supply chain” AND “resilience” OR “supply chain resilience” NOT “organizational resilience”), (“supply chain” AND “reconfiguration”), (“supply chain reconfiguration” OR “reconfigure”), (“supply chain reconfiguration” NOT “redesign”), (“supply chain” AND

"reconfiguration" OR "reconfigure"), ("supply chain reconfiguration" AND "characteristics" OR "attributes" OR "component"), and ("supply chain" AND "reconfiguration" OR "supply chain reconfiguration" NOT "organizational redesign").

2.6.2.2 Resources

An automatic search was performed using the pre-constructed search terms in three databases:

- Emerald
- Science Direct
- Scopus

These databases were chosen because they contained a number of known papers on the supply chain resilience (Ali et al., 2017a; Datta, 2017; Hohenstein et al., 2015). Google Scholar was excluded to avoid any irrelevant studies. The search was limited to articles published between 2009 and 2019. As per Ali and Gölgeci (2019), there is an exponential growth in the studies on resilience and dynamic supply chain networking published in last decade. In addition, economic slowdown i.e. recession started in 2009. It has led to increase in interest of the academicians and practitioners towards resilience and reconfiguration. Also, the frequency of natural disasters have increased in the last decade, which has played a major role in focusing the research on SC resilience and reconfiguration. Each database was searched separately. The search was based on title, abstract, and keywords.

To ensure the quality of the search and avoid missing any relevant papers, a two-stage process was used.

- **Stage 1. Initial Search**

A primary search was conducted in the three electronic databases using the identified search terms. The papers found were grouped together to form a set of candidate papers and any duplicate papers were removed.

- **Stage 2. Secondary Search**

The candidate papers were checked against the inclusion and exclusion criteria and their references lists reviewed to identify any further papers relevant to supply chain resilience.

2.6.2.3 Screening

This step was designed to identify studies that matched the research questions, based on their title, abstract, and keywords. Candidate studies identified in the initial search step were evaluated by two researchers using the inclusion and exclusion criteria. A third researcher was involved when required, for example, where there was no consensus on whether to include an article. The systematic mapping review process is shown in more detail in Figure 2. The inclusion criteria were:

1. Peer reviewed articles in journals.
2. The article was published between 2009 and 2019.
3. The articles were written in English.
4. The articles contained the search terms
5. The articles were published in a journal listed on ABDC 2016 and ABS only.

The exclusion criteria were:

1. The studies provided summaries of conferences or were editorials or guidelines for mapping studies.
2. The studies were not peer reviewed.
3. The studies were not written in English.
4. The studies were not accessible in full-text.
5. The articles were from conferences, book chapters, or workshops.

This stage provided a final set of 82 articles that met the study inclusion and exclusion criteria. The final stage was to read all the selected articles in full (see Table 2.3).

Table 2.3. Search results

Phases	**Number of papers remaining**
All papers	224
After removing non-related papers	192
After screening of papers	100
After full reading of papers	82

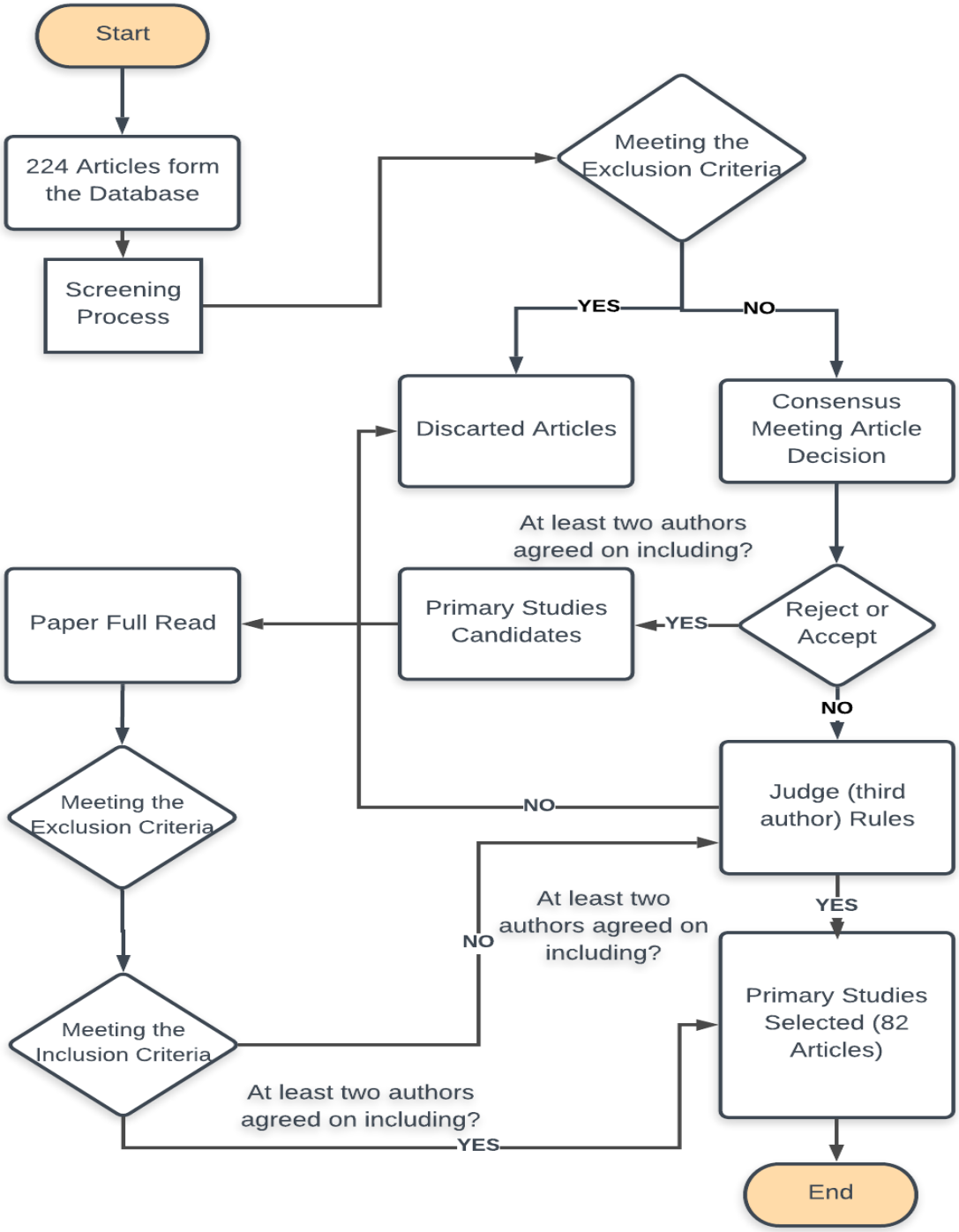

Figure 2.4. The systematic mapping review process

2.6.3 Data Extraction

The primary studies were scanned to extract the information required for the systematic mapping review. This included author names, year, title, aim, type of study, methodology, resilience enablers, reconfiguration characteristics, and geographical region (see Table 2.4). Once the data had been extracted from the selected studies, they were synthesized and tabulated to aggregate the evidence to answer the mapping questions(see The Appendix A&B). The first author's extraction was reviewed by the second author (Petersen et al., 2008), by retracting the information in the extraction form and checking its accuracy. The third author also checked the accuracy of the extraction data (Table 2.4).

Table 2.4. Data extraction variables

Data Item	Value	MQ
Study ID	Integer ID	
Article Title	The article label name	
Author Name	Set of authors' names	
Year of Publication	Year of publication	MQ1
Aim/Scope	The purpose of the study	MQ1
Geographical Areas	Which region the research covered	MQ2
Research Type	The type of research selected	MQ3
Research Methods	The method(s) used in the study	MQ4
Resilience Enablers	The list of resilience enablers reported	MQ5
Reconfiguration Characteristics	The list of reconfiguration characteristics reported	MQ6

2.6.4 Results

This section describes the results of the systematic mapping review of supply chain resilience and reconfiguration, based on 82 selected articles.

2.6.4.1 Descriptions of the selected articles (MQ1)

Figure 2.5 shows the distribution of the articles by subject. The largest number was on supply chain resilience (69 articles, 84%), followed by supply chain reconfiguration (13 articles, 16%). Figure 2.6 shows the trends in publication of these articles over the 10 years from 2009 to 2019. The number of supply chain resilience and reconfiguration studies dramatically increased during these 10 years. Over the last few years, the rate of increase in supply chain resilience and reconfiguration studies has accelerated, as firms try to build reactive and proactive strategies to manage pressure from environmental uncertainty, and reduce the damage from supply chain disruptions.

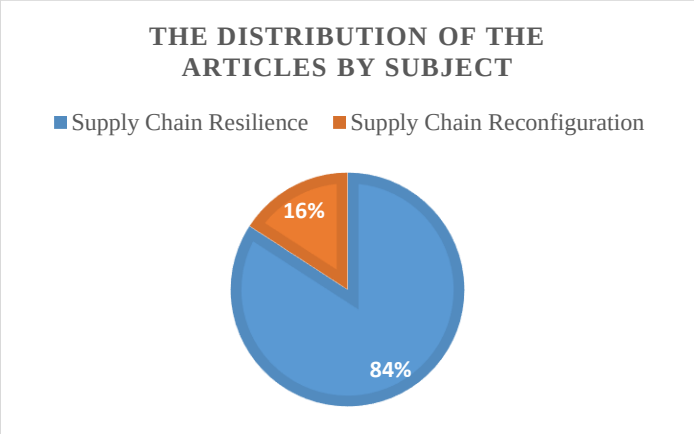

Figure 2.5. The distribution of the articles by subject

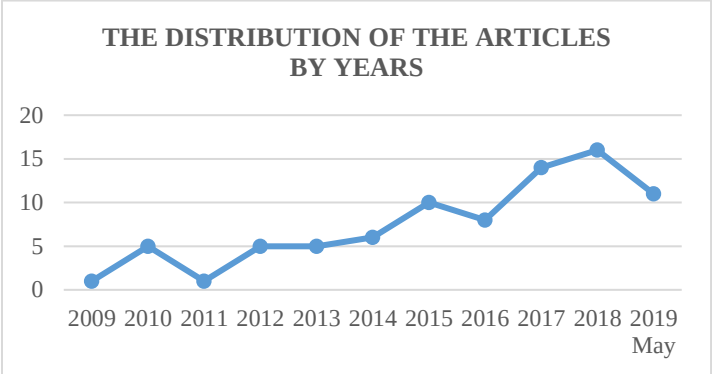

Figure 2.6. The distribution of the articles over time

Figure 2.7 shows the distribution of articles by journal of publication. The most popular journals were *Supply Chain Management: International Journal* (17 articles), *International Journal of Production Research* (11 articles), *International Journal of Production Economics* (seven articles), and *International Journal of Physical Distribution and Logistics Management* (five articles). It is reasonable that *Supply Chain Management: International Journal* contained the most articles, because this journal has a stated aim to push the boundaries of supply chain research and practices.

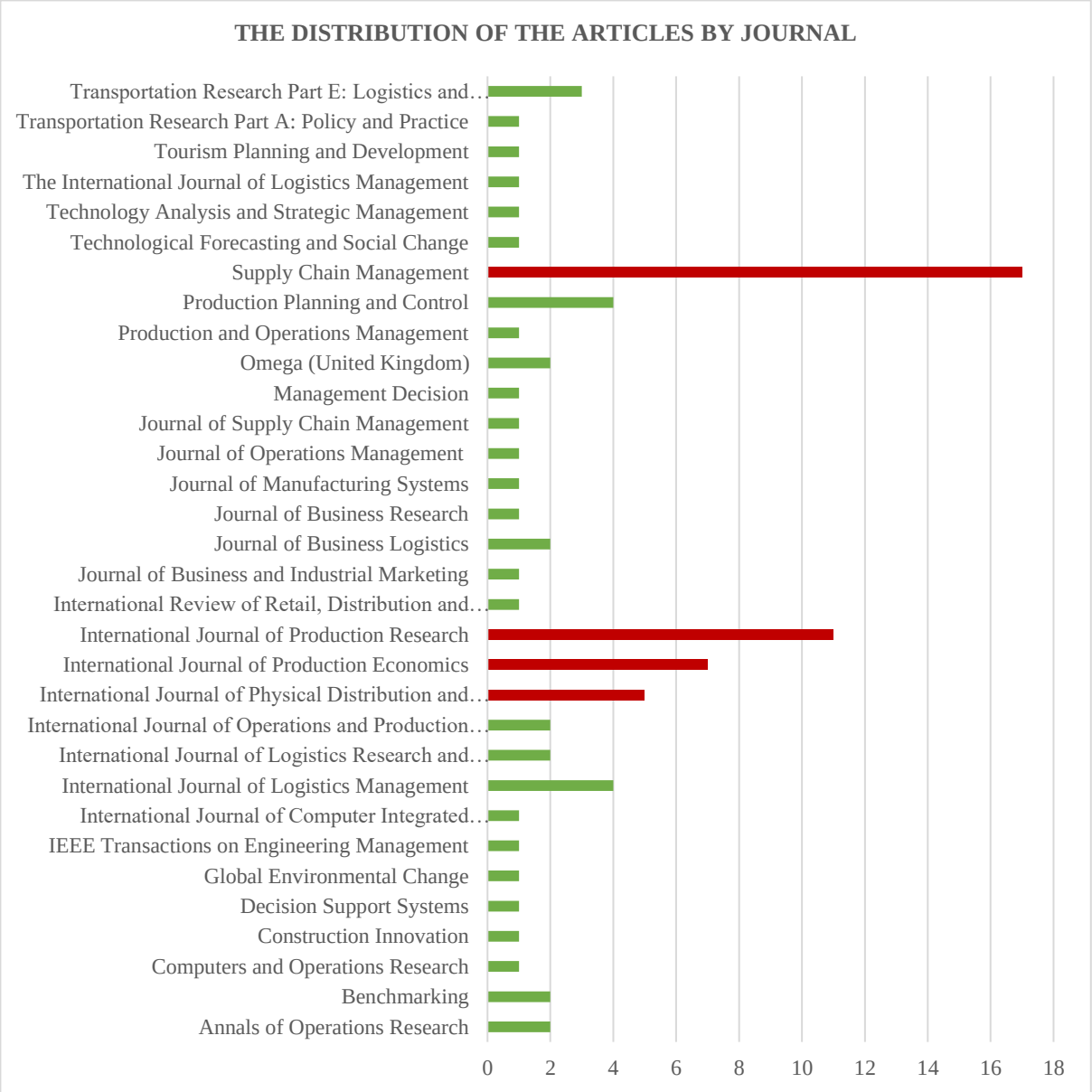

Figure 2.7. The distribution of the articles by journal

2.6.4.2 Geographical Areas (MQ2)

Studies on supply chain resilience and reconfiguration had been carried out in 19 countries (see Figure 2.8) across five main geographical areas (Figure 2.9). The majority of studies took place in either Europe (38%) or Asia (36%). The US, Australia, and South Africa had seen 17%, 6%, and 4% of studies. However, 32 of the reviewed articles did not specify the location.

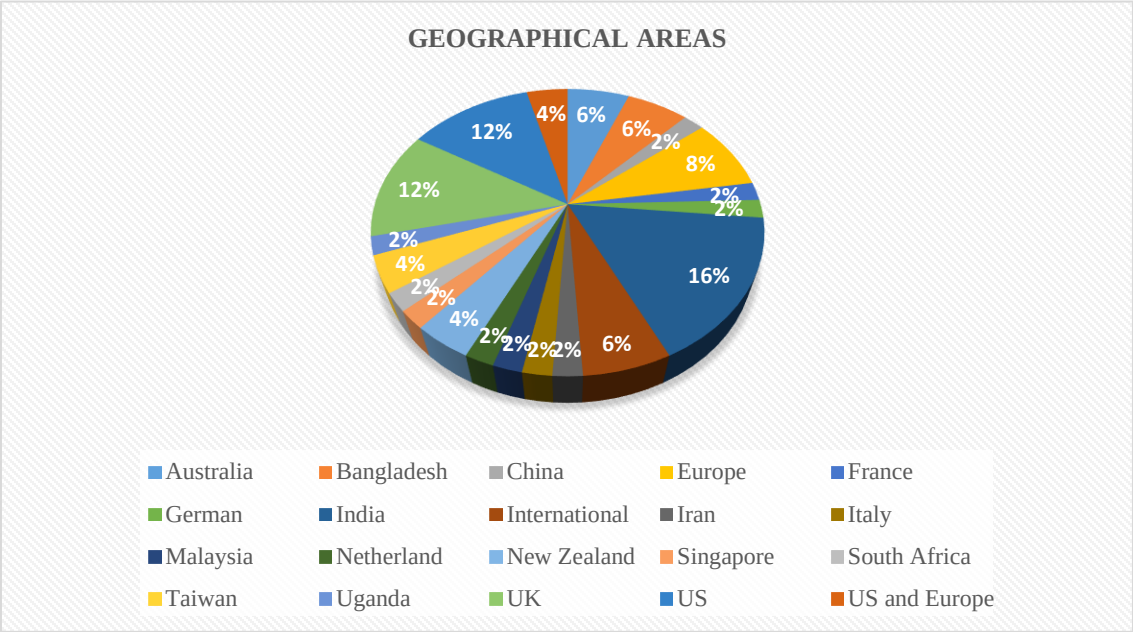

Figure 2.8. Country covered by the study (32 studies)

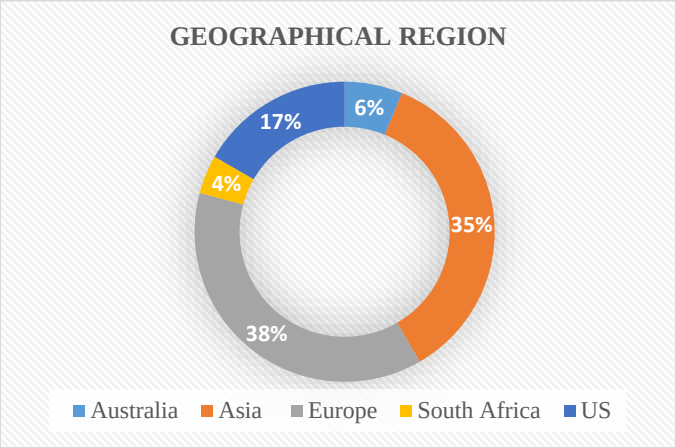

Figure 2.9. Geographical region covered by the study (32 studies)

2.6.4.3 Type of Research (MQ3)

Petersen et al. (2015) classified papers into three types: proposal of solution, validation research, and evaluation research. Table 2.5 outlines the three types of research and provides a description of each.

Table 2.5. Classification of research type (Petersen et al., 2015):

Research Type	Description
Proposal of Solution	"A novel solution for a problem or new significant extension to an existing technique"
Validation Research	"Investigating a proposed solution, which is novel and has not yet been implemented in practice. Investigations are carried out systematically, prototyping, simulation, experiments, mathematical systematic analysis and mathematical proof of properties"
Evaluation Research	"Evaluating a problem or an implemented solution in practice, case studies, field studies, and field experiments"

Figure 2.10 shows the main types of research in the selected papers, divided into case study, literature review, conceptual paper, and research paper. The majority were research papers (58 papers, 71%), with 14 literature reviews (17%), eight case studies (10%) and two conceptual papers (2%).

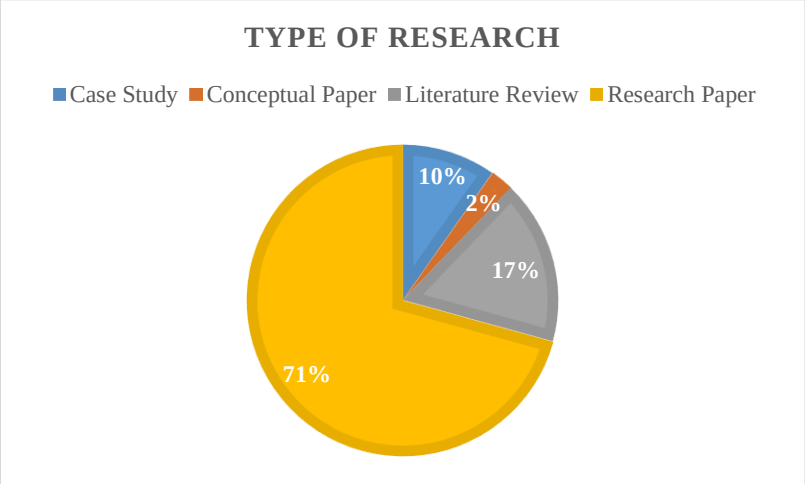

Figure 2.10. Type of research

Half the selected papers were considered evaluation research (Petersen et al., 2015) (see Figure 2.11). This suggests that researchers were trying to validate supply chain resilience and reconfiguration approaches by using case studies and quantitative approaches in different geographical areas. The other 50% were divided into 30% validation research and 20% proposals of solutions. In total, therefore, 24 studies aimed to evaluate supply chain resilience and reconfiguration approaches through mathematical or simulation models, lessons learnt, and Interpretive Structural Modeling (ISM), and only 16 studies aimed to propose a solution.

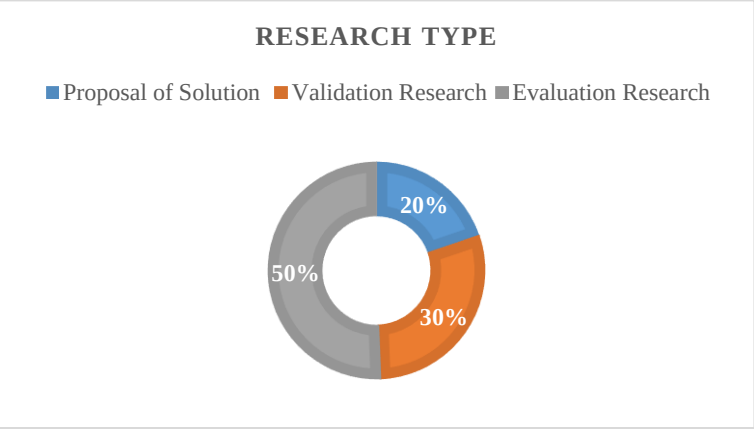

Figure 2.11. Research type (Petersen et al., 2008)

2.6.4.4 Research Method (MQ4)

Figure 2.11 shows the distribution of research methods used in the articles. In total, 28% used a survey as the predominant research method, and 25% a mathematical model. Almost 60% of supply chain reconfiguration studies, however, used mathematical models, including graph-based cost models, two-stage stochastic models, and agent-based simulation and decision tree learning. This compared to just 19% of the supply chain resilience studies. A total of 18 studies (22%) used case studies, of which 17 examined supply chain resilience enablers and one the characteristics of supply chain reconfiguration. Only 17% of studies were review papers, and none of these covered supply chain reconfiguration. It is perhaps not surprising, because this is a very new area of research. Future review papers are needed on supply chain reconfiguration to provide insights into the current state of knowledge on supply chain reconfiguration processes and characteristics.

2.6.5 Definitions

2.6.5.1 Supply Chain Resilience

Supply chain resilience is a relatively new phenomenon in the supply chain management domain, designed to help organizations to move away from traditional approaches to mitigating risk and managing production strategies (Ali et al., 2017b). The main use of supply chain resilience is to deal with the complexities of global supply chains (Pettit et al., 2013). There are several definitions of supply chain resilience. The most cited definition was set out by Christopher and Peck (2004) as "the ability of a system to return to its original state, within an acceptable period of time, after being disturbed" (Brandon-Jones et al., 2014; Cardoso et al., 2015;Chowdhury and Quaddus, 2016; Cheng and Lu, 2017). There are a number of significant similarities and differences to supply chain resilience definitions (see Table 2.6). The majority of studies commented only on supply chain resilience as a way to recover from unexpected disruptions (Ponomarov and Holcomb, 2009; Blackhurst et al., 2011; Ambulkar et al., 2015; Hohenstein et al., 2015; Tukamuhabwa et al., 2015; Kamalahmadi and Parast, 2016; Datta, 2017; Dubey et al., 2019a). However, there are contradictory views about the time, cost and speed of recovery (Hohenstein et al., 2015; Datta, 2017). Each of these dimensions has been measured in different ways.

Other researchers have defined supply chain resilience in terms of proactive strategies. For example, Ponomarov and Holcomb (2009) and Hohenstein et al., (2015) defined supply chain resilience as the ability to prepare for unexpected risk events, respond to disruptions and recover from them. These definitions revolve around four main dimensions of supply chain resilience capabilities: re-engineering, collaboration, agility, and

risk management culture. Overall, the definitions generally split into two groups: proactive definitions rely on building resilience capabilities, and reactive ones respond and recover after disruption.

Table 2.6. Definitions of supply chain resilience set out in the studies

Authors\Years	Scope	Definition
Ponomarov and Holcomb (2009)	Supply chain resilience - adaptive aspects	"The 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."
Pettit et al. (2010)	The value of resilience concept	"The capacity for an enterprise to survive, adapt, and grow in the face of turbulent change."
Jüttner and Maklan, (2011)	Supply chain resilience capability	"The capacity for enterprises to survive, adapt and grow in the face of turbulent change."
Pettit et al. (2013)	Business context	"The capacity for an enterprise or set of business entities to survive, adapt, and grow in the face of change and uncertainty."
Wieland and Walleburg (2013)	Supply chain resilience	"The ability of [the] supply chain to cope with change."
Brandon-Jones et al. (2014)	Supply chain resilience	"The ability of a supply chain to return to normal operating performance, within an acceptable period of time, after being disturbed."

Ambulkar et al. (2015)	Firm resilience	"The capability of the firm to be alert to, adapt to, and quickly respond to changes brought by supply chain disruption."
Hohenstein et al., (2015)	Supply chain resilience – adaptive and reactive aspects	"[The] supply chain's ability to be prepared for unexpected risk events, responding and recovering quickly to potential disruptions to return to its original situation or grow by moving to a new more desirable state in order to increase customer services market share and financial performance."
Tukamuhabwa et al. (2015)	Supply chain resilience – adaptive and reactive aspects	"The adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost effective recovery, and therefore progress to a post-disruption state of operations [that is] ideally a better state than prior to the disruption."
Chowdhury and Quaddus (2016)	Supply chain resilience – adaptive and reactive aspects	"The capability of a supply chain to prevent disruptions and to reduce the impact of disruptions through developing required level of readiness, quick response and recovery ability."
Kamalahmadi and Parast (2016)	Supply chain resilience – adaptive and reactive aspects	"The adaptive capability of a supply chain to reduce the probability of facing sudden disturbances, resist the spread of disturbances by maintaining control over structures and functions, and recover and respond by immediate and effective reactive plans to transcend the disturbance and restore the supply chain to a robust state of operations."
Chowdhury and Quaddus (2017)	Supply chain resilience – adaptive and reactive aspects	"The characteristics of a well-designed supply chain network with proactive and reactive capabilities which enables the supply chain members to reduce the probability of disruptive events (or to reduce their

		impact) to take the organization to a stronger and more sustainable state."
Datta (2017)	Supply chain resilience – dynamic process	"A dynamic process of steering actions so that the organization always stays out of [the] danger zone and if the disruptive/uncertain event occurs, resilience implies initiating a very rapid and efficient response to minimize the consequences and maintaining or regaining a dynamically stable state which allows it to adapt operations to the requirements of the changed environment before the competitors and succeed in the long run."
Liu et al. (2018)	Resilient enterprise	"An enterprise's ability to identify bottlenecks and potential risks in managing a supply chain, which allows it to adopt effective measures before a supply chain is disconnected."
Dubey et al. (2019a)	Supply chain resilience	"The ability of the system to return to its original state within an acceptable period after being disturbed."
Dubey et al. (2019b)	Supply chain resilience	"The property of a supply chain that enables the disrupted supply chain to recover its normal operating performance, within an acceptable period, after the disrupting forces are withdrawn or disappear."

2.6.5.2 Supply Chain Reconfiguration

None of the reviewed studies clearly defined supply chain reconfiguration, except the empirical paper by Ambulkar et al. (2015). This proposed a definition for resources reconfiguration of "the ability of a firm to reconfigure, realign, and reorganize their resources

in respond to changes in the firm's external environment". A clear definition of supply chain reconfiguration is therefore needed to ensure greater consistency among future studies.

2.6.6 Supply Chain Resilience Enablers (MQ5)

The three main components that help organizations to build resilience are enablers, practices, and resources (Ponomarov and Holcomb, 2009). These help strategic decision-making processes and allow organizations to recover from disruption and improve their performance, as well as providing competitive advantage (Ponomarov and Holcomb, 2009). The articles reviewed provided 36 supply chain resilience enablers (see Figure 2.12). Collaboration and flexibility have been widely discussed in supply chain resilience articles, but are controversial. 'Visibility and readiness' and 'response and recovery' were the third and fourth most discussed enablers. However, very few studies have examined supply chain reengineering, velocity, adaptive capability, market sensitiveness, trust, multiple sourcing, company knowledge, coordination and control, anticipation, robustness, backup capability, and security. More recently, researchers have explored the importance of government aid and programs, risk and revenue sharing, supply chain structure, sustainability in supply chain, lead time variability, dynamic capabilities, stockpiling inventory, changing climate, dispersion, egocentric network-based strategies, procurement portfolio, sensing, seizing and transforming, and learning orientations.

This study therefore focused more on the top 15 enablers from this list, and their effects on supply chain risk that may lead to supply chain reconfiguration.

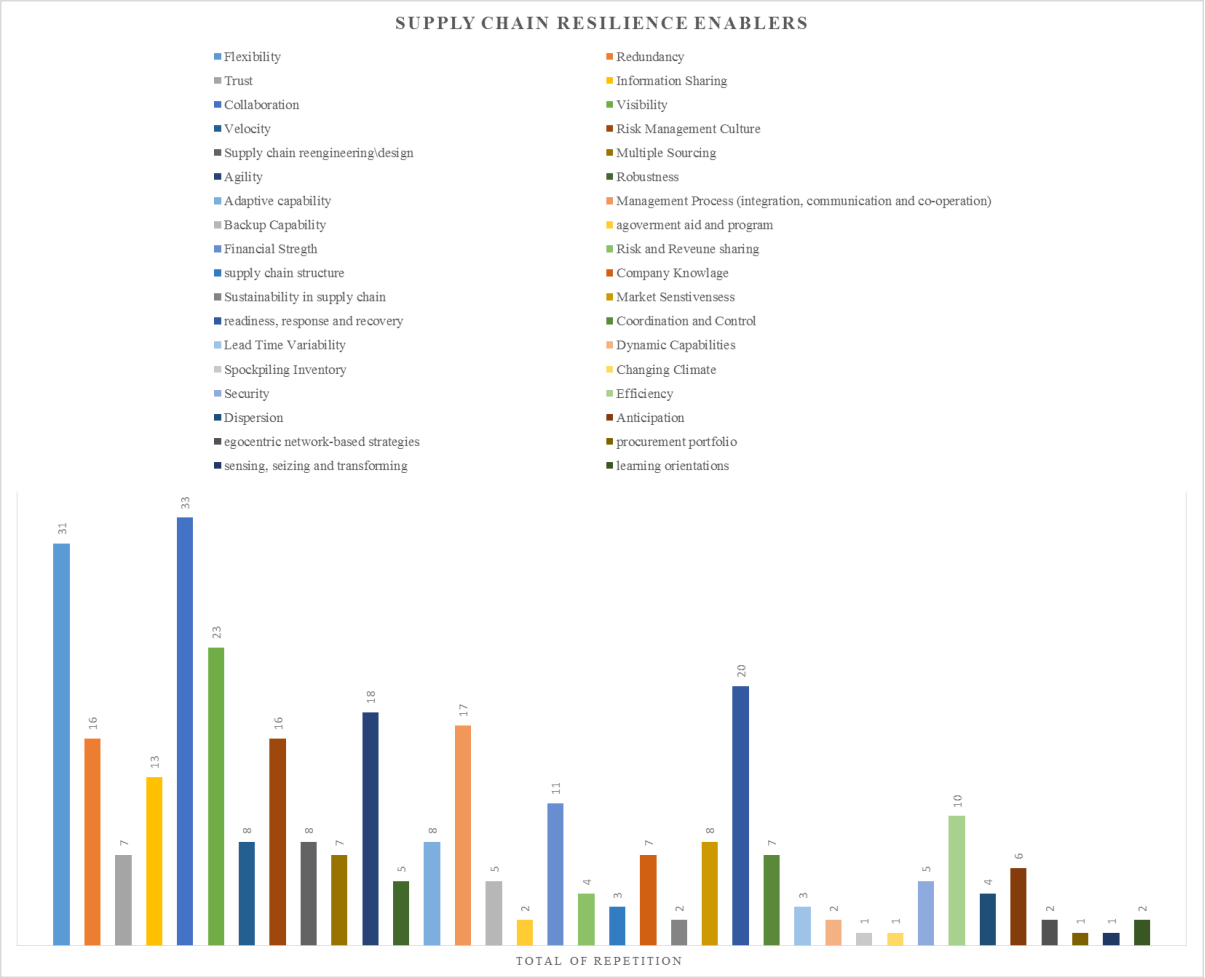

Figure 2.12. Supply chain resilience enablers

2.6.6.1 Risk management culture

A risk management culture is an important enabler to building supply chain resilience into the organization (Kamalahmadi and Parast, 2016; Jain et al., 2017; Liu et al., 2018). It is defined as “infusing a culture of resilience and risk awareness to make it the concern of everyone” (Lima et al., 2018; Liu et al., 2018). A risk management culture is highly desirable for improved resilience in any organization (Jain et al., 2017). Many researchers have also argued that a culture of risk management should go beyond the boundaries of corporate risk

and business continuity, to support supply chain continuity management (Scholten et al., 2014; Liu et al., 2018).

A risk management culture also helps the organization to identify the likelihood of risks, and increase the capability of the supply chain to mitigate risks and reduce its vulnerability (Jüttner and Maklan, 2011; Wieland and Wallenburg, 2013; Chowdhury and Quaddous, 2016). The supply chain can therefore only act to mitigate the risk and reduce vulnerability when organizations develop a risk management culture, for example, through the implementation of a total quality management approach (Jüttner and Maklan, 2011; Wieland and Wallenburg, 2013; Chowdhury and Quaddous, 2016). However, organizations must also enhance the continuity of the supply chain to create a risk management culture. Organizations can effectively integrate risk management procedures into operating structures, management policies, or response to uncertainty (Liu et al., 2018).

2.6.6.2 Coordination and control

Organizations need a strong control system for their supply chains, to detect disruptions quickly and provide speedy corrective action (Ponomarov and Holcomb, 2009; Stone and Rahimifard, 2018; Dubey et al., 2019a). Coordination and control are types of formative resilience capabilities that help organizations to manage their resources, especially those that span functional areas to maintain the supply chain process (Ponomarov and Holcomb, 2009; Jüttner and Maklan, 2011; Sharma and George, 2018). Coordination, information-sharing and pre-existing knowledge among supply chain partners also improve the level of situational awareness (Ali et al., 2017b; Sharma and George, 2018). Cooperation,

as a relational competence, positively influences supply chain resilience (Wieland and Wallenburg, 2013).

2.6.6.3 Risk and revenue sharing

Sharing the risk and revenue across supply chains is highly desirable. Previous studies have found that it is essential for both long-term focus and collaboration among supply chain partners (Pettit et al., 2013; Jain et al., 2017). Partners should collaborate to identify direct supply chain risks and their possible causes or source. Sharing revenue is a key factor in increasing competitive advantage for all the supply chain partners (Jain et al., 2017).

2.6.6.4 Financial strength

Financial strength enables organizations to absorb fluctuations in cash flow (Pettit et al., 2010; Pettit et al., 2013). Supply chains must interpret the market position to recover from supply chain disruptions through financial strength (Ali et al., 2017b) and organizational efficiency (Ponomarov and Holcomb, 2009). Some studies on supply chain resilience have shed light on the important of financial strength in building supply chain resilience (Gunasekaran et al., 2015; Chowdhury and Quaddus, 2016). Specific capabilities of organizations with financial strength include insurance, portfolio diversification, financial reserves and liquidity, price margin, profitability, and availability of funds (Pettit et al., 2010; Pettit et al., 2013; Chowdhury and Quaddus, 2015). Financial strength is also an important part of supply chain readiness to build resilience (Kochan and Nowicki, 2018).

2.6.6.5 Robustness

Robustness is defined as “the ability of a supply chain to resist change without adapting its initial stable configuration” (Wieland and Wallenburg, 2012). Ongoing operation during a disturbance is therefore an important indicator of robustness (Purvis et al., 2016; Behzadi et al., 2017). Supply chain robustness can mitigate the threat of poor organizational performance and maintain long-term economic stability in the face of supply chain disruptions (Brandon-Jones et al., 2014). Some authors have suggested that robustness is a subset of resilience (Brandon-Jones et al., 2014; Behzadi et al., 2017), with a slight difference in the process. However, others have argued that there is a trade-off between robustness and flexibility (Jüttner and Maklan, 2011; Johnson et al., 2013): flexibility enables supply chains to take more possible forms, and robustness increases the number of changes that the supply chain can manage.

2.6.6.6 Collaboration

Some studies have suggested that collaboration is vital in overcoming risk (Ponomarov and Holcomb, 2009). Collaboration is defined as the ability of organizations or supply chains to work effectively and respond quickly to supply chain disruptions with partners and other supply chain entities (Tukamuhabwa et al., 2015). Good relationships will ensure the exchange of information and knowledge, visibility, flexibility, operational effectiveness and efficiency, and customer service (Jüttner and Maklan, 2011; Pettit et al., 2013; Scholten et al., 2014; Gunasekaran et al., 2015; Scholten and Schilder, 2015). Most

importantly, collaboration is a formative element of a resilient supply chain (Scholten and Schilder, 2015), which reduces uncertainty by distributing risk (Kamalahmadi and Parast, 2016). Several previous studies have examined the relationship between collaboration and supply chain resilience and found that collaboration had a positive relationship with supply chain resilience (Jüttner and Maklan, 2011; Scholten and Schilder, 2015; Chowdhury and Quaddus, 2016).

2.6.6.7 Agility

Agility is the ability to respond to changes and positional or actual unpredictable events (Scholten et al., 2014; Tukamuhabwa et al., 2015). It is associated with responsiveness to supply chain disruption and emergencies, to reduce the impact of disturbances (Ponomarove and Holcomb, 2009; Ali et al., 2017a). Visibility and velocity are two dimensions of agility (Scholten et al., 2014). They both reduce the intensity of resources required and increase the speed of recovery (Brandon-Jones at al., 2014). Creating supply chain visibility that embraces confidence and encourages product tracking helps firms to understand that visibility is important (Jüttner and Maklan, 2011; Brandon-Jones et al., 2014). On the other hand, velocity may affect three different areas of risk: the rate at which events happen, the rate at which they fade, and the time of discovery (Jüttner and Maklan, 2011). It is therefore considered an important part of agility. Flexibility and collaboration can also improve agility by allowing the companies to react faster and select a suitable plan and strategy to mitigate the effects of disruptions (Gunasekaran et al., 2015).

2.6.6.8 Supply chain re-engineering/design

Supply chain re-engineering is mainly designed to achieve the two objectives of cost optimization and customer satisfaction (Kamalahmadi and Parast, 2016). The complexity of the business environment means that traditional supply chain designs are no longer valid. They need to be redesigned to integrate resilience into their design, because it is difficult to develop a prevention strategy after disruption has happened (Scholten et al, 2014). Instead, supply chains must be flexible and contain redundancy to manage disruptions. Flexibility is the capability of the supply chains to respond quickly to positive and negative environmental influences and select the most suitable options (Gunasekaran et al., 2015). Researchers studying supply chain flexibility (Scholten et al., 2014; Scholten and Schilder, 2015; López and Ishizaka, 2017; Rajesh 2017; Liu et al., 2018) have argued that flexibility increases the responses to disruption (Brusset and Teller, 2017). Redundancy is having organizational resources that can be used during disturbances to replace lost resources or capital (Lima et al., 2018). Both are therefore core elements for supply chain resilience (Hohenstein et al., 2015).

2.6.6.9 Backup capacity

Backup capacity is an important resilience strategy (Behzadi et al., 2017; Datta, 2017) and has been widely highlighted in previous studies (Pettit et al., 2013). It provides flexibility by obtaining supplies from backup sources in the event of a disruption to production time or yield (Behzadi et al., 2017). Backup suppliers, locations, and facilities can all help to maintain production processes (Namdar et al., 2018). Some authors have noted

that having backup suppliers could create redundancy in the supply chain (Chowdhury and Quaddus, 2016; Kamalahmadi and Parast, 2016; Chowdhury and Quaddus, 2017).

2.6.6.10 Multiple sourcing

Multiple souring is another resilience strategy designed to enhance general supply chain resilience by providing contingency and mitigation strategies to reduce the impact of disruption (Yang and Xu, 2015). Multiple or dual sourcing mitigates risk of disruption by having multiple suppliers or enlarging the supply base to include new suppliers (Behzadi et al., 2017). Organizations need to invest in preventive measures, such as multiple suppliers, to ensure resilience and have strong readiness and growth phases (Hohenstein et al., 2015). Like a backup capability, multiple sourcing is a redundancy component used to prevent stockouts (Hohenstein et al., 2015; Kamalahmadi and Parast, 2016; Ali et al., 2017b).

2.6.6.11 Adaptive capability

Adaptive capability is a common factor in supply chain resilience definitions. Most researchers have described it as the ability to prepare for unexpected events, and respond to and recover from disruption (Ponomarov and Holcomb, 2009; Jüttner and Maklan, 2011). Adaptive capability deals with temporary disruptive events and is realized through three distinct phases: supply chain readiness, responsiveness, and recovery (Jain et al., 2017).

2.6.6.12 Trust

The concept of trust can be described as the facilities, cooperation, and collaboration within and across the boundary of supply chains (Adobor, 2019). Trust is an important enabler of supply chain resilience (Jain et al., 2017). Lack of trust and collaboration can limit flexibility in the supply chain (Jüttner and Maklan, 2011). The interrelationship between trust, cooperation and commitment therefore helps the supply chain partners to reduce network uncertainty (Chowdhury and Quaddus, 2016). Therefore, there is a positive relationship between supply chain orientation and integration (or trust), and supply chain resilience (Chowdhury and Quaddus, 2016; Liu et al., 2018).

2.6.6.13 Information sharing

Information sharing is important between supply chain partners (Lima et al., 2018). Relevant information shared effectively and efficiently between supply chain partners can enhance collaboration by maintaining transparency and building trust (Mandal, 2017). Collaboration activities, information sharing, collaborative communication, mutually-created knowledge, and joint relationship efforts all increase supply chain resilience through flexibility, velocity, and visibility (Brandon-Jones at al., 2014; Scholten and Schider, 2015). Information sharing alone also positively influences supply chain resilience (Chowdhury and Quaddus, 2016).

2.6.6.14 Integration

Integration capability is a proactive aspect of supply chain resilience (Chowdhury and Quaddus, 2017; Jüttner and Maklan, 2011) and helps to mitigate supply chain disruption (Pettit et al., 2010, 2013). It is also one of the relational capabilities (i.e. communication, co-operation and integration) that affect supply chain resilience (Wieland and Wallenburg, 2013). Supply chain integration is defined as "the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter- organization processes. The goal is to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the customer at low cost and high speed" (Naylor et al., 1999; Frohlich and Westbrook, 2001; Flynn et al., 2010, Brusset and Teller, 2017). The main elements of supply chain integration are information sharing, internal integration, collaboration, and ICT adoption (Chowdhury and Quaddus, 2015; Chowdhury and Quaddus, 2017; Mandal, 2017; Adobor, 2019). Many researchers have claimed that collaboration, coordination, customers, and management culture can enhance integration of both relationships and supply chain flows, which in turn improve operational routines and procedures, and develop commitment and trust between partners (Ponomarov and Holcomb, 2009; Mandal, 2017; Adobor, 2019; Liu et al., 2018). Empirically, Liu et al. (2018) found that internal integration had the highest impact on supply chain resilience, above customers and integration with partners.

2.6.6.15 Readiness, response and recovery

The concepts of readiness, response, and recovery are fundamental to an understanding of supply chain resilience capability (Ponomarov and Holcomb, 2009; Hohenstein et al., 2015; Chowdhury and Quaddus, 2016; Kochan and Nowicki, 2018; Scholten et al., 2019). "Readiness" is a measurement of the extent to which a supply chain can overcome disruptive events (Chowdhury and Quaddus, 2016). Disruption detection, readiness training, readiness resources, early warning systems, forecasting, and security are all sources of supply chain readiness mentioned in previous studies (Pettit et al.,2013; Chowdhury and Quaddus, 2017). Each of these plays an important role in reducing the impact of disruptions. Higher readiness decreases the impact of disruption.

"Response" is the ability to manage disruptions in a short time with low impact (Pettit et al., 2013; Wieland and Wallenburg, 2013). The speed of response plays a major role in reducing the cost of disruption (Pettit et al., 2013; Wieland and Wallenburg, 2013; Rajesh, 2017; Singh et al., 2018; Ivanov et al., 2018). Agility, velocity, visibility, flexibility, and redundancy all place a strong emphasis on the efficiency of the supply chain responses and recovery (Jüttner and Maklan, 2011; Scholten and Schilder, 2015; Kochan and Nowicki, 2018).

The ability to recover from disruptions and return to a normal state is a unique ability of organizations and supply chains (Pettit et al., 2013; Ambulkar et al., 2015; Chowdhury and Quaddus, 2016). Two factors are particularly important in recovery: time and cost (Tukamuhabwa et al., 2015; Scholten and Schilder, 2015; Singh et al., 2019). They depend on the ability of the supply chain to respond to disruptions.

2.6.7 Supply chain reconfiguration characteristics (MQ6)

A number of studies have found that many organizations choose to make decisions about allocation and reallocation of activities (Hammami and Frein, 2014), facilities (Wilhelm et al., 2013), inventory (Kristianto et al., 2012), suppliers and plants (Guo, et al., 2018), production (Kinkel, 2012), and capabilities (Osman and Demirli, 2012) to manage supply chain risks. Allocation and reallocation characteristics have become increasingly ubiquitous in supply chain reconfiguration studies, the challenge for allocation and reallocation is to protect supply chain uniqueness, while also expanding reach to enable the supply chain to stand out, across a multi-period planning horizon (Hammami and Frein, 2014). Differentiation can occur at any point in the reconfiguration process, including supplier selection, physical flow, transfer pricing, information sharing, distribution of materials, supply chain design and structure, and change items, such as change path, start point, style, target, roles, and levels (Van Hoek et al., 2010; Osman and Demirli, 2012; Hammami and Frein, 2014; Dev et al., 2016).

Redesigning supply chains usually leads to closing existing facilities and opening new ones. Many researchers have argued that the capacity of facilities usually remains stable over time (Wilhelm et al., 2013). This means that facilities tend to remain in the same state (i.e. open or closed) until the end of the planning horizon (Wilhelm et al., 2013). The capacity of a particular facility therefore cannot be changed during the planning period (Wilhelm et al., 2013), though the cost of closing and open facilities is still rarely considered. Hammami and Frein (2014) found that if the cost of closing a facility was more than 30,000 or 20,000 Euros, organizations tended to keep the original site. However, the nature of the function is

even more important in supply chain reconfiguration. The main objective of supply chain reconfiguration is therefore to establish a balance between the cost of supply chain reconfiguration (i.e. cost of replacing suppliers, or changing the transportation network) and supply chain operation (i.e. the cost of transportation, procurement, and manufacturing) (Guo et al., 2018). Organizations can also use echelons inventory, which involves finding new ways to do things such as introducing or removing echelons. Different suppliers, and production and distribution options for raw materials, finished goods, and final products are involved in each reconfiguration alternative (Dev et al., 2014). The performance of each echelon is therefore unique. Each echelon serves a particular product and is linked with a viable transportation system that allows shipment from a facility in one echelon to another (Wilhelm et al., 2013).

2.7 Gaps in Contemporary Literature:

No modern supply chain can survive without some form of resilience, and investment in resilience can also enhance a supply chain in previously unimagined ways (Chowdhury and Quaddus, 2016; Dubey et al., 2019a). Supply chain resilience can be used to improve productivity or reliability, or to decrease the risk in the supply chain. Previous researchers have called for new research on building supply chain resilience (e.g. Jüttner and Maklan, 2011; Johnson et al., 2013; Scholten and Schneider, 2015; Mandal et al., 2016; Chowdhury and Quaddus, 2016). None of the existing papers on supply chain resilience has attempted to develop an integrated framework of supply chain resilience, particularly proactive and reactive capabilities, with supply chain reconfiguration, except for Ambulkar et al. (2015),

who proposed an integrated framework for firm resilience and supply chain disruptions on the basis of resource reconfiguration and risk management resources infrastructure. They also developed a measurement scale to examine the impact of supply chain disruption orientation, resources reconfiguration, and risk management infrastructure on firm resilience. Several empirical papers have proposed supply chain resilience frameworks to assist practitioners to reduce the impact of disruptions and help organizations and supply chains to recover quickly from disruptions (see, for example, Jüttner and Maklan, 2011; Wieland and Wallenburg, 2013; Ambulkar et al., 2015; Scholten and Schider, 2015; Chowdhury and Quaddus, 2016; Liu et al., 2018). However, so far no papers have looked together at supply chain resilience and supply chain reconfiguration.

Examining the different dimensions of supply chain resilience can give a reasonably complete picture, but is not considered sufficient (Ambulkar et al., 2015). There are multiple levels involved across the four dimensions of supply chain resilience (i.e. integration, collaboration, agility, and risk management culture) (Chowdhury and Quaddus, 2016). Supply chain resilience can be considered at various levels including national (Khan et al., 2012), industry (Lim-Camacho et al, 2017; Rajesh, 2017), supply chain (Johnson et al., 2013; Urciuoli et al., 2014; Behzadi et al., 2017), and organizational levels (Jüttner and Maklan, 2011; Scholten and Schider, 2015; Tukamuhabwa et al., 2017). However, the majority of supply chain reconfiguration studies have considered the industry level of analysis (Godsell et al., 2010; Kinkel, 2012; Dev, et al., 2016). There is therefore a shortage of multilevel studies on supply chain resilience and reconfiguration. Most of the previous studies have also been in developed countries, and their results varied by industry and setting, making it

difficult to develop effective theories and practices. Research in other contexts, such as Arab Middle East countries, can therefore provide useful insights for both researchers and practitioners. This approach will also add to supply chain management literature about supply chain resilience and reconfiguration processes in these countries.

Many previous studies used a case study approach (Khan et al., 2012; Cardoso et al., 2015; Scholten and Schider, 2015; Behzadi et al., 2017; López and Ishizaka, 2017; Tukamuhabwa et al., 2017). Others have used surveys across different sectors and organizations (Pettit et al., 2013; Chowdhury and Quaddus, 2016; Brusset and Teller, 2017). None of the previous studies used mixed methods to address the limitation of response bias and improve generalizability. A mixed method study could provide a deeper understanding of the phenomenon and enhance internal and external validity. Further "proposal of solution"-type research is also required to provide a broader picture of problems and solutions, and benefit both academics and organizations.

"Built to last" may sound essential in any form of production, but there is no clear model or process of supply chain reconfiguration. Further research is needed on how supply chains are reconfigured following issues or to address risks. Linking supply chain resilience to reconfiguration may also add to the supply chain risk management literature. First, it will advance our knowledge on the role of resilience in reconfiguring supply chains. Second, it will help managers to understand whether investing in resilience will reduce reconfiguration costs. Third, it will provide a clear view of supply chain reconfiguration process. Finally, it will enhance knowledge on which resilience enablers help in reconfiguring the supply chain before and after disturbances.

2.6 Conclusion

This chapter provides a comprehensive discussion of the literature on supply chain resilience and reconfiguration. It used a new review methodology to analyze this literature. This methodology outlined the main review topics, and provided a description of the selected papers, geographical areas, type of research, and research methods. The chapter provided definitions of supply chain resilience and reconfiguration, and an overview of the supply chain resilience enablers identified in the literature, along with the characteristics of supply chain reconfiguration. Finally, the chapter identified major gaps in the literature presented and set out the research objective of this thesis. The next chapter describes the research approach taken to address these objectives.

CHAPTER 3: INTERPRETIVE STRUCTURAL MODELING OF ENABLERS OF SUPPLY CHAIN RESILIENCE

3.1 Introduction:

Today the key issues in supply chain management are the formulation of supply chain resilience and it development in a company's strategy with objective of providing variety of options in decision-making and responsiveness of the company in critical times. Supply chain resilience deals with multiple type of risks at multiple stages of the risk management process at the supply chain unite of analysis (Ponomarove and Holcomb, 2009). This required complex flow of information, materials, and funds across multiple functional areas both within and among companies. To achieve this, the company's must identify, evaluate, rank, and manage it supply chain resilience. The lack of resilient capabilities can cause considerable adverse effects to companies. Supply chain resilience is focused on preparing the company's for unexpected events, responding to disruptions, and recovering from them by maintain continuity of operations at the desired level of connectedness and control over structure and function (Ponomarov and Holcomb, 2009; Blackhurst et al., 2011; Ambulkar et al., 2015; Hohenstein et al., 2015; Tukamuhabwa et al., 2015; Kamalahmadi and Parast, 2016; Datta, 2017; Dubey et al., 2019a). The stages of supply chain resilience are: sensing (i.e. how the organizations sensing the challenges/threats), seizing (i.e. how organizations seizing the opportunities), and transforming (how the organization beginning the process) (Hendry et al., 2019).

Generally, organizations plan to protect against recurrent, low impact risks in their supply chain but ignore high impact, low likelihood risks. Nevertheless, in recent times, disaster both natural and man-made has forced organization to rethink their risk management approach on context of supply chain resilience. According to Ambulkar et al., (2015) level of disruptions play an important role in developing the supply chain resilience. Responding to the disruption depend on the motivation of act that influence by the size of the impact of the disruption (Bode et al., 2011). In the case of high impact disruption, the ability to quickly acquire new resources or restructure existing resources is important to quickly adopt and respond to changes resulting from disruptions (Blackhurst et al., 2011). In worst scenarios, the high impact disruptions may lead the firm's to reconfigure their resources to recover from the disruption. Thus, the reconfiguration option may not be necessary to establish resilience during the low impact disruption (Ambulkar et al., 2015). Firms can deal with the low impact disruptions, such as delay on shipments, by using their prior disruption experience in recover such disruption.

Interpretive Structural Modelling (ISM) can be used for identifying and summarizing relationships among specific variables, which define a problem or an issue (Warfield, 1974; Sage, 1977). This technique will provide us a means by which order can be imposed on the complexity of such variables (Jharkharia and Shankar, 2004; Ravi et al., 2005). Recently, ISM methodology received high attention among supply chain context. It been used to evaluate the successful implementation of sustainable supply chain practices (Diglwar et al., 2020; Kumar et al., 2020; Narayanan et al., 2019). It been also used to develop an energy-

efficient supply chains through the critical success factors (Moktadir et al., 2019). In terms of supply chain resilience, Soni et al., (2014), Jain et al., (2017), Rajesh (2017), and Singh et al., (2018) applied ISM methodology to identify and analyse the factors to develop the resilience in the supply chain. Therefore, herein, the enablers of the supply chain resilience have been analysed using the ISM methodology, which shows the interrelationships of the enablers and their levels. These enablers are also categorized depending on their driving power and dependence.

The purpose of this chapter was therefore to develop a hierarchy-based model for the enablers of supply chain resilience to econo-political risks. The research questions were:

RQ 1: What are the variables that affect supply chain resilience to econo-political risks?

RQ 2: What are the interrelationships among these variables and which of these variables can be considered most important to manage econo-political risks to a supply chain?

Thus, this chapter organized as follows. First, an ISM based model for the enablers of supply chain resilience is developed. Model development includes the identification of enablers and barriers of supply chain resilience of select Qatari organizations clusters, followed by the development of ISM models. These models depict the hierarchy based relationships among the enablers. Subsequently MICMAC analysis of developed ISM is carried out followed by the discussion for each model.

3.2 Enablers of supply chain resilience

Supply chain resilience is proactive because it enables members of the supply chain to overcome challenges and capitalize on environmental opportunities (Gölgeci and Kuivalainen, 2020). The three main components of supply chain resilience are enablers, organizational practices, and resources. These all help strategic decision-making processes, and enable organizations to recovery from disruption and improve their performance (Ponomarov and Holcomb, 2009). They also provide competitive advantage (Ponomarov and Holcomb, 2009). A list of supply chain resilience was highlight in Chapter 2 see Figure 2.12.

Previous research using ISM in supply chain management (Agarwal and Shankar, 2003, Thakkar et al., 2008) suggested that it was important to review the large number of variables with input from experts. This will eliminate redundancy and ensure that the most important variables are used in developing the model. We therefore consulted five experts, three from industry and two from academia. The experts from industry had an average of ten years' experience in areas including purchasing, supply chain, and materials management. The academic experts were members of faculty in two major universities working in supply chain research. Both had an *h*-index of more than 25 from Google Scholar. Before the discussion, all experts were told that the focus of the study was supply chain resilience to econo-political risks. This was considered important, because it may affect which enablers to retain and exclude. After discussion with experts, some of the variables were combined, and others were considered to be a subset of another enabler. Finally, 13 enablers were

selected to develop the ISM-based model for supply chain resilience to economic-political risk. These enablers are discussed in the next few sections.

3.2.1 Risk management culture.

Risk management culture helps the organization to identify the chances of risks, and increase the ability of the supply chain to mitigate those risks and so reduce its vulnerability (Wieland and Wallenburg, 2013). Risk management culture is defined as "infusing a culture of resilience and risk awareness to make it a concern of everyone" (Lima et al., 2018; Liu et al., 2018). Many researchers have argued that a culture of risk management should go beyond the boundaries of the corporate risk and business continuity teams, to develop supply chain continuity management (Liu et al., 2018; Scholten et al., 2014). This means that risk management responsibility is broader than simply 'risk managers' and it must be effectively integrated into general practice (Stone and Rahimifard, 2018; Tukamuhabwa et al., 2017).

3.2.2 Coordination and control.

Organizations need a strong control system for supply chains, to enable them to detect disruption quickly and take fast corrective actions (Dubey et al., 2019a; Stone and Rahimifard, 2018). Coordination and control help organizations to manage their resources, which often span functional areas, to maintain the supply chain (Sharma and George, 2018). Coordination among supply chain partners improves the level of situational awareness (Ali et al., 2017b). The interrelationship between trust, cooperation, and commitment helps supply chain partners to reduce network uncertainty (Sharma and George, 2018).

3.2.3 Risk- and revenue-sharing.

Sharing risk and revenue is essential for both long-term focus and collaboration among supply chain partners (Jain et al., 2017; Pettit et al., 2013). Supply chain partners should therefore develop risk- and revenue-sharing mechanisms, including shared identification of the supply chain risks and their sources. Revenue-sharing is important in improving the competitive advantage for the whole supply chains (Jain et al., 2017).

3.2.4 Financial strength.

Financial strength is essential to absorb fluctuations from market disruptions (Pettit et al., 2010, 2013) and to build resilience (Chowdhury and Quaddus, 2016; Gunasekaran et al., 2015). Supply chains must understand the market position to enable them to use their financial strength (Ali et al., 2017a) and organizational efficiency (Ponomarov and Holcomb, 2009) to recover. Specific financial strength capabilities include insurance, portfolio diversification, financial reserves and liquidity, price margin, profitability, and availability of funds (Chowdhury and Quaddus, 2015; Pettit et al., 2013). Financial strength is also a measure of readiness to build supply chain resilience (Kochan and Nowicki, 2018).

3.2.5 Robustness.

Robustness is defined as “the ability of a supply chain to manage change and return to its initial stable configuration” (Wieland and Wallenburg, 2012). It is therefore a way to remove vulnerability by building capacity (Hosseini and Barker, 2016). Supply chain robustness can mitigate threats and maintain long-term economic viability (Brandon-Jones

et al., 2014). Some authors consider robustness as a subset of resilience (Behzadi et al., 2017; Brandon-Jones et al., 2014), with slight differences in the process. However, others argue that there is a trade-off between robustness and flexibility (Johnson et al., 2013; Jüttner and Maklan, 2011). Flexibility increases the number of possible states for the supply chain, and robustness expands the number of changes it can manage.

3.2.6. Collaboration.

Some authors have argued that the key to overcoming supply chain risk is collaboration among the supply chain members (Ponomarov and Holcomb, 2009). Collaboration is defined as the ability of organizations to work effectively and respond quickly to supply chain disruptions (Tukamuhabwa et al., 2015). Collaborative relationships will therefore ensure the exchange of information and knowledge, and increase visibility, flexibility, operational effectiveness and efficiency, and customer service (Gunasekaran et al., 2015; Jüttner and Maklan, 2011; Scholten and Schilder, 2015). Collaboration can be considered as a formative element of a resilient supply chain (Scholten and Schilder, 2015), reducing uncertainty by distributing risk (Kamalahmadi and Parast, 2016).

3.2.7 Agility.

Agility is the ability to respond rapidly and flexibly to disruption and unpredictable events, and reduce their impact (Ali et al., 2017b). Its two main dimensions are visibility and velocity (Scholten et al., 2014). These reduce the resource intensity required to respond, and increase the speed of recovery (Brandon-Jones at al., 2014). Flexibility and collaboration

also improve agility by allowing companies to react faster and select a suitable plan and strategy to mitigate the effects of disruptive events (Gunasekaran et al., 2015). Building flexibility and agility therefore helps to develop resilience, and both should be incorporated into supply chain structure, inter-organizational processes, and strategies (Rajesh, 2018).

3.2.8 Backup capacity/redundancy.

Backup capacity or redundancy is a resilience strategy (Datta, 2017) that is widely highlighted in the literature (Rezapour et al., 2017; Mandal, 2012). It provides flexibility to the supply chain by making arrangements to obtain supplies from backup sources in the event of disruption (Behzadi et al., 2017). Torabi et al. (2015) found that having a backup supplier is an effective strategy to mitigate supply chain disruption. Redundancy means having resources that can be used during disturbances to replace lost resources or capital (Lima et al., 2018). It is a proactive strategy to provide resilience (Sadghiani et al., 2015), and is therefore a core element at each stage of developing supply chain resilience (Hohenstein et al., 2015).

3.2.9 Readiness, response and recovery.

Readiness is a measure of the extent to which a supply chain can overcome disruptive events (Chowdhury and Quaddus, 2016; Scholten et al., 2019). It includes disruption detection, readiness training, readiness resources, and early warning signals (Chowdhury and Quaddus, 2017; Pettit et al., 2013). Response is the ability to mitigate disruptions rapidly and with low impact (Wieland and Wallenburg, 2013). The speed of response plays a major

role in reducing cost of recovery (Ivanov et al., 2018; Rajesh, 2017; Singh et al., 2018). Two factors are important in recovery: time and cost (Tukamuhabwa et al., 2015; Scholten and Schilder, 2015; Singh et al., 2019). They depend on the ability of the supply chain to respond to disruptions.

3.2.10 Trust.

Trust facilitates cooperation and collaboration within and beyond supply chains (Adobor, 2018). Jain et al. (2017) found that it an important enabler of supply chain resilience. Lack of trust and collaboration can limit flexibility in the supply chain (Jüttner and Maklan, 2011). The interrelationship between trust, cooperation and commitment helps the supply chain partners reduce network uncertainty (Chowdhury and Quaddus, 2016). There is a positive relationship between supply chain orientation and trust with supply chain resilience (Liu et al., 2018).

3.2.11 Information sharing.

Sharing of information effectively and efficiently between the supply chain partners can enhance collaboration by maintaining transparency and building trust (Mandal, 2017). Collaboration activities, information sharing, collaborative communication, mutually-created knowledge, and joint relationship efforts all increase supply chain resilience by improving flexibility, velocity, and visibility (Brandon-Jones at al., 2014; Scholten and Schilder, 2015). Effective information sharing can take a variety of forms, including through

sophisticated, automated systems, or more informal and less explicit mechanisms (Urciuoli and Hintsa, 2018).

3.2.12 Integration.

Integration is a relational capability that influences supply chain resilience (Wieland and Wallenburg, 2013) and helps to mitigate disruption (Pettit et al., 2010, 2013). It is defined as "the degree to which an organization strategically collaborates with its supply chain partners and collaboratively manages intra- and inter- organization processes" (Brusset and Teller, 2017). Radhakrishnan et al. (2018) proposed an improved measurement model for integration grounded in resource dependency theory. Collaboration, coordination, and management culture can all enhance integration (Adobor, 2019; Mandal, 2017; Ponomarov and Holcomb, 2009). Liu et al. (2018) found that internal integration has the highest impact on supply chain resilience.

3.2.13 Multiple sourcing.

Multiple sourcing aims to enhance supply chain resilience with contingency plans and mitigation strategies to reduce the impact of disruption (Rezapour et al., 2017; Yang and Xu, 2015). It mitigates risk of disruption by expanding the supply base to include new suppliers (Behzadi et al., 2017), and is therefore a preventive measure (Hohenstein et al., 2015). A critical question in adopting multiple sourcing strategy is the number of suppliers, and Kumar et al. (2018a) suggested that the optimal number of suppliers is three for low-cost items and two for costlier ones.

3.3 ISM Methodology and Model Development

There are a number of models and techniques for exploring supply chain resilience (Hosseini et al., 2019), including Analytic Hierarchy Process (Hosseini and Khaled, 2016; López and Ishizaka, 2019), multi-objective, mixed integer, linear programming (MOMILP) (Sahebjamnia et al., 2018), and dynamic simulation (Mancheri et al., 2018). However, no studies have discussed the interrelationships among the variables influencing supply chain resilience. This study aims to fill this gap, using ISM to derive a model of variables affecting the system in a pattern using graphics and words (Faisal and Talib, 2017). The model facilitates exploration of associations between qualitative variables, which cannot be done by statistical techniques (Jabeen et al., 2018). Insights into relationships among variables can be developed by asking: Does variable 'X' improve variable 'Y' or does variable 'Y' improve variable 'X'? Do 'X' and 'Y' affect each other or is there no relationship between them? This is done for all pairs of variables affecting the problem.

The steps involved in developing the ISM model (Kumar et al., 2018b) for this study were:

- **Step 1:** Identify the main enablers of supply chain resilience using previous studies and expert opinions.
- **Step 2:** Develop a structural self-interaction matrix (SSIM) of variables to establish the pairwise relationship between enablers, with input from experts.
- **Step 3:** Deduce an initial reachability matrix from SSIM. After incorporating transitivities, develop the final reachability matrix.

- **Step 4:** Partition the final reachability matrix into different levels using an iterative process.
- **Step 5:** Draw a directed graph and convert it into an ISM-based model by introducing statements in place of the element nodes. Review the model for conceptual inconsistency and make any necessary modifications.
- **Step 6:** Categorize variables based on driving power and dependence.

3.3.1 Identification of Enablers of Supply Chain Resilience

The enablers of supply chain resilience were identified using a comprehensive literature review and input from experts.

3.3.2 Structural Self-Interaction Matrix (SSIM)

In this step, brainstorming sessions and interviews with experts were conducted to establish contextual relationships among the variables. A focus group of five experts was consulted. The contextual relationship "leads to" was chosen to analyse the enablers of resilience in supply chains. The connection of each enabler to the other 13 enablers was about their contextual relationship (helps to).

Each pair of enabler was therefore analysed separately after the formation of a grid. The four keywords used to represent the direction of the relationship between the enablers (i and j) were:

- O: enabler i and j are not related;

- X: enabler i will help to achieve enabler j and enabler j will help to achieve enabler i;
- A: enabler j helps to achieve enabler i, and;
- V: enabler i helps to achieve enabler j.

The relationships were then classified into two kinds of pairs, one having no significant relationship, represented by ‘O’, and the other having a significant relationship, indicated by V, X or A. The opinions of the experts were marked in a matrix called an SSIM. This was developed incorporating the interrelationships among the 13 enablers (see Table 3.1).

Table 3.1. Structural Self-Interaction Matrix (SSIM)

Enabler No.	Enablers of Supply Chain Resilience	13	12	11	10	9	8	7	6	5	4	3	2	1
1.	Risk Management Culture	V	O	V	V	V	V	V	V	V	V	V	O	-
2.	Coordination and Control	V	X	A	A	V	V	V	A	V	O	X	-	
3.	Risk- and Revenue-Sharing	X	X	A	A	O	O	V	A	V	X	-		
4.	Financial Stability	X	X	A	A	O	V	O	A	V	-			
5.	Robustness	A	A	A	O	V	A	X	A	-				
6.	Collaboration	V	V	X	X	O	V	V	-					
7.	Agility	O	A	A	O	V	X	-						
8.	Backup Capacity	A	A	O	O	V	-							
9.	Readiness, Response and Recovery	A	A	A	O	-								
10.	Trust	V	V	X	-									
11.	Information Sharing	V	V	-										
12.	Integration	O	-											
13.	Multiple Sourcing	-												

Notes: V: Variable i will help achieve variable j ; **A:** Variable j will be achieved by variable i ; **X:** Variable i and j will help achieve each other; and **O:** Variables i and j are unrelated.

3.3.3 Reachability Matrix

The reachability matrix was derived from the SSIM in two steps. The first (initial) reachability matrix was obtained by converting each cell of the SSIM into binary digits '0' or '1'. The second (final) reachability matrix was obtained by considering transitivities. For the initial reachability matrix, the rules for the substitution were (Chandra and Kumar, 2018; Faisal et al., 2019):

- If the Xij entry in SSIM is 'V', then Xij entry becomes '1' and Xji entry becomes '0';
- If the Xij entry in SSIM is 'A' then Xij entry becomes '0' and Xji entry becomes '1';
- If the Xij entry in SSIM is 'X' then Xij entry becomes '1' and Xji entry becomes '1'; and
- If the Xij entry in SSIM is 'O' then Xij entry becomes '0' and Xji entry becomes '0'.

The final reachability matrix was developed by incorporating transitivities using the transitivity rule i.e. if variable '1' is related to '2' and '2' to '3', then '1' is also related to '3' (see Table 2). Table 2 also shows the driving and dependence power for each enabler. The driving power of an individual enabler is the total number of enablers (including itself) that it influences. The dependence power is the total number of enablers that help to achieve it (Khan et al, 2015). The results of Table 3.2 were then used in Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) analysis.

Table 3.2. Final Reachability Matrix

Enabler No.	Enablers of Supply Chain Resilience	1	2	3	4	5	6	7	8	9	10	11	12	13	Driving Power
1.	Risk Management Culture	1	1†	1	1	1	1	1	1	1	1	1	1†	1	**13**
2.	Coordination and Control	0	1	1	1†	1	0	1	1	1	0	0	1	1	**9**
3.	Risk- and Revenue-Sharing	1	1	1	1	1	0	1	1†	1†	0	0	1	1	**9**
4.	Financial Stability	0	1†	1	1	1	0	1†	1	1†	0	0	1	1	**9**
5.	Robustness	0	0	0	0	1	0	1	1†	1	0	0	0	0	**4**
6.	Collaboration	0	1	1	1	1	1	1	1	1†	1	1	1	1	**12**
7.	Agility	0	0	0	0	1	0	1	1	1	0	0	0	0	**4**
8.	Backup Capacity	0	0	0	0	1	0	1	1	1	0	0	0	0	**4**
9.	Readiness, Response and Recovery	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
10.	Trust	0	1	1	1	1†	1	1†	1†	1†	1	1	1	1	**12**
11.	Information Sharing	0	1	1	1	1	1	1	1†	1	1	1	1	1	**12**
12.	Integration	0	1	1	1	1	0	1	1	1	0	0	1	1†	**9**
13.	Multiple Sourcing	0	1†	1	1	1	0	1†	1	1	0	0	1†	1	**9**
	Dependence Power	1	9	9	9	12	4	12	12	13	4	4	9	9	

Note: †entries are included to incorporate transitivity.

3.3.4 Level Partitions

The final reachability matrix can be partitioned into different levels. The basis for these levels were the reachability and antecedent sets associated with each variable. The reachability set for a particular enabler consisted of the enabler itself and the other enablers that it influences. The antecedent set consisted of the enabler itself and the other enablers that affect it. Next, the intersection of these two sets was derived for all enablers. The enablers for which the intersection and reachability set were the same formed the top level of the hierarchy in the ISM model. These enablers do not help to achieve any other enabler above their level, implying that they cannot improve enablers above their level. The first iteration of the level partition was classified as level I (Table 3.3). The procedure was repeated until the level of each factor had been determined. The results for iterations ii–vii (levels II–VII) are shown in Table 3.4. These levels were used to build the diagraph and the final model.

Table 3.3. Enablers of supply chain resilience – Level I – Iteration i

Enabler (E_i)	Reachability set R(E_i)	Antecedent set A (E_i)	Intersection set R(E_i)∩A(E_i)	Level
1.	1,2,3,4,5,6,7,8,9,10,11,12,13	1		
2.	2,3,4,5,7,8,9,12,13	1,2,3,4,6,10,11,12,13		
3.	2,3,4,5,7,8,9,12,13	1,2,3,4,6,10,11,12,13		
4.	2,3,4,5,7,8,9,12,13	1,2,3,4,6,10,11,12,13		
5.	5,7,8,9	1,2,3,4,5,6,7,8,10,11,12		
6.	2,3,4,5,6,7,8,9,10,11,12,13	1,6,10,11		
7.	5,7,8,9	1,2,3,4,5,6,7,8,10,11,12,13		
8.	5,7,8,9	1,2,3,4,5,6,7,8,10,11,12,13		
9.	9	1,2,3,4,5,6,7,8,9,10,11,12,13	9	**I**
10.	2,3,4,5,6,7,8,9,10,11,12,13	1,6,10,11		
11.	2,3,4,5,6,7,8,9,10,11,12,13	1,6,10,11		
12.	2,3,4,5,7,8,9,12,13	1,2,3,4,6,10,11,12,13		
13.	2,3,4,5,7,8,9,12,13	1,2,3,6,10,11,12,13		

Table 3.4. Enablers of supply chain resilience – Levels II to V – Iteration ii–v

Enabler (E_i)	Iteration	Reachability set R(E_i)	Antecedent set A (E_i)	Intersection set R(E_i)∩A(E_i)	Level
1.		1,2,3,4,5,6,7,8,10,11,12,13	1		
2.	iii	2,3,4,5,7,8,12,13	1,2,3,4,6,10,11,12,13	2,3,4,12,13	**III**
3.	iii	2,3,4,5,7,8,12,13	1,2,3,4,6,10,11,12,13	2,3,4,12,13	**III**
4.	iii	2,3,4,5,7,8,12,13	1,2,3,4,6,10,11,12,13	2,3,4,12,13	**III**
5.	ii	5,7,8	1,2,3,4,5,6,7,8,10,11,12	5,7,8,	**II**
6.	iv	2,3,4,5,6,7,8,10,11,12,13	1,6,10,11	6,10,11	**IV**
7.	ii	5,7,8	1,2,3,4,5,6,7,8,10,11,12,13	5,7,8	**II**
8.	ii	5,7,8	1,2,3,4,5,6,7,8,10,11,12,13	5,7,8	**II**
10.	iv	2,3,4,5,6,7,8,10,11,12,13	1,6,10,11	6,10,11	**IV**
11.	iv	2,3,4,5,6,7,8,10,11,12,13	1,6,10,11	6,10,11	**IV**
12.	iii	2,3,4,5,7,8,12,13	1,2,3,4,6,10,11,12,13	2,3,4,12,13	**III**
13.	**iii**	**2,3,4,5,7,8,12,13**	**1,2,3,4,6,10,11,12,13**	**2,3,4,12,13**	**III**

3.3.5 Formation of the ISM-Based Model

A structural model for enablers of supply chain resilience was generated from the level partitions (see Tables 3.3 and 3.4). The model was obtained by connecting nodes representing variables, based on the nature of their relationships. This results in a directed graph. The transitivity was then removed from the directed graph, giving an ISM model (Figure 3.1) with the variable ‘risk management culture’ at the bottom. This shows that this variable affects all the other variables above it. The top level variables, like ‘supply chain agility’ and ‘supply chain robustness’, do not have any variables above them, implying that these variables are affected by lower level variables, but do not affect any others. The variables were then grouped into clusters based on their driving power and dependence.

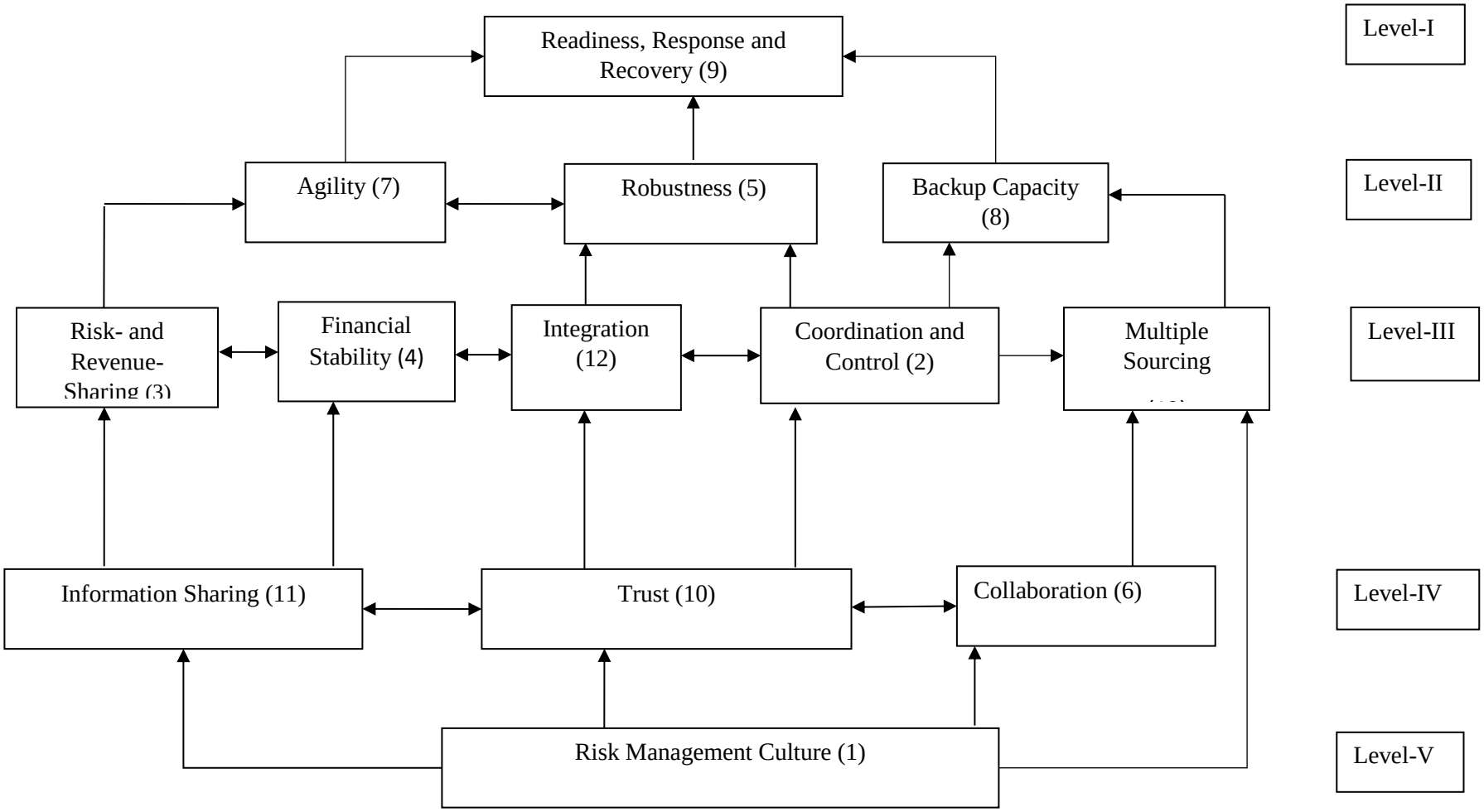

Figure 3.1. ISM Model for the enablers of supply chain resilience to econo-political risk

3.3.6 Classification of Enablers (MICMAC Analysis)

MICMAC analysis was used to classify the enablers into categories (Duperrin and Godet, 1973). The main objective of MICMAC analysis is to analyse the driving power and dependence of the enablers (Faisal et al., 2019) using information in Table 3.2. In this study, the enablers were classified into four clusters (Faisal and Khan, 2016; Mani et al., 2015) (see Figure 3.2):

a. **Autonomous variables:** Enablers in quadrant I have weak driving power and weak dependence, and can be considered to be disconnected from the system with little impact on it.

b. **Dependent variables:** This cluster, in quadrant II, includes enablers with weak driving power but strong dependence power. High dependence power shows that they are influenced by other variables in the system.

c. **Linkage variables:** In quadrant III, variables have reasonable driving power and dependence. They are called linkages because any action on them will have an effect on other variables and also provide feedback.

d. **Independent variables:** The variables in quadrant IV influence a large number of other variables. They have strong driving power and weak dependence.

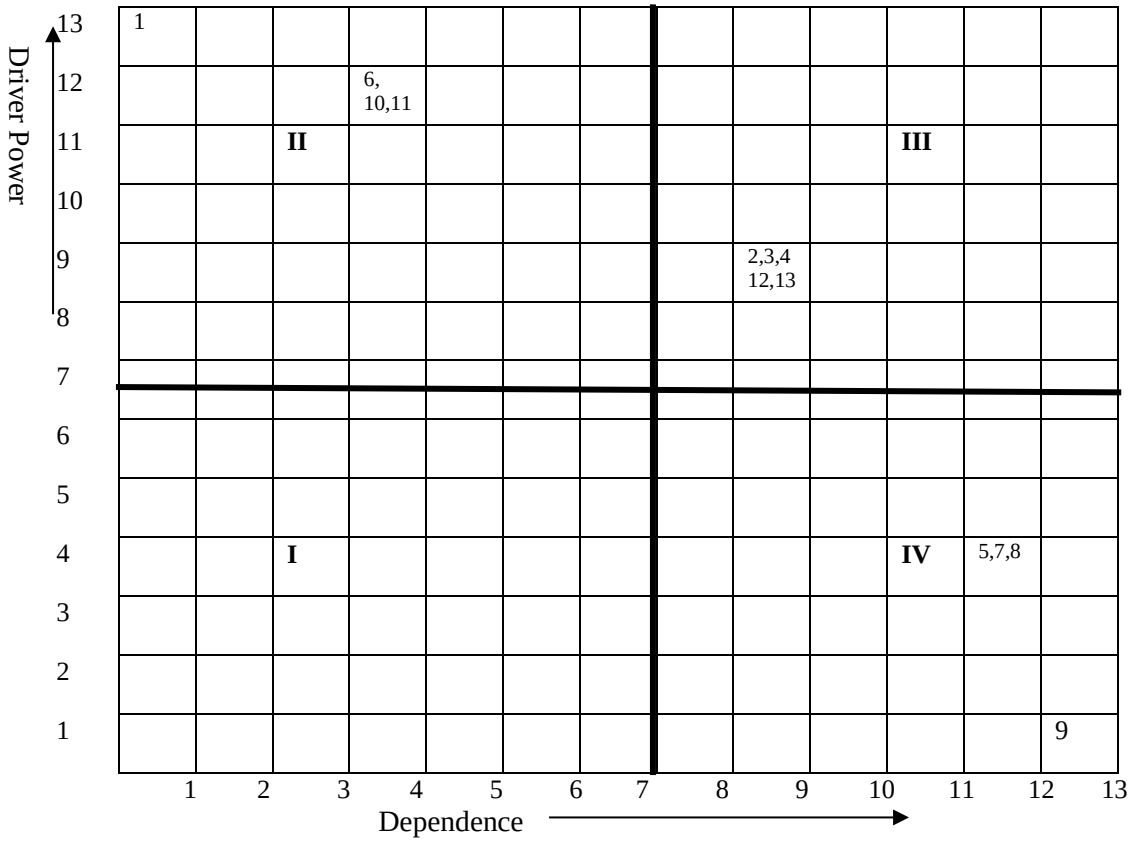

Figure 3.2. Graph of driver power and dependence for all variables

3.4 Discussion

There is increasing interest in supply chain resilience, but it remains a new and largely unexplored topic (Cardoso et al., 2015). The objective of this research was to use ISM to study and analyse the inter-relationships among the enablers of supply chain resilience to econo-political risks. The results provide some useful insights that can be used by supply chain managers to increase resilience. Supply chains face increased risks because of globalization of operations. If resilience is not properly embedded, there are increased chances of supply chain failure, leading to losses among all the partners (Chopra and Sodhi, 2004). In some cases, this may even result in companies going out of business (Chopra and Sodhi, 2004).

The structural model in Figure 3.1 shows that a 'risk management culture' (enabler 1) is at the bottom level of the model. This variable has the highest driving power, and a high impact on other variables. Liu et al. (2018) found that risk management culture had a positive influence on agility and integration. Supply chain managers should therefore make particular efforts to create a risk management culture, including through activities like understanding the network (Ponis and Koronis, 2012), identification of disruptive and recurrent risks, making supply chain risk assessment a formal part of decision-making at all levels (Scholten et al., 2014) and continual assessment of supply chain resilience.

The MICMAC analysis showed that three other enablers, information sharing (enabler 11), collaboration (enabler 6), and trust (enabler 10) also have high driving power and low dependence. Suppliers are a prominent source of a variety of supply chain risks (Blackhurst et al., 2011), so supply chain collaboration plays an important role in developing

resilience (Scholten and Schilder, 2015). Chen el al. (2019) studied supply chain resilience in the information and communication industry, and found that collaboration and coordination was a core requirement for recovering from disruptions. This study also found that collaboration is affected by information sharing, which is consistent with previous work (Daugherty et al., 2006). Previous studies also concur that information sharing can provide flexibility and improve agility of the supply chain (Brusset and Teller, 2017).

The structure of a supply chain network significantly determines the degree of impact of disruption (Ivanov, 2018). If a single central node acts as a converging point of supplies and a diverging point of demand, then any disruption of this node renders the entire supply chain non-operational (Dixit et al., 2020). Previous studies found that this impact is aggravated by lack of trust (Pournader et al., 2016) and our results also suggest that trust is a key element in supply chain resilience. Trust may help to keep the supply chain network stable (Hou et al., 2018).

The dependent variables cluster consisted of enablers with low driving power and high dependence. These are called resultant variables, because their role in resilience is influenced by other variables. The MICMAC analysis indicated that variables like agility (enabler 7), robustness (enabler 5), backup capacity (enabler 8) and readiness, response and recovery (enabler 9) fall into this category. These variables are required to tackle risks through supply chain resilience, but cannot be improved independently. They can only be improved by working on lower level variables in the ISM model. Agility helps supply chains to adapt effectively to disturbances, maintaining the same output level.

Another way to reduce the effect of supply chain disruption is to create backup capacity or redundancy. This provides additional capacity to replace any lost during unexpected events (Ivanov and Sokolov, 2013). This therefore creates resilience, but also increases inefficiency in the network. Wang et al. (2018) suggested that this inefficiency could be minimized by sharing backup capacity across the whole supply chain, requiring cooperation.

The linkage variables include enablers with moderate driving and dependence power. These enablers form a bridge between the lower and high level variables. The MICMAC analysis suggests that these include risk- and revenue-sharing (enabler 3), financial stability (enabler 4), integration (enabler 12), coordination and control (enabler 2) and multiple sourcing (enabler 13). A supply chain works well if the incentives for its members are aligned, which requires the risks, costs, and rewards of doing business to be distributed fairly across the network (Soni et al., 2014). Financial stability is a necessary condition, because resources are needed to build resilient supply chains (Li et al., 2017). Integration is also necessary, because it provides the ability to reduce the costs and risks of coordination by identifying the most important areas for attention (Brusset and Teller, 2017). Integration may be either internal or external. Internal integration is coordination between organizational functions. External integration is the long-term commitment of partners to work together to meet customers' demands (Cao et al., 2015).

3.5 Conclusion:

Risk management and resilience are still new to supply chain management (Sáenz et al., 2018). Resilient supply chains help to delay the occurrence of disruptions, minimize their impact, and speed up recovery, reducing the cost (Gölgeci and Kuivalainen, 2020). This may have severe advantage for the entire supply chain as now most of the organizations depend on resilience capabilities to manage unexpected events and marketplace requirement. The interactive process of ISM modelling approach provides an understanding of how various enablers of supply chain resilience interact with each other. This is important as generally management focuses on one or two of the variables, which it thinks are significant without taking into consideration those that may be the real enabler to effective supply chain resilience. The hierarchy based ISM model further delineates those enablers, which are most important and need more focus and the root cause of the problem.

Global supply chains are more vulnerable to larger threats and uncertainties than local supply chains, because they operate in more complex markets (Hohenstein et al., 2015). Our model provides a useful framework for decision-making on developing resilience in supply chains. Managers can use the model to ensure that they focus scarce organizational resources on the most important factors. Through ISM on the basis of perception of the experts of supply chain from supply chains in the food, construction, and manufacturing sectors, the result are restricted to supply chains in Qatar, but the model could easily be replicated in other countries in the region. Some minor modifications may be required to extend it to other industries.

In this chapter ISM methodology was applied to understand the most important enablers and the model suggest that a group of enablers with high driving power and low dependence are the most crucial enablers affecting supply chain resilience. This would certainly help organizations to be well prepared and counter risks in supply chains more effectively. ISM model presented in this chapter was developed on the basis of inputs from experts in the area of supply chain management. Therefore, the model need to be validated by a large-scale questionnaire study which would test the relationships among the most important enablers utilizing structural equation modelling. To achieve this objective, the following two chapters presents the research model, the associated hypotheses and finally the results of the questionnaire based study.

CHAPTER 4: CONCEPTUAL MODEL AND HYPOTHESIS DEVELOPMENT

4.1 Introduction

The previous chapter provided a critical review for supply chain resilience and reconfiguration literature using systematic mapping review methodology. It used the seven perspectives of these reviews (description of the selected article, geographical areas, type of research, research method, definitions, enablers, and characteristics). This chapter builds upon that by identifying the effects of different resilience enablers, to develop a conceptual model and testable hypotheses. Testing of the conceptual model and hypotheses will be discussed in the next chapter, along with a discussion of how this fills the gaps in the literature identified in Chapter 2.

4.2 Supply chain resilience

A supply chain is a critical operational activity, functioning in a dynamic and vulnerable context. It needs a coordinated and planned approach and good resilience strategies (Beheshtian et al., 2018; Behzadi et al., 2017; Bhattacharjya, 2018; Cardoso et al., 2015; Scholten et al., 2019). Supply chain research has identified the importance of building resilience into supply chains, particularly to enable responses to disruptions (Ali et al., 2017a; Brusset and Teller, 2017; Hendry et al., 2019; Ishfaq, 2012; Ivanov, 2018; Jain et al., 2017; Johnson et al., 2013; Lam and Bai, 2016; Liu et al., 2016; Purvis et al., 2016; Singh et al., 2018; Urciuoli et al., 2014). Learning models, egocentric network-based strategies, sourcing strategies, and technological capabilities can all play a role in building supply chain

resilience (Bhattacharjya, 2018; Mandal and Saravanan, 2019; Namdar et al., 2018; Rajesh, 2017; Scholten et al., 2019). Researchers have found that learning models and egocentric network-based strategies ensure knowledge creation within an organization and knowledge transfer across the supply chain. The egocentric network of upstream firms responds to disruptions (Bhattacharjya, 2018; Scholten et al., 2019). These approaches are therefore important enablers of supply chain resilience (Mandal and Saravanan, 2019). Sourcing strategies and technological capability also play a role in enhancing supply chain resilience, through buyers' warning, design, and planning capabilities (Namdar et al., 2018; Rajesh, 2017).

The supply chain resilience literature suggests that supply chain disruption can be addressed by building resilience. However, resilience is also a function of how well the organization uses its capabilities to respond to disruptions. Several researchers have discussed the important role of supply chain resilience in mitigating supply chain disruptions (Ambulkar et al., 2015; Behzadi et al., 2017; Chowdhury and Quaddus, 2015; Colicchina et al., 2010; Forbes and Wilson, 2018; Ivanov et al., 2018; Ivanov and Sokolov, 2019; Jüttner and Maklan, 2011; Lim-Camachoa et al., 2017; Pournader et al., 2016; Sharma and George, 2018; Yang and Xu, 2015; Zainal and Ingirige, 2018). Firms that adopt proactive strategies are more likely to plan and prepare to respond to unexpected supply chain disruptions (Ambulkar et al., 2015; Ivanov and Sokolov, 2019). It is therefore no surprise that when an organization develops an analytical assessment model, it is more likely to be able to develop resilience to a wide range of supply chain risks, including upstream, downstream, organizational, network, and external environmental risks (Pournader et al., 2016). Behzadi

et al. (2017) concluded that organizations must develop robust resilience strategies to effectively mitigate supply chain disruption and prevent reductions in organizational profit.

Other authors have explored the direct relationship between supply chain resilience and business operations (Cheng and Lu, 2017; Munoz and Dunbar, 2015; Scholten et al., 2014). Supply chain resilience can be linked to organizational culture (Mandal, 2017), customer value (Wieland and Wallenburg, 2013), and product design (Khan et al., 2012), and effectively improves organizational resilience and responsiveness. Firms are likely to be willing to share values and reward mechanisms, and develop new products together more frequently with a supply chain that satisfies them.

Previous studies have sought to examine the link between supply chain resilience and performance, with most studies suggesting that there is a positive association (Altay et al., 2018; Brandon-Jones et al., 2014; Liu et al., 2018). Agility, risk management culture, integration, visibility, and supply chain reengineering are all essential ways in which supply chain resilience can positively influence risk management, firm performance, and supply chain performance (Altay et al., 2018; Brandon-Jones et al., 2014; Liu et al., 2018). Innovativeness as a dynamic capability can enable firms to respond to adversity and disruptions (Gölgeci and Ponomarov, 2015). Firms with an ability to innovate can generate benefits, such as ability to respond to disruptions and disasters (Gölgeci and Ponomarov, 2015). Innovation therefore improves supply chain resilience (Gölgeci and Ponomarov, 2013, 2015).

Several researchers have developed instruments to measure supply chain resilience (Ambulkar et al., 2015; Chowdhury and Quaddus, 2016, 2017; Pettit et al., 2013).

Chowdhury and Quaddus (2017) developed an instrument that measures the proactive capability (flexibility, redundancy, integration, efficiency, market strength, financial strength, and readiness), reactive capability (response and recovery), and supply chain design quality (density, complexity, and criticality). They found that their scales predicted supply chain vulnerability and performance. Other instruments have enabled a significant improvement in supply chain resilience level by examining flexibility, visibility, backup capacity, response, recovery, capacity, efficiency, adoptability, anticipation, market position, security, financial strength, and collaboration (Chowdhury and Quaddus, 2016; Pettit et al., 2013;).

A number of empirical studies have examined different enablers of supply chain resilience. These were reviewed in detail in Chapter 2. Most supply chain resilience studies have focused on a limited number of resilience enablers, which has resulted in contradictory findings. It has also left supply chain resilience scholars unable to establish the key enablers influencing supply chain resilience. Inconsistencies among studies highlight the need for future research to examine the relationship between supply chain resilience and resilience enablers for particular types of disruptions (Ambulkar et al., 2015). Figure 4.1 summarizes the assumptions underlying supply chain resilience relationships.

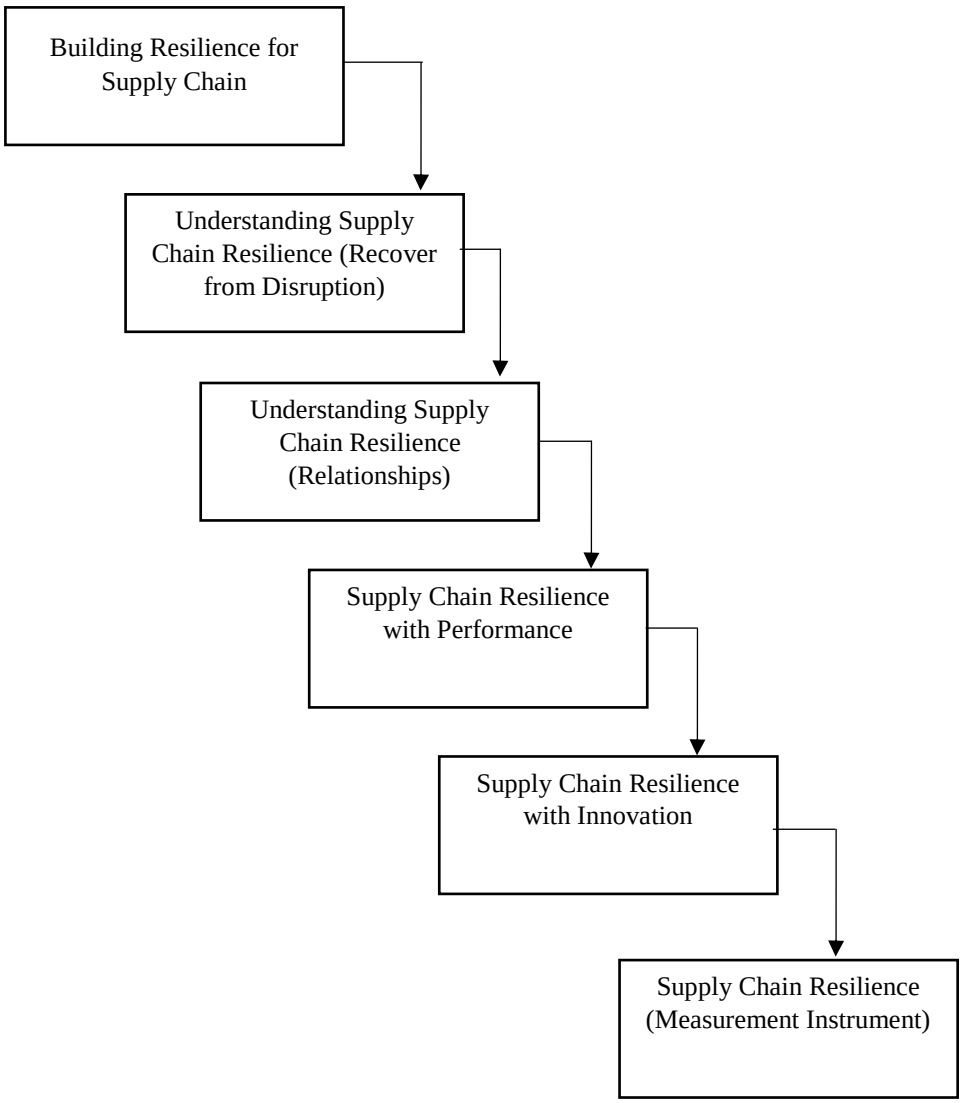

Figure 4.1. Areas of Supply Chain Resilience Studied

4.3 Supply chain reconfiguration

The supply chain literature is largely silent about the effect of supply chain resilience on supply chain reconfiguration (Adobor and McMullen, 2018; Ambulkar et al., 2015; Bag et al., 2019; Ivanov and Sokolov, 2019). However, several authors have discussed the importance of remanufacturing capabilities and reconfiguration resources in mitigating supply chain disruptions (Ambulkar et al., 2015; Bag et al., 2019). For example, Ambulkar et al. (2015) found that when the impact of disruptions is high, companies should reconfigure resources. If low, they should manage infrastructure. Ivanov and Sokolov (2019) suggested that firms must first evaluate feedback about disruptions to adjust recovery decisions across the organization. They also found that it was essential to have proactive control models for supply chain reconfiguration.

The majority of the supply chain reconfiguration literature focuses on dynamic reconfiguration of supply chain systems (Dev et al., 2014; Godsell et al., 2010; Hammami and Frein, 2014; Kinkel, 2012; Osman and Demirli, 2010; Rezaee et al., 2017; Van Hoek et al., 2010; Wilhelm et al., 2013). Many organizations reconfigure their supply chain to fit with the business environment (Hammami and Frein; 2014; Rezaee et al., 2017). Hammami and Frein (2014) studied the redesign of global supply chains and its relationship with transfer pricing and profit maximization. They found that logistics decisions had a strong correlation with transfer pricing and that relocation decisions led to significant improvements in optimal profit.

Some organizations reconfigure their supply chain for environmental reasons. For example, one firm in Australia redesigned its supply chain to develop a green supply chain

in a carbon-trading environment (Rezaee et al., 2017). In this case, supply chain configuration was highly sensitive to the probability distribution of the carbon credit price. Carbon price and budget availability for supply chain reconfiguration could both have a positive but nonlinear relationship with greening of the supply chain.

Other researchers have highlighted aspects of supply chain reconfiguration such as technological, non-technological, social, and behavioral (Van Hoek et al., 2010). They found that changes were non-linear and required re-planning and learning throughout the change effort to build the capacity and capability for change. Osman and Demirli (2010) and Kinkel (2012) studied features of changing outsourcing strategies to improve customer satisfaction and reallocation of production activities after an economic crisis. They found that companies wanted to minimize the disruption cost, improve customer satisfaction, and increase demand, and these were all reflected in the management vision for the new supply chain. Using a real example of supply chain reconfiguration, Godsell et al. (2010) noticed that organizations must identify the successful elements of change in their supply chain reconfiguration programs to ensure business alignment. Dev et al. (2014) identified seven operational enablers of supply chain network reconfiguration. These were information sharing, review period, lead-time, deviations from lead-time and standards, inventory control policy, supply chain structure, and demand. These enablers enhanced supply chain performance under particular operational conditions.

There are two distinct systems identified in the supply chain reconfiguration literature: manufacturing systems (Guo et al., 2018; Niroomand et al., 2012; Sasson and Johnson, 2016) and decision systems (Dev et al., 2016). Manufacturing systems tend to

introduce alternative supply chain systems to improve the level of integration, such as inventory allocation, capacity allocation, and manufacturing processes (Guo et al., 2018; Kristianto et al., 2012; Niroomand et al., 2012). Manufacturing systems are also associated with direct digital manufacturing (DDM) capability assessment tools to evaluate and monitor supply chain disruptions (Sasson and Johnson, 2016). Decision systems are used to determinate alternative decisions for operational units of the supply chain. Dev et al. (2016) found that decision support systems (DSS) help managers to make decisions in operational units, such as how to maintain inventory level performance through reconfiguration. Both these systems were developed to help organizations reconfigure their supply chain to address both disruptions and particular purposes or approaches.

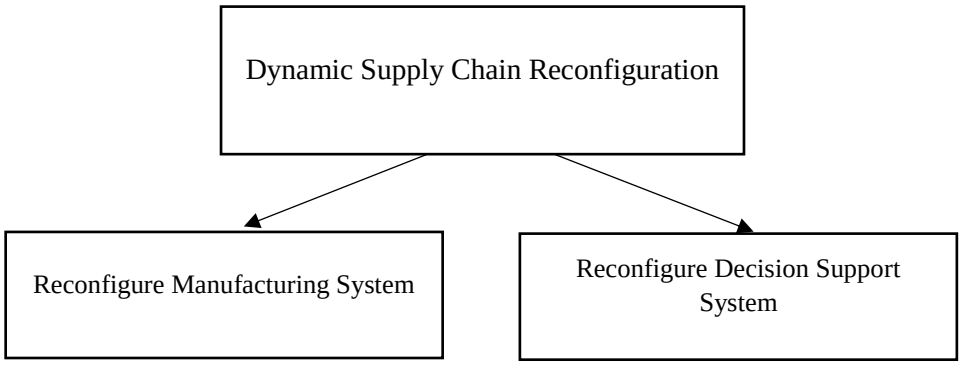

Figure 4.2 Areas of Supply Chain Reconfiguration Studied

4.4 Linking supply chain resilience and reconfiguration

Overall, studies on supply chain resilience have found significant relationships between supply chain resilience enablers and ability to respond to supply chain disruptions. However, the implications of supply chain reconfiguration for supply chain resilience are less clear, perhaps because a focus on individual disruptions of supply chains is required to understand such a complex phenomenon.

In line with previous studies (Adobor and McMullen, 2018; Ambulkar et al., 2015; Bag et al., 2019; Ivanov and Sokolov, 2019), this study considered resilience enablers to include a risk management culture, collaboration, agility, and integration, because these are associated with supply chain reconfiguration. However, an alternative view questions the assumption that supply chain resilience has positive implications for supply chain reconfiguration. To test the link between supply chain resilience and reconfiguration in a context of eco-political risk, such as Qatar blockage, we used fault tree analysis to identify the best way to determine the rate of supply chain failure under the blockage.

4.5 Conceptual model and research hypotheses

The vast majority of existing models do not capture the multi-dimensionality of supply chain resilience. Previous studies have suggested that empirical research should focus on testing models of supply chain resilience using only one type of disruption. Some degree of progress has been made (Forbes and Wilson, 2018; Ishfaq, 2012; Lam and Bai, 2016; Zainal and Ingirige, 2018). However, much more empirical research is needed (Adobor and McMullen, 2018; Ambulkar et al., 2015; Bag et al., 2019; Ivanov and Sokolov, 2019) to

develop a more thorough understanding of this complex phenomenon. There is agreement on the importance of resilience enablers for supply chain resilience research, but no clear consensus has emerged on the precise effects of supply chain resilience on supply chain reconfiguration (Ambulkar et al., 2015; Bag et al., 2019; Ivanov and Sokolov, 2019). Empirical evidence about the effect on supply chain resilience of resilience enablers is limited (Brusset and Teller, 2017; Chowdhury and Quaddus, 2015; Dubey et al., 2019a; Jain et al., 2017; Johnson et al., 2013; Jüttner and Maklan, 2011; Kamalahmadi and Parast, 2016; Liu et al., 2018; López and Ishizaka, 2017; Pettit et al., 2013; Ponomarov and Holcomb, 2009).

Supply chain resilience models, which simultaneously examine multiple resilience enablers, can provide a better understanding of how supply chain resilience affects supply chain reconfiguration and also predict variation in supply chain resilience (Adobor and McMullen, 2018 Ambulkar et al., 2015; Ivanov and Sokolov, 2019). This type of research can significantly improve understanding of supply chain resilience and reconfiguration, which in turn can improve practice (Bag et al., 2019). It is important to establish empirically whether risk management culture, agility, collaboration, and integration are resilience enablers, and assess how each one influences supply chain resilience and supply chain reconfiguration. This study treated each one as a separate characteristic of supply chain resilience, linking this with supply chain reconfiguration.

There is relatively little research on supply chain reconfiguration, so this study attempts to provide insights into supply chain resilience and complement existing studies on supply chain resilience enablers. Many previous studies have focused on information

analysis and evaluation, and neglected collaboration and integration between supply chains and constituent firms. A focus on enablers of supply chain resilience has the potential to explain a range of supply chain reconfiguration practices. This study therefore aims to contribute to knowledge on supply chain resilience and reconfiguration by developing and testing a conceptual model (see Figure 3.3) that includes risk management culture, agility, collaboration and integration. The following subsections discuss each of these in turn.

4.6.1 Risk management culture

The supply chain resilience literature generally suggests that supply chains vary across cultures, locations, and time zones, and that this complicates supply chain management (Liu et al., 2018). Lima et al. (2018) and Stone and Rahimifard (2018) both found that a culture of resilience may help to mitigate specific vulnerabilities. Organizations can achieve this by creating a risk management culture and establishing sustainable practices in supply chains to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations (Jain et al., 2017). A number of studies have provided empirical evidence about the effect of a risk management culture in responding to supply chain risks. For example, Soni et al. (2014) found that a risk management culture is considered a major enabler of resilience. Wieland and Wallenburg (2013) stated that sharing a risk management culture between supply chain partners can help to identify risks and to take action to mitigate them. A risk management culture appears to have more significant direct effects on supply chain resilience than other enablers such as agility, integration, collaboration, and reengineering (Lui et al, 2018). Its positive impact can be at either firm

or supply chain level (Adobor, 2018; Chowdhury and Quaddus, 2016). Thus, the following hypothesis is advanced.:

H1: Risk management culture has a significant relationship with supply chain resilience

4.6.2 Agility

The role of agility in preventing and mitigating supply chain disruption was considered by Ponomarov and Holcomb (2009), Pettit et al. (2010), Kamalahmadi and Parast (2016), Ali et al. (2017b), and Jain et al. (2017). Agility may include flexibility, visibility, and velocity (Ali et al., 2017a; Jüttner and Maklan, 2011; Kamalahmadi and Parast, 2016; Scholten et al., 2014). Flexibility can increase both supply chain agility and resilience by coordinating firm processes to cope with high levels of environmental and operational uncertainty (Pereira et al., 2014; Scholten et al., 2014). Visibility can also result in agility through identifying changes and being able to respond faster to changes in the supply chain (Hohenstein et al., 2015; Tukamuhabwa et al., 2015; Wieland and Wallenburg, 2013). Velocity is also an important part of agility because the pace of flexible adaptation determines the supply chain's time to recover from a risk event (Jüttner and Maklan, 2011; Tukamuhabwa et al., 2015).

There is relatively little empirical evidence at the firm level, but both Wieland and Wallenburg (2013) and Scholten et al. (2014) found a significant and positive relationship between agility and supply chain resilience. This means that when supply chain disruptions occur, agility enables supply chains to be rapidly redesigned (i.e. supply chain reconfiguration), for example, by rerouting materials and increasing capacity at other

manufacturing plants when there are problems at a particular production facility (Hohenstein et al., 2015; Wieland and Wallenburg, 2013). Thus, the following hypothesis is advanced:

H2: Agility has a significant relationship with supply chain resilience

4.6.3 Collaboration

Empirical studies have shown that collaboration is also a significant influence on supply chain resilience (Jüttner and Maklan, 2011; Pettit et al., 2013). Scholten and Schilder (2015) found that collaboration influenced supply chain resilience through collaboration activities, information sharing, collaborative communication, mutually-created knowledge, and joint relationship efforts. Pettit et al (2010) found that global supply chains that specified strong capabilities appeared to have the greatest connectivity in the areas of collaboration, visibility, and flexibility. This enabled them to effectively manage a vast number of interrelated operations with multiple tiers of suppliers and customers. Collaboration between supply chain partners can help to mitigate disruptive risks through exchange of information (Pettit at al., 2013; Ponomarov and Holcomb, 2009; Tukamuhabwa et al., 2015). Both Wieland and Wallenburg (2013) and Rajesh (2017) found that collaborative supply chain relationships at different levels can increase supply chain resilience. Trust and information sharing were two important elements of collaboration, and the main prerequisites to cooperation and resilience (Chowdhury and Quaddus, 2016; Kamalahmadi and Parast, 2016). Empirically, collaboration has been found to have a significant influence on supply chain resilience (Datta, 2017; Jain et al., 2017; Scholten et al., 2014). Thus, the following hypothesis is advanced:

H3: Collaboration has a significant relationship with supply chain resilience

4.6.4 Integration

Integration is a relational capability that affects supply chain resilience (Wieland and Wallenburg, 2013). It covers both coordination, especially enterprise resource planning, and processes, such as inventory management (Lui et al., 2018; Wieland and Wallenburg, 2013). These two forms of integration can enhance supply chain resilience by enabling active, effective and efficient flows of products, services, information, money and decisions. This provides maximum value to customers at low cost and high speed (Brusset and Teller, 2017). The two types of integration are often accompanied by high risk, so organizations need to share information effectively with partners to reduce the impact of supply chain disruptions (Lui et al., 2018). However, there is little clear empirical evidence of the effects of integration on supply chain resilience. Mandal (2012, 2017) found that both internal and external integration positively enhanced supply chain resilience. Wieland and Wallenburg (2013), however, found no significant relationship between integration and resilience. Examining the relationship between integration and resilience during a particular type of disruption will therefore provide an important contribution to the supply chain resilience literature. It may identify advantages and disadvantages of integration for resilience and supply chain vulnerabilities. Thus, the following hypothesis is advanced:

H4: Integration has a significant relationship with supply chain resilience

4.6.5 The effect of supply chain resilience on supply chain reconfiguration

Enablers of resilience have a positive impact on supply chain resilience in complex and fast-moving environments (Brandon-Jones et al., 2014; Cheng and Lu, 2017; Jüttner and Maklan, 2011; Lui et al., 2018; Mandal, 2017; Wieland and Wallenburg, 2013). However, it remains unclear how supply chain resilience affects supply chain reconfiguration when the supply chain is disrupted. This is particularly important when there are few resources for reconfigurations or opportunities to develop resilience and re-establish the supply chain after disruption (Ambulkar et al., 2015; Bag et al., 2018; Ivanov and Sokolov, 2019; Ivanov et al., 2018). Both Ambulkar et al. (2015) and Bag et al. (2018) examined the relationship between reconfiguration resources and supply chain resilience. They found that dynamic remanufacturing capability and reconfiguration resources positively influenced supply chain resilience when there was a high level of risk. Thus, the following hypothesis is advanced:

H5: Supply chain resilience has a significant relationship with supply chain reconfiguration

Figure 4.3 shows the conceptual model used in this study.

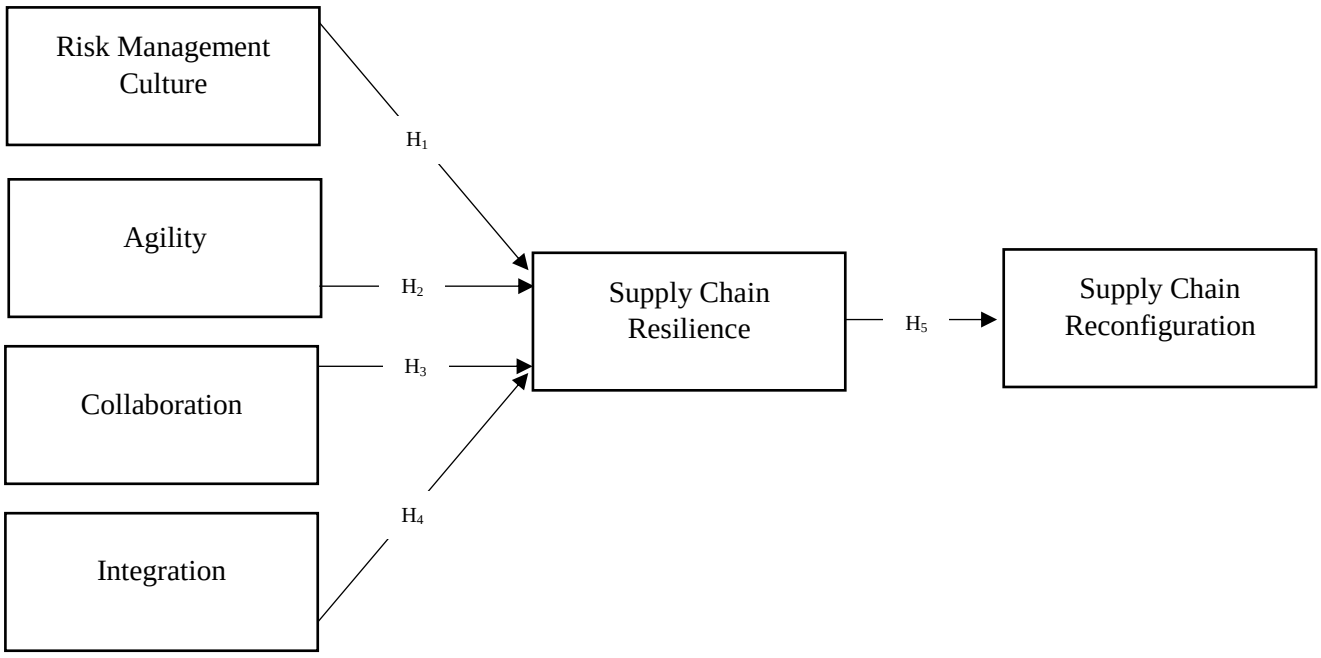

Figure 4.3. Research Model

4.6 Research questions

The conceptual model set out in Figure 3.3 is used to examine the following questions:

1. Which resilience enablers (risk management culture, agility, collaboration, and integration) have the most significant influence on supply chain resilience?
2. What are the effects of supply chain resilience on supply chain reconfiguration?
3. Do risk management culture, agility, collaboration, and integration play a major role in building supply chain resilience?

Based on these research questions, testable hypotheses were developed and are summarized in Table 4.1.

Table 4.1. Study hypotheses

Hypothesis Number	Hypothesis Examination	Hypothesis Name
H1	Examine the role of risk management culture in enhancing supply chain resilience	*Risk culture management has a significant relationship with supply chain resilience*
H2	Examine the role of agility in enhancing supply chain resilience	*Agility has a significant relationship with supply chain resilience*
H3	Examine the role of collaboration in enhancing supply chain resilience	*Collaboration has a significant relationship with supply chain resilience*
H4	Examine the role of integration in improving supply chain resilience	*Integration has a significant relationship with supply chain resilience*
H5	Examine the impact of supply chain resilience on supply chain reconfiguration	*Supply chain resilience has a significant relationship with supply chain reconfiguration*

4.7 Ethical considerations

The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (2014) stated that the three core principles of ethical research were the respect of persons, beneficence, and justice (US Department of Health and Human Services, 1979). Qatar University has an institutional review board, which ensures compliance with ethical practice. A copy of the approval letter from the committee is included at Appendix

C, providing the approval reference number. In accordance with the requirement set out by the university and institutional review board, all ethical considerations and principles were followed in this quantitative causal survey study. Beneficence was achieved by requesting consent from the participants. Participants were informed that participation was voluntary. Each participant received a copy of the informed consent form, which explained the purpose of the research and the role of the data collection. Participants were informed that the survey was anonymous and that data were to be used solely for academic purposes. They understood that filling out the survey and returning it was optional and that they were under no obligation to do so. Following the guidelines of Qatar University, the survey results were kept in a secure filing system, with access only available to the researchers.

4.8 Conclusion

This chapter has described and justified the relationships underpinning the current thesis across the two stages of the supply chain context used in this research, resilience and reconfiguration. It has also developed the conceptual model and research hypotheses. Five hypotheses were proposed, and the validity testing of these is described in the next chapter. The research questions were also listed, with a table summarizing the hypotheses. The ethical considerations taken into account in the study were described, and the chapter made clear that the study fits with the requirements of the Institutional Review Board of Qatar University. The next chapter will discuss the hypothesis testing and analyses.

CHAPTER 5: QUESTIONNAIRE AND HYPOTHESIS TESTING

5.1 Introduction

The previous chapters have explained the theoretical foundation of the conceptual model used in this study. This chapter provides an in-depth discussion of the survey method used to examine the conceptual model and hypotheses set out in Chapter 3.

The purpose of this survey study was to test the relationships between risk management culture, agility, collaboration, and integration, and supply chain resilience. In other words, how do these factors enable supply chains to continue, respond, and recover from disruptions, returning quickly to their original state? The study also tested whether the relationship between supply chain resilience and reconfiguration was a predictor for redesigning the supply chain to address unexpected disruptions. The measurement model and survey items on risk management culture, agility, collaboration, integration, supply chain resilience, and reconfiguration were used to measure each construct in the research model, shown in Figure 3.3.

The rest of this chapter has six sections:

1. Research methodology (content validity, construct validity, reliability, pilot testing, sample size and data collection, and measurement)
2. Survey responses and response bias
3. Data analysis and results (including evaluation and results for both the measurement model and structural model)
4. Hypothesis testing

5. Discussion
6. Conclusion

5.2 Research Methodology

The study aimed to develop a questionnaire-based survey on supply chain resilience and reconfiguration. It pooled items measuring the research constructs from previous studies, and selected the most significant (see Appendix D). It was felt that the response rate for surveys like this is often not high, and potential respondents are generally unenthusiastic about spending their spare time responding to questionnaires. The questions were therefore closed, so that less time and effort were needed to complete the questionnaire. The questionnaire was designed using a seven-point Likert scale. It was divided into three sections. Section 1 was about the respondent, section 2 supply chain resilience, and section 3 supply chain reconfiguration. A pilot test was conducted in the same survey sample setting to investigate crucial components of the main study. The instrument's validity and reliability were also assessed from the survey sample.

5.2.1 Content validity

The content validity describes whether the items adequately cover all aspects of the variables being measured (Nunnally, 1978). The survey items were taken from the supply chain literature. The survey was initially designed in English and then translated into Arabic. The Arabic version was translated by native speakers of Arabic with prior experience of translation. When the Arabic version was checked against the English version, some questions were reworded to improve the accuracy of the translation. To ensure content

validity, the targeted respondents were employees who (1) were familiar with supply chain practices, and (2) had worked in their companies for at least one year. On average, respondents had spent five to ten years in their companies. To ensure credibility, a professional market research company was employed to collect the data. Data collectors were trained on the study objective, method, and study instrument. All the trainees went through the survey question by question for clarification and discussion. Data were gathered through individual data collection interviews using a fully standardized survey.

5.2.2 Construct validity

The construct validity is how well an item measures what it is supposed to measure with respect to a common concept. It is shown by the existence of significant factor loadings for measures and constructs (Anderson and Gerbing, 1988). Indicator loading was conducted for all the items to assess the validity of the questions. Only those items with indicator loading of more than 0.70 were used in the questionnaire (Hair et al., 2014).

5.2.3 Reliability

Reliability is the internal consistency of the responses. An item with a Cronbach's alpha of more than 0.5 is considered adequate for this type of exploratory work (Nunnally, 1978). The value of α for all the questions was more than 0.5 (see Appendix E). This implies that there is a high degree of internal consistency in the responses to the questionnaire.

5.2.4 Pilot testing

A pilot study was conducted to ensure the relevancy of the data collection. The questionnaire was sent to a sample of 26 companies randomly selected from the list provided by the Chamber of Commerce and Industry in Qatar, to pretest the survey items. The pilot test was completed in 4 working days. Each of the two assigned data collectors conducted four interviews. The length of each interview was 20 to 25 minutes. After a further review of the pilot test, the instrument was deemed ready to be sent to a large sample to gather data to test the research model.

5.2.5 Sample size and data collection

The context of this research was companies operating in Qatar. The target population was supply chain managers in these companies. The study therefore considered all export and import firms of any size, small, medium, and large. The analysis was at firm level. The survey data were collected by face-to-face interviews with managers in the selected companies in Qatar. The supply chain managers were approached using a list of companies operating in Qatar in the import and export sector obtained from Qatar Chamber of Commerce and Industry. A total of 314 companies was randomly selected from this list. In total, 253 complete surveys were obtained, which was considered adequate for partial least squares structural equation modeling (PLS-SEM) analysis.

5.2.6 Measurement

For all constructs, the study used existing multi-item scales from previous research on supply chain reconfiguration. All had shown strong measurement properties in research. Appendix E describe the measures.

Supply chain resilience was evaluated using eight items from Golgeci and Ponomarove (2013) and Ambulkar et al. (2015). Each respondent was asked to assess the resilience of the company's supply chain on a seven-point Likert scale from "strongly disagree" (1) to "strongly agree" (7). The scale for risk management culture was from Liu et al. (2018), and originally from work by Christopher and Peck (2004), Jüttner and Maklan (2011) and Johnson et al. (2013). The questions asked about elements of a risk management culture, including the sharing of employee knowledge about risk management, relationship to overall risk culture, risk awareness, and the internal and external attributes driving risk culture. Agility was measured using four items form Liu et al. (2018) and Mandal et al. (2016). These items suggested that effective collaboration between supply chain members can allow sharing of information, reduce vulnerability, and find the best solution to problems. Collaboration was measured by asking respondents to indicate how firms exchanged information with their suppliers (three items from Brandon-Jones et al., 2014), and their plan for collaboration and sharing decision-making practices with supply chain partners (one item from Chowdhury and Quaddus, 2017). Integration was measured using four items from Liu et al. (2018). These items were chosen to investigate the impact of integration on supply chain resilience, customers, and collaboration.

Four items were used to evaluate supply chain reconfiguration. Three were from Wei and Wang (2010), and were initially used by Pavlou and El Sawy (2006). These items measured the firm's capability and resources to reconfigure the supply chain to fill the local market need. The other item measured the firm's capability to reconfigure the supply chain after disruption (Ambulkar et al., 2015).

5.3 Survey responses and response bias

The survey was administered in person by a market research agency. In the first meeting, a sample frame was identified by preparing a random sample of companies operating in Qatar. The sampling frame was an accurate and complete representation of the population, to avoid any frame errors. A total of 314 companies was then selected for the survey. A cover letter explaining the purpose of the study and the survey questionnaire was also developed. In the second meeting, a work plan was identified by outlining the key collectors, work duration, and timeline required to collect the data. Seven weeks later, a total of 314 questionnaires had been completed. In total, 61 of these were discarded from the analysis because they were inaccurate and/or incomplete. This give a response rate of 80.57%, higher than in many similar studies (Cheng and Lu, 2017).

5.3.1 Non-response bias

There are different ways to test the non-response bias. The strategy used in this study was to examine the respondents' job level (i.e. general manager, procurement staff/manager, operational staff/manager, supply chain staff/manager). The logic behind this was that it

seemed likely that specialist staff were more likely to answer the questionnaire than those who were not specialists in the supply chain or operations sector. The non-response bias was assessed by comparing the job-level characteristics of responders and non-responders.

5.4 Data analysis and results

This section provides details of the descriptive statistical analysis for the questionnaire. It also discusses the PLA path modeling results for both measurement model and structural model.

5.4.1 Descriptive statistics

The survey included seven questions on the respondents themselves, to provide an understanding of their profile. These questions asked about participants' gender, nationality, level of education, age, years of experience, job level, and type of organization. The descriptive data were analyzed using IBM SPSS 26 software. Table 5.1 shows the distribution of responses by gender. In total, 87.7 % of respondents were male and 12.3% female.

Table 5.1. Summary of responses by gender

Gender		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Male	222	87.7	87.7	87.7
	Female	31	12.3	12.3	100.0
	Total	253	100.0	100.0	

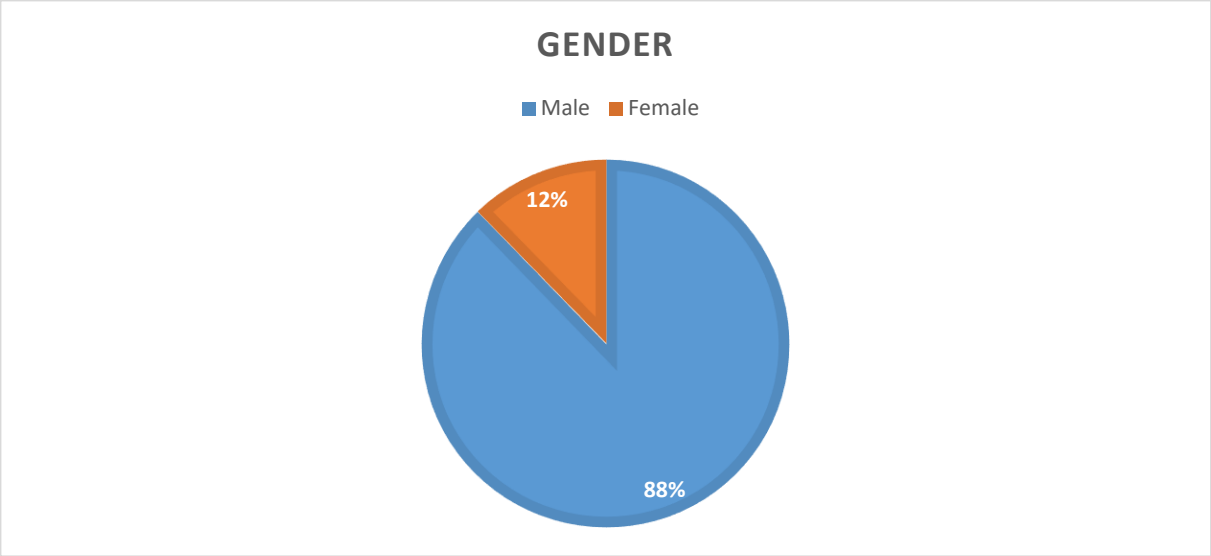

Figure 5.1. Summary of responses by gender

Table 5.2 shows the responses by nationality. In total, 249 respondents, 98.4% of the participants, were non-Qatari, and 1.6% were Qatari.

Table 5.2. Summary of responses by nationality

Nationality		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Qatari**	4	1.6	1.6	1.6
	Non-Qatari	249	98.4	98.4	100.0
	Total	253	100.0	100.0	

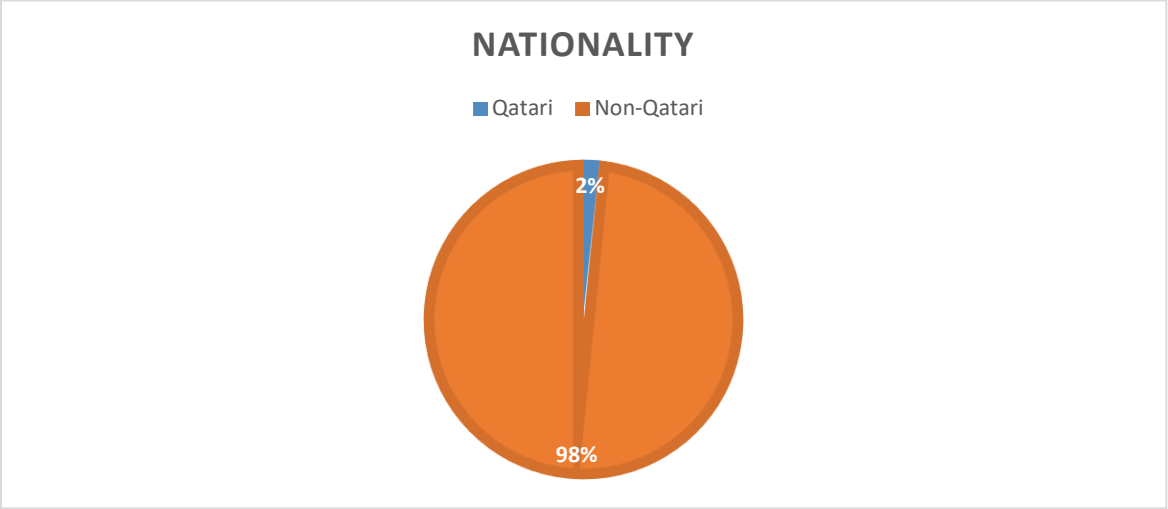

Figure 5.2. Summary of responses by nationality

Table 5.3 shows the participants' level of education. Overall, more than half of the participants (59.3%) had a graduate degree, three times more than other levels of education. However, 6.3% had only a high school education.

Table 5.3. Summary of responses by education level

Education		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**High School**	16	6.3	6.3	6.3
	Undergraduate Degree	68	26.9	26.9	33.2
	Graduate Degree	150	59.3	59.3	92.5
	Any Additional Qualification	19	7.5	7.5	100.0
	Total	253	100.0	100.0	

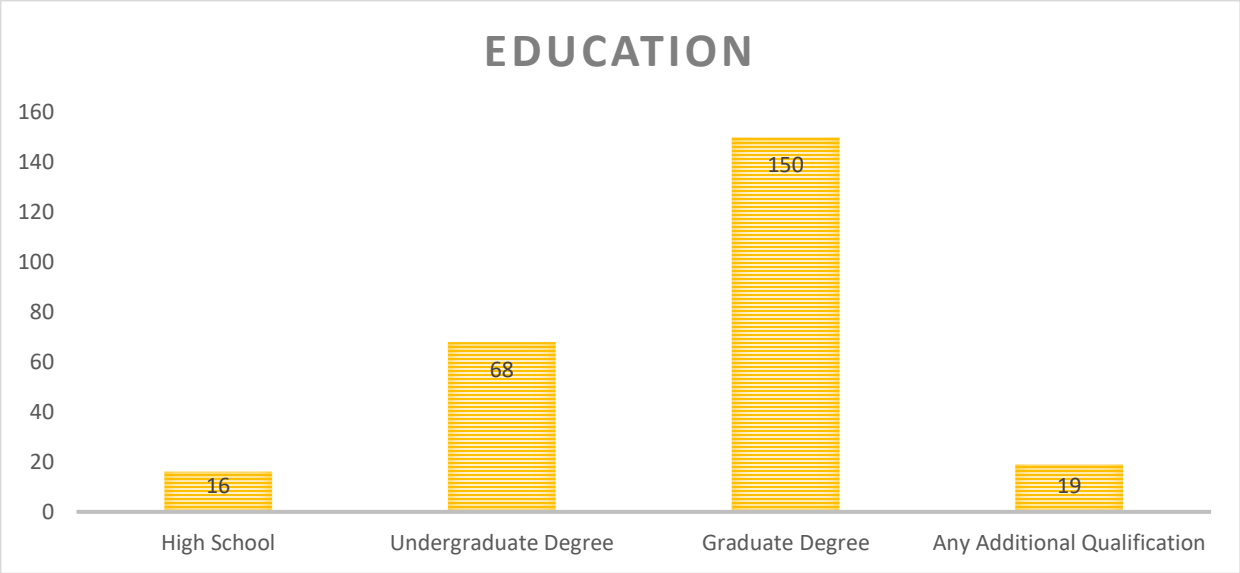

Figure 5.3. Responses by education level

The age of the participants ranged from 18 to 57, with 54.5% (138) aged 18 to 25 years, 30% (76) aged 25 to 35 years, and 11.1% (28) aged between 36 and 46. The last age group (47 to 57) contained only 4.3% (11) of the respondents (see Table 5.4).

Table 5.4. Summary of responses by age

Age		**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**18 – 25**	138	54.5	54.5	54.5
	25 – 35	76	30.0	30.0	84.6
	36 – 46	28	11.1	11.1	95.7
	47 – 57	11	4.3	4.3	100.0
	Total	253	100.0	100.0	

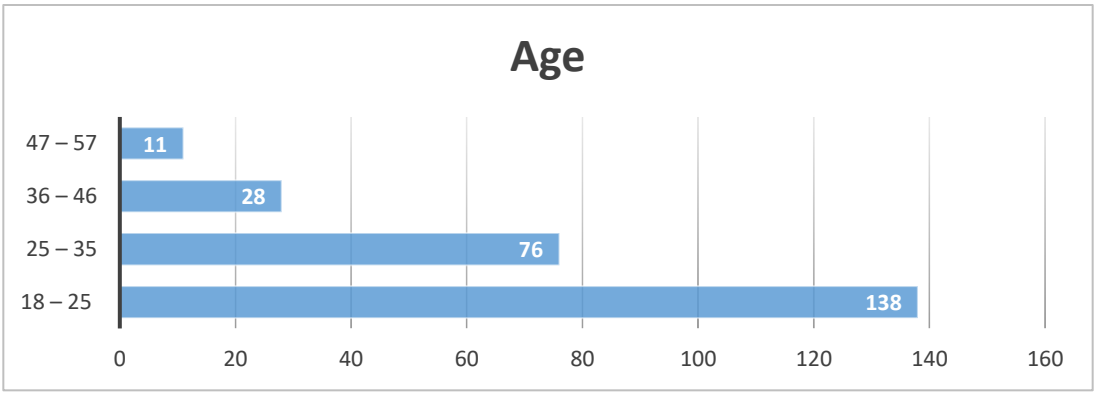

Figure 5.4. Responses by age

Participants' years of professional experience are shown in Table 5.5. In total, 91 of the participants (36%) had spent 5 to 10 years working in their companies. There were more people with 11 to 15 years' experience than less than five years (23.3% vs. 19%). Only 29 of the participants (11.5%) had spent more than 20 years working in the supply chain sector.

Table 5.5. Summary of responses by experience

Experience					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Less than 5 years**	48	19.0	19.0	19.0
	5–10	91	36.0	36.0	54.9
	11–15	59	23.3	23.3	78.3
	16–20	26	10.3	10.3	88.5
	More than 20 years	29	11.5	11.5	100.0
	Total	253	100.0	100.0	

Study participants were asked to indicate what job level represented their job position. In total, 74 (29.3%) were operations staff or managers, 27.7 % (70) were procurement staff or managers, and 19.8% were Chief Executive Officers (CEO), Chief Financial Officers (CFO), or sales managers. A total of 33 (13%) were general managers. Only 10% (26) were supply chain staff or managers (see Table 5.6).

Table 5.6. Summary of responses by job level and position

Job Level					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**General Manager**	33	13.0	13.0	13.0
	Procurement Staff/Manager	70	27.7	27.7	40.7
	Operation Staff/Manager	74	29.2	29.2	70.0
	Supply Chain Staff/Manager	26	10.3	10.3	80.2
	Other, Please Specify	50	19.8	19.8	100.0
	Total	253	100.0	100.0	

All the participants worked in private sector organizations.

5.4.2 PLS Path Modeling

SmartPLS V.3 was used to analyze the PLS path modeling by uploading a CSV file of the dataset. Following the approach of Hair et al. (2014), two models, a measurement model and a structural model, were used to evaluate the research path model through PLS-SEM. The measurement model shows the relationships between the observed data and the latent variables, and the structural model evaluates the relationships between the latent variables. Figure 5.5 shows the results of the PLS path modeling.

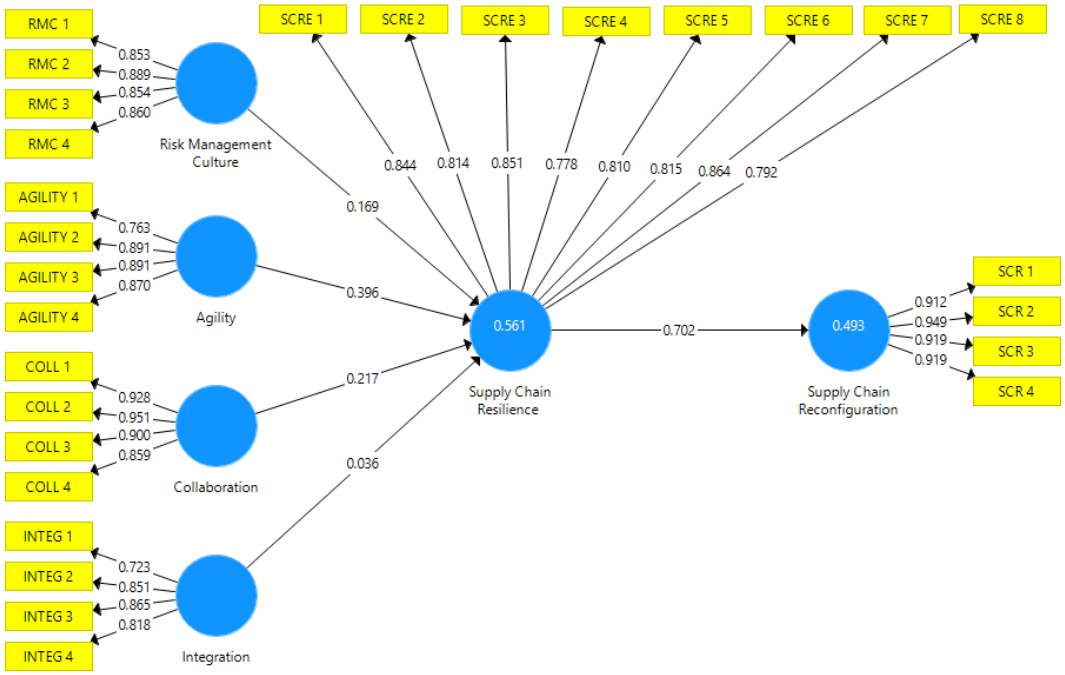

Figure 5.5. PLS path modeling results

5.4.2.1 Part I: Measurement Model Evaluation and Result

The measurement model focuses on the validity and reliability of the research model. Four steps were used to evaluate the measurement model (see Figure 5.6).

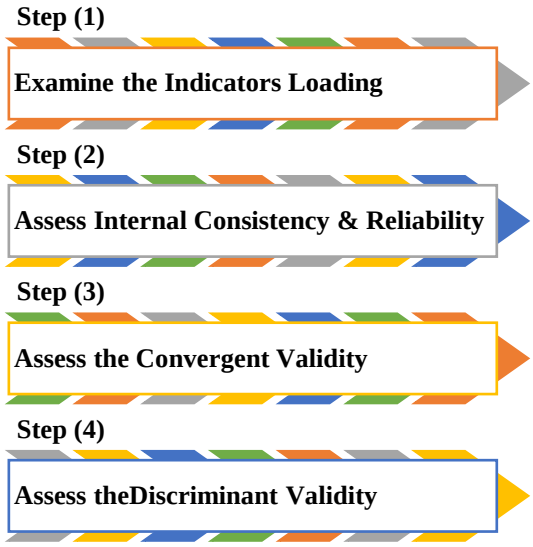

Figure 5.6. Steps in the measurement model

Step (1): Examine the indicator loading

All outer loadings of the reflective constructs for risk management culture (RMC), agility (AGILITY), collaboration (COLL), integration (INTEG), supply chain resilience (SCRE), and supply chain reconfiguration (SCR) were well above the threshold value of 0.70, which suggested that the indicators were sufficiently reliable. The indicator INTEG 1 (outer loading 0.723) had the lowest reliability, with a value of 0.523 (0.723^2). COLL 2

(outer loading 0.951) had the highest reliability, with a value of 0.904 (0.951^2) (see Table 5.7).

Table 5.7. Indicator loading

	Agility	Collaboration	Integration	Risk Management Culture	Supply Chain Reconfiguration	Supply Chain Resilience
AGILITY 1	0.763					
AGILITY 2	0.891					
AGILITY 3	0.891					
AGILITY 4	0.870					
COLL 1		0.928				
COLL 2		0.951				
COLL 3		0.900				
COLL 4		0.859				
INTEG 1			0.723			
INTEG 2			0.851			
INTEG 3			0.865			
INTEG 4			0.818			
RMC 1				0.853		
RMC 2				0.889		
RMC 3				0.854		
RMC 4				0.860		
SCR 1					0.912	
SCR 2					0.949	
SCR 3					0.919	
SCR 4					0.919	
SCRE 1						0.844

SCRE 2	0.814
SCRE 3	0.851
SCRE 4	0.778
SCRE 5	0.810
SCRE 6	0.815
SCRE 7	0.864
SCRE 8	0.792

Step (2): Assess internal consistency and reliability

2.1 Composite reliability

All composite reliability values exceeded the threshold (Figure 5.7). All the indicators were above 0.7 (the horizontal blue line in the figure), the common minimum threshold level for composite reliability. The three reflective constructs had values of 0.959 (supply chain reconfiguration), 0.951 (collaboration), and 0.943 (supply chain resilience), showing high levels of internal consistency and reliability (Table 5.8).

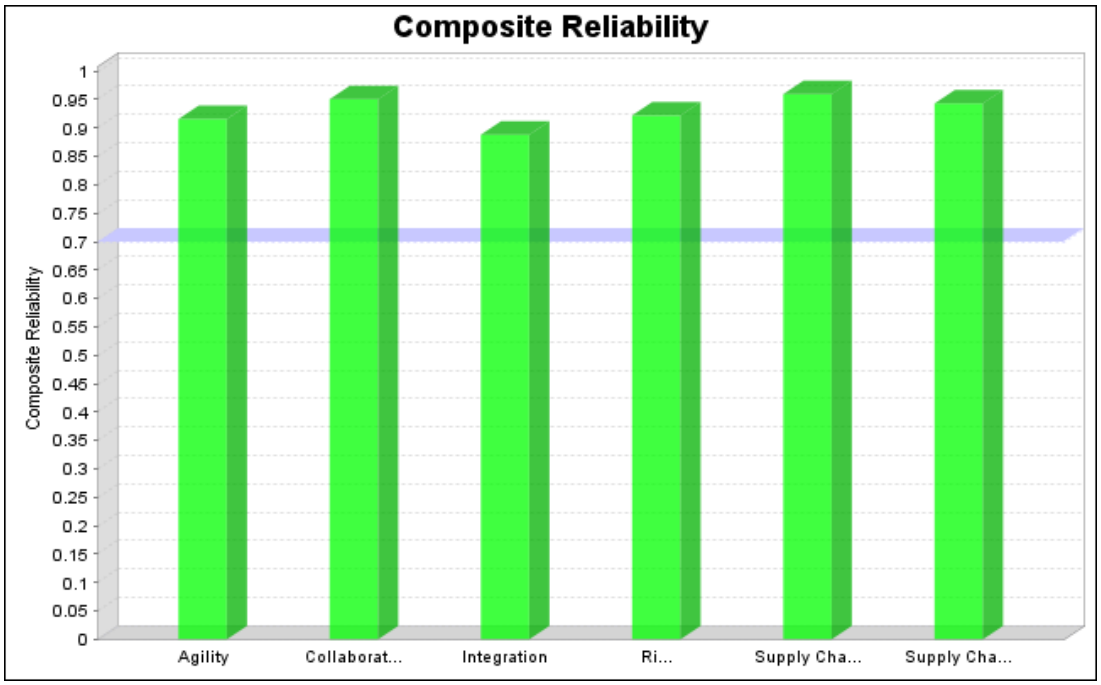

Figure 5.7. Composite reliability

2.2 Cronbach's alpha

All the constructs had a Cronbach's alpha of more than the 0.70 threshold (see Figure 5.8). Table 5.8 shows that the value ranged from 0.944 for supply chain reconfiguration to 0.833 for integration.

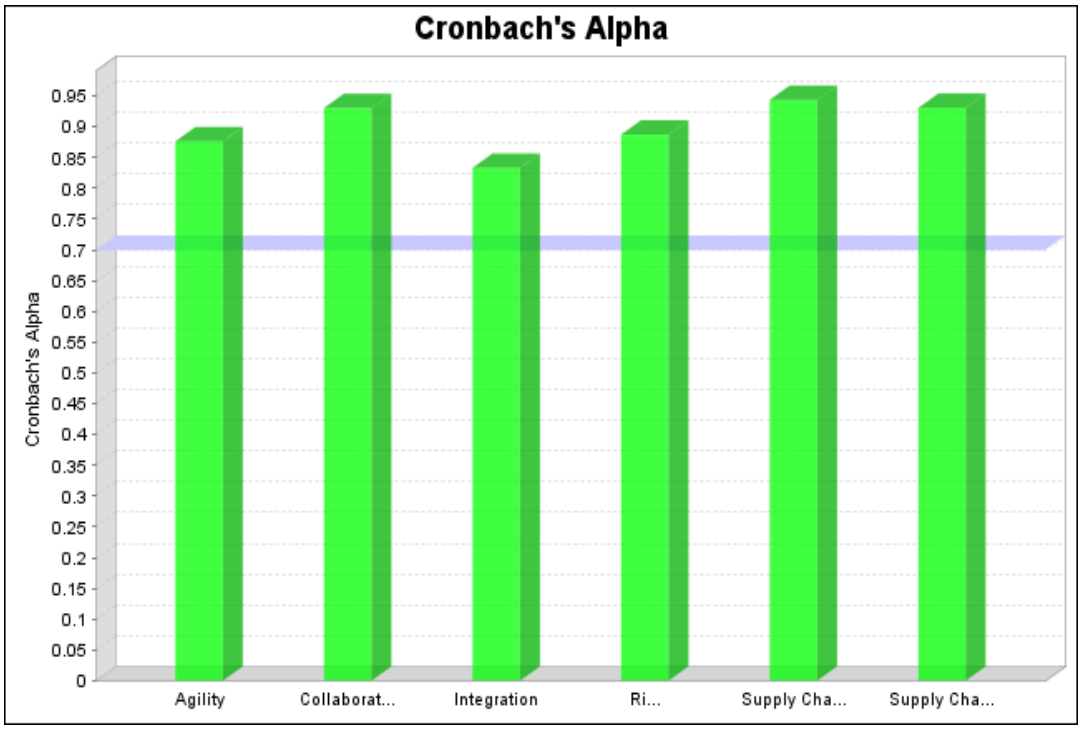

Figure 5.8. Cronbach's alpha values for the study constructs

Step (3): Assess the convergent validity

3.1 Convergent validity

The convergent validity was assessed by estimating the average variance extracted (AVE) (Figure 5.9). All the AVE values in the model were above the required minimum of 0.50: supply chain reconfiguration (0.855), collaboration (0.828), risk management culture (0.747), agility (0.731), supply chain resilience (0.675), and integration (0.666). The measures of the six reflective constructs therefore had high levels of convergent validity (Table 5.8).

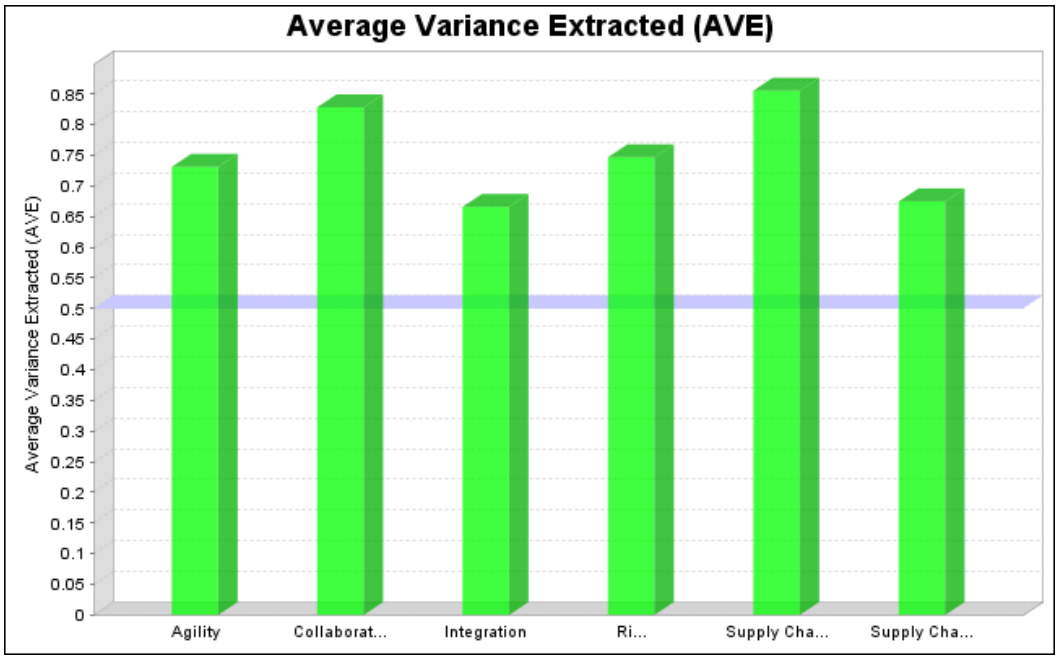

Figure 5.9. Convergent validity

Table 5.8. Internal consistency and reliability

	Cronbach's alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Agility	0.876	0.888	0.916	0.731
Collaboration	0.930	0.933	0.951	0.828
Integration	0.833	0.857	0.888	0.666
Risk Management Culture	0.887	0.891	0.922	0.747
Supply Chain Reconfiguration	0.944	0.945	0.959	0.855
Supply Chain Resilience	0.931	0.932	0.943	0.675

Step (4): Assess discriminant validity

4.1 Discriminant validity

Three criteria were used to assess the discriminant validity (Figure 5.10).

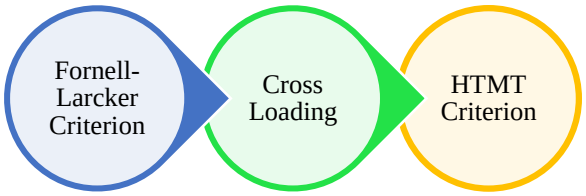

Figure 5.10. Discriminant validity criteria

The discriminant validity describes whether the constructs are distinct. There are several ways to measure this. The Fornell-Larcker criterion requires the square root of the AVE of each construct to be higher than the construct's highest correlation with any other construct in the model. Table 5.9 shows the results of the Fornell-Larcker criterion assessment with the square root of the reflective constructs' AVE on the diagonal and the correlation between the constructs on the off-diagonal position. The square roots of the AVEs for the reflective constructs Agility (0.855), Collaboration (0.910), Integration (0.816), Risk Management Culture (0.864), Supply Chain Reconfiguration (0.925), and Supply Chain Resilience (0.822) were all higher than the correlations of these constructs with other latent variables in the path model. This suggested that all the constructs were valid measures of unique concepts.

Table 5.9. Fornell-Larcker criterion assessment

	Agility	Collaboration	Integration	Risk Management Culture	Supply Chain Reconfiguration	Supply Chain Resilience
Agility	0.855					
Collaboration	0.799	0.910				
Integration	0.719	0.748	0.816			
Risk Management Culture	0.755	0.663	0.693	0.864		
Supply Chain Reconfiguration	0.739	0.667	0.655	0.634	0.925	
Supply Chain Resilience	0.723	0.672	0.600	0.637	0.702	0.822

An alternative way to assess discriminant validity is cross-loading. Table 5.10 shows the loading and cross-loading for every indicator. AGILITY 2 and AGILITY 3 had the highest value for the loading with their corresponding construct AGILITY (0.891). The cross-loading of other constructs was considerably lower. For instant, AGILITY 2 showed a cross-loading of 0.708 and AGILITY 3 of 0.682 with Collaboration. This was also true for the other indicators of integration, as well as the indicators measuring risk management culture, supply chain resilience, and supply chain reconfiguration. COLL 2 had the highest value for the loading with its corresponding construct COLL (0.951), and cross-loading with all other constructs were considerably lower. INTEG 3 had the highest value for the loading with its corresponding indicator (0.865). RMC 2 (0.889) had the highest value in the risk

management culture construct. In supply chain reconfiguration, SCR 2 had the highest value (0.949) for the loading with its corresponding construct, and the cross-loading with other constructs was considerably lower. All the risk management culture construct indicators had a lower cross-loading with the supply chain reconfiguration construct (0.597, 0.588, 0.586, and 0.573). For supply chain resilience, SCRE 7 had the highest loading value. The supply chain resilience construct's cross-loading values were generally higher than the other constructs' cross-loading values (Table 5.10).

Table 5.10. Cross-loading criterion assessment

	Agility	**Collaboration**	**Integration**	**Risk Management Culture**	**Supply Chain Reconfiguration**	**Supply Chain Resilience**
AGILITY 1	0.763	0.548	0.558	0.605	0.542	0.523
AGILITY 2	0.891	0.708	0.649	0.650	0.677	0.701
AGILITY 3	0.891	0.682	0.625	0.700	0.617	0.607
AGILITY 4	0.870	0.781	0.624	0.630	0.680	0.625
COLL 1	0.784	0.928	0.654	0.587	0.637	0.620
COLL 2	0.733	0.951	0.693	0.605	0.620	0.630
COLL 3	0.663	0.900	0.663	0.543	0.555	0.552
COLL 4	0.721	0.859	0.708	0.668	0.611	0.637
INTEG 1	0.487	0.493	0.723	0.484	0.374	0.385
INTEG 2	0.608	0.666	0.851	0.534	0.542	0.447
INTEG 3	0.724	0.696	0.865	0.659	0.654	0.599
INTEG 4	0.494	0.562	0.818	0.558	0.523	0.490
RMC 1	0.657	0.613	0.624	0.853	0.620	0.603

RMC 2	0.624	0.535	0.603	0.889	0.506	0.545
RMC 3	0.633	0.559	0.569	0.854	0.519	0.484
RMC 4	0.690	0.578	0.593	0.860	0.534	0.555
SCR 1	0.683	0.622	0.624	0.597	0.912	0.642
SCR 2	0.699	0.617	0.619	0.588	0.949	0.673
SCR 3	0.687	0.581	0.591	0.586	0.919	0.662
SCR 4	0.664	0.653	0.590	0.573	0.919	0.618
SCRE 1	0.562	0.480	0.451	0.470	0.574	0.844
SCRE 2	0.525	0.455	0.410	0.454	0.517	0.814
SCRE 3	0.598	0.584	0.498	0.533	0.590	0.851
SCRE 4	0.584	0.534	0.435	0.509	0.542	0.778
SCRE 5	0.576	0.516	0.507	0.530	0.538	0.810
SCRE 6	0.594	0.559	0.541	0.497	0.641	0.815
SCRE 7	0.634	0.642	0.552	0.553	0.574	0.864
SCRE 8	0.657	0.619	0.529	0.617	0.617	0.792

Overall, the Fornell-Larcker criterion and the cross-loading provided evidence that the constructs had sufficient discriminant validity. However, neither are able to detect discriminant validity issues reliably. A third alternative criteria, the heterotrait–monotrait (HTMT) ratio, should be used to address the shortcomings of both alternatives. Table 5.11 shows the HTMT values for all constructs in matrix format. All of the HTMT values were lower than the relevant threshold level (0.85), except agility with collaboration (0.879) and agility with risk management culture (0.856) (Figure 5.11). This suggested that there was a lack in discriminant validity and potential multicollinearity problem among the latent constructs. Some of the agility, collaboration, and risk management culture items may be measuring the same thing.

Table 5.11. Heterotrait–monotrait ratio (HTMT) criterion assessment

	Agility	Collaboration	Integration	Risk Management Culture	Supply Chain Reconfiguration	Supply Chain Resilience
Agility						
Collaboration	0.879					
Integration	**0.828**	**0.840**				
Risk Management Culture	0.856	**0.725**	**0.794**			
Supply Chain Reconfiguration	**0.810**	**0.712**	**0.722**	**0.689**		
Supply Chain Resilience	**0.792**	**0.716**	**0.664**	**0.693**	**0.745**	

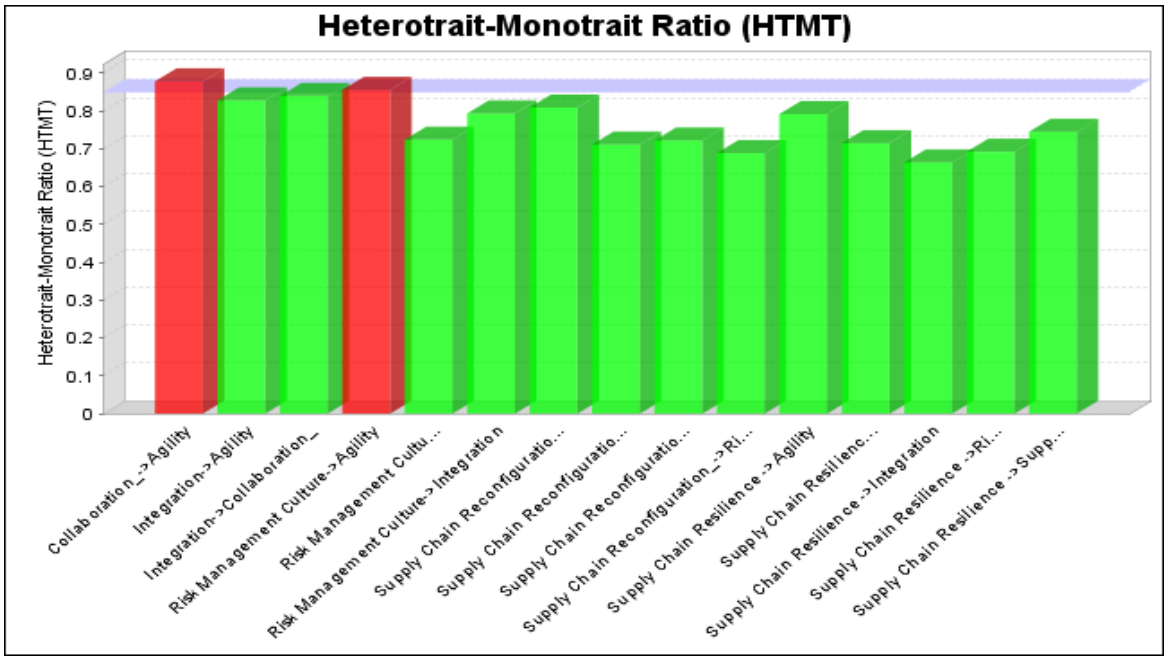

Figure 5.11. Heterotrait-monotrait ratio

The HTMT ratio must be computed to test the significance of the HTMT value and obtain confidence intervals by running the bootstrap option with 5,000 subsamples. Table 5.12 shows the bias-corrected confidence intervals. The lower and upper bounds of the confidence intervals (columns labeled 2.5% [lower] and 97.5% [upper]) show the relationships between constructs. The interval for the relationship between agility and supply chain resilience was 0.203 to 0.587, and that for the relationship between collaboration and supply chain resilience was between 0.046 and 0.382. The ratio for integration and supply chain resilience was between −0.128 and 0.206, lower than the other relationships. This mean that there is little information about the effect of integration on supply chain resilience, and the relationship was not significant. The relationship between risk management culture

and supply chain resilience was between 0.003 and 0.338, and that between supply chain resilience and supply chain reconfiguration was between 0.617 and 0.765.

Table 5.12. HTMT ratio

	Original Sample (O)	**Sample Mean (M)**	**Bias**	**2.5%**	**97.5%**
Agility → Supply Chain Resilience	0.396	0.397	0.001	0.203	0.587
Collaboration → Supply Chain Resilience	0.217	0.214	-0.003	0.046	0.382
Integration → Supply Chain Resilience	0.036	0.041	0.005	−0.128	0.206
Risk Management Culture → Supply Chain Resilience	0.169	0.170	0.001	0.003	0.338
Supply Chain Resilience → Supply Chain Reconfiguration	0.702	0.704	0.002	0.617	0.765

5.4.2.2 Part II: Structural Model Evaluation and Result

The main purpose of the structural model is to examine the causes and effect of the research variables, to determine how well the empirical data support the research theory. The structural model also provides evidence about the research model and variables' ability in recovering the supply chain disruption. Six steps must be followed to predict the accuracy of the relationships (Figure 5.12).

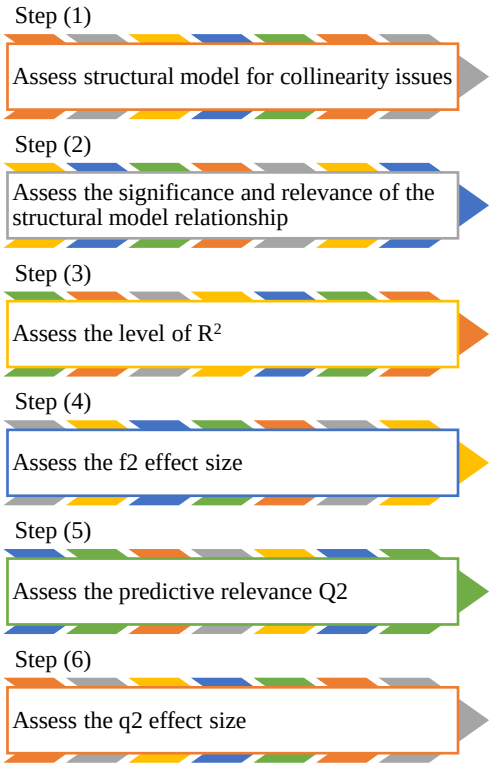

Figure 5.12. Steps in the structural model

Step (1): Collinearity Assessment

The results table (Table 5.13) shows the variance inflation factor (VIF) values for all the combinations of endogenous constructs (agility, collaboration, integration, risk

management culture, supply chain reconfiguration, supply chain resilience) and corresponding exogenous constructs (agility, collaboration, integration, risk management culture, supply chain reconfiguration, supply chain resilience). All the VIF values were below the threshold of 5. Collinearity among the predictor constructs was therefore not a critical issue in the structural model.

Table 5.13. VIF values in the structural model

	Agility	**Collaboration**	**Integration**	**Risk Management Culture**	**Supply Chain Reconfiguration**	**Supply Chain Resilience**
Agility						3.758
Collaboration						3.345
Integration						**2.744**
Risk Management Culture						**2.608**
Supply Chain Reconfiguration						
Supply Chain Resilience					**1.000**	

Step (2): Structural Model Path Coefficients

The path coefficients show the hypothesized relationships among the constructs. The standardized values of the path coefficients range from −1 to +1. Values close to +1 show strong positive relationships and values close to −1 strong negative relationships.

Statistically, values close to zero show weak relationships, which are probably not significant (see Figure 5.13). The model's path coefficients were all positive and close to one, except for integration. This was closer to zero (see Table 5.14). The relative importance of the exogenous driver constructs for supply chain reconfiguration showed that supply chain resilience was most important, followed by agility and collaboration. However, risk management culture and integration had very little bearing on supply chain reconfiguration. The relationship between supply chain resilience and supply chain reconfiguration was strongly positive, and the relationships between agility, collaboration, and risk management culture, and supply chain resilience, were all positive and significant. However, the relationship between integration and supply chain resilience was not significant.

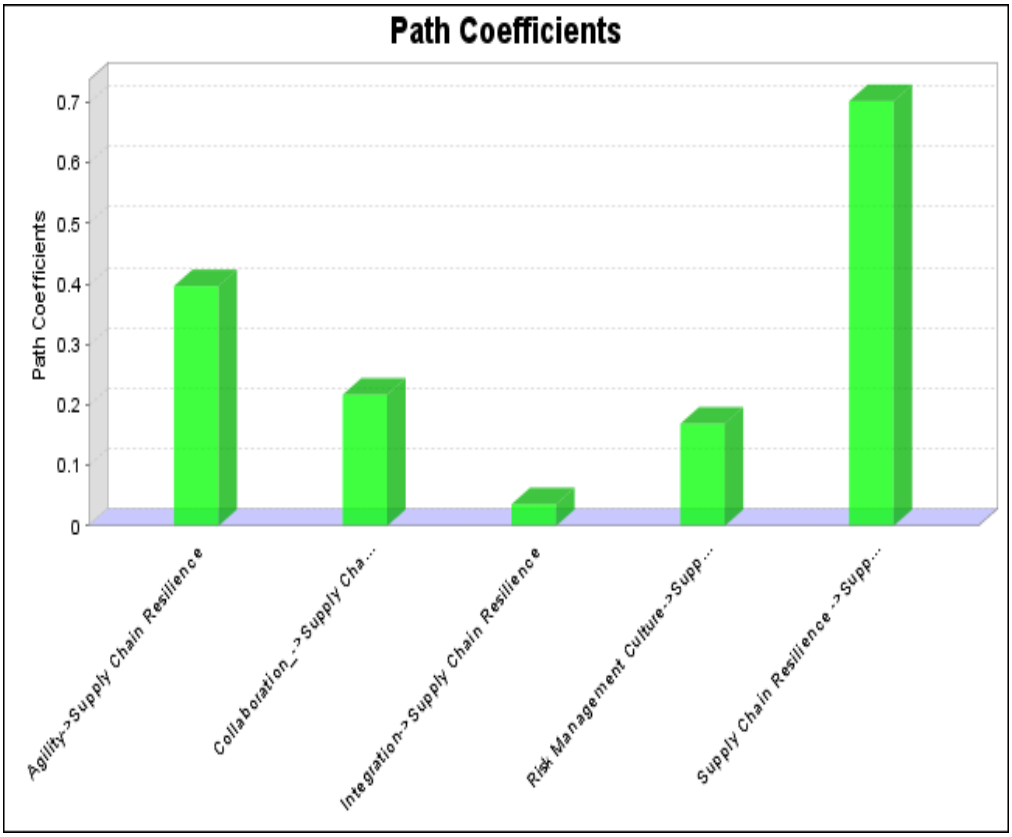

Figure 5.13. Path coefficients

Table 5.14. Structural model path coefficients

	Agility	Collaboration	Integration	Risk Management Culture	Supply Chain Reconfiguration	Supply Chain Resilience
Agility						0.396
Collaboration						0.217
Integration						0.036
Risk Management Culture						0.169
Supply Chain Reconfiguration						
Supply Chain Resilience					0.702	

A bootstrapping option was run with 5,000 subsamples to test the significance of all the hypotheses (Table 5.15). Assuming a 5% significance level, all the relationships in the structural model were significant except the relationship between integration and supply chain resilience ($p = 0.675$). These results suggest that companies should concentrate their supply chain resilience efforts on enhancing agility, collaboration, and risk management culture. They should strengthen collaboration with partners, and try to develop a shared culture of resilience and risk awareness to ensure the exchange of information and knowledge, visibility, flexibility, operational effectiveness and efficiency, and customer service. They should not focus on integration as a way to maximize supply chain resilience. Supply chain resilience can also help companies to reconfigure their supply chain in response to unexpected disruptions. Economic-political risks are intangible, so effective supply chain resilience plays a much more important role in supply chain reconfigurations in response.

Table 5.15. The p-values of the hypotheses

	Original sample (O)	Sample mean (M)	Standard deviation (SD)	*t* statistic (|O/STDEV|)	p values
Agility → Supply Chain Resilience	0.396	0.397	0.099	4.015	**0.000**
Collaboration → Supply Chain Resilience	0.217	0.214	0.086	2.535	**0.011**
Integration → Supply Chain Resilience	0.036	0.041	0.086	0.420	**0.675**
Risk Management Culture → Supply Chain Resilience	0.169	0.170	0.085	1.988	**0.047**
Supply Chain Resilience → Supply Chain Reconfiguration	0.702	0.704	0.038	18.662	**0.000**

Step (3): R^2 assessment

The measure that is most commonly used to evaluate the structural model is the coefficient of determination (R-squared or R^2). This indicates the percentage of the variance in the dependent variable that can be explained collectively by the independent variables. R^2 measures the strength of the relationship between the model and the dependent variable on a scale from 0 to 100%, to show whether the model is effective in explaining changes in the dependent variable.

Table 4.16. R^2 value

	R-squared	Adjusted R-squared
Supply chain reconfiguration	0.493	0.491
Supply chain resilience	0.561	0.554

The R^2 value for supply chain reconfiguration was 0.493, suggesting that 49.3% of the variance in reconfiguration was explained by supply chain resilience. Agility, collaboration, integration, and risk management culture explained 56.1% (0.561) of the variance in supply chain resilience (Figure 5.14). According to Pallant (2005), an R^2 value of around 0.45 is a respectable result.

In scholarly research that focuses on marketing, there is a general rule of thumb that R^2 values of 0.75, 0.50, and 0.25 for endogenous latent variables can be described as substantial, moderate, or weak (Hair et al., 2012a,b; Henseler et al., 2009). The R^2 values for supply chain resilience (0.561) and supply chain reconfiguration (0.493) can therefore be considered moderate.

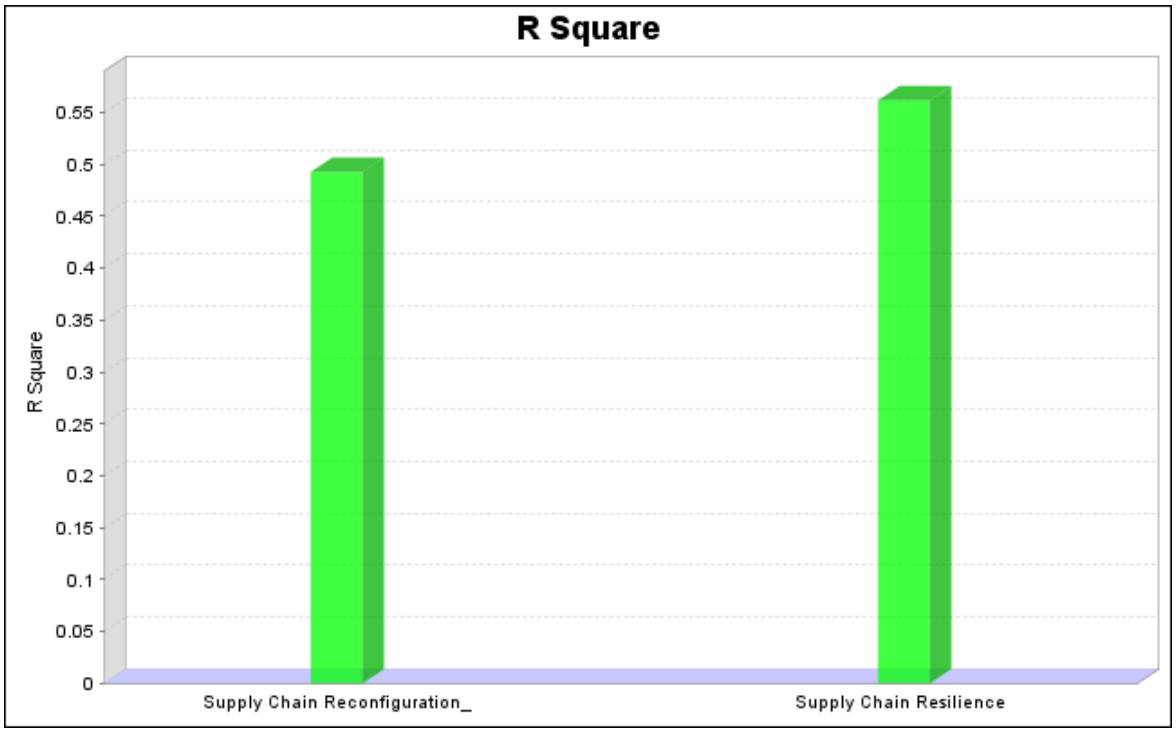

Figure 5.14. R^2 value

Step (4): f^2 Assessment

Three assessment values of the f^2 value are commonly used: 0.02, 0.15, and 0.35 for small, medium, and large effects of the exogenous latent variable (Cohen, 1988; Hair et al., 2014). An effect value of less than 0.02 indicates that there is no effect. Table 5.17 shows the f^2 values for all combinations of endogenous constructs and corresponding exogenous constructs. Supply chain resilience had a large effect (0.971) on supply chain reconfiguration. The effects of collaboration (0.32), agility (0.095), and risk management culture (0.025) on supply chain resilience were weak. Integration had no effect on supply chain resilience, because the effect value was less than 0.02 (0.001) (Figure 5.15).

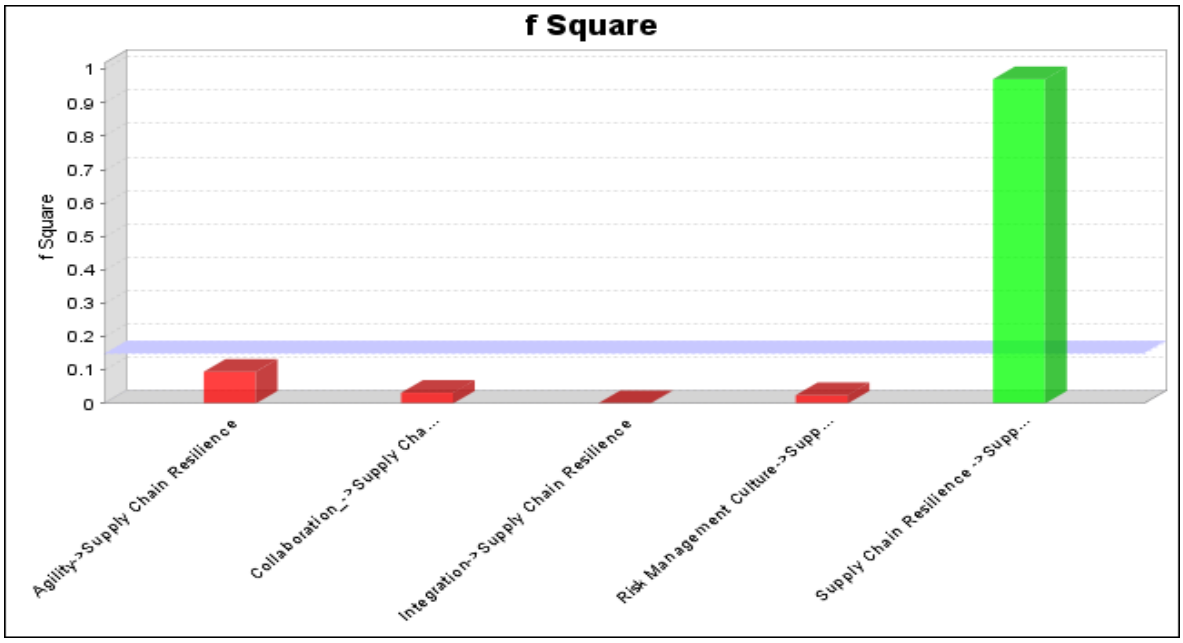

Figure 5.15. f^2 value

Table 5.17. f^2 value

	Agility	Collaboration	Integration	Risk Management Culture	Supply Chain Reconfiguration	Supply Chain Resilience
Agility						0.095
Collaboration						0.032
Integration						**0.001**
Risk Management Culture						0.025
Supply Chain Reconfiguration						
Supply Chain Resilience					**0.971**	

Step (5): Assess the predictive relevance, Q^2

Q^2 is a measurement instrument that indicates the model's out-of-sample predictive power (Hair et al., 2014). A Q^2 value larger than zero for a certain endogenous latent variable indicates that the PLS path model has predictive relevance for this construct (Hair et al., 2017). Supply chain reconfiguration had the highest Q^2 value (0.393) followed by supply chain resilience (0.347) (Table 5.18). These results provide clear support for the model's predictive relevance for the endogenous latent variables.

Table 5.18. Predictive relevance, Q^2

	SSO	**SSE**	**Q^2 (1−SSE/SSO)**
Agility	1,012.000	1,012.000	
Collaboration	1,012.000	1,012.000	
Integration	1,012.000	1,012.000	
Latent Variable 1	1,012.000	614.734	0.393
Latent Variable 2	2,024.000	1,321.137	0.347
Risk Management Culture	1,012.000	1,012.000	

Step (6): Assess the q^2 effect size

The q^2 effect size measures the relative impact of predictive relevance (Hair et al., 2014). It must be computed manually because the SmartPLS software does not provide it. To compute the q^2 value of a selected endogenous latent variable requires the value of $Q^2_{included}$ and $Q^2_{excluded}$. $Q^2_{included}$ is obtained from the blindfolding estimation (Table 5.18).

$Q^2_{excluded}$ is calculated by re-estimating the blindfolding after deleting specific predecessors of the endogenous latent variable in turn. The path model was re-estimated after deleting supply chain resilience. The Q^2 of supply chain reconfiguration rose to 0.464 ($Q^2_{excluded}$). These two values were used as the inputs to compute the q^2 effect size of supply chain resilience on supply chain reconfiguration:

$$q^2_{supply\ chain\ resilience \rightarrow supply\ chain\ reconfiguration} = \frac{Q^2_{included} - Q^2_{excluded}}{1 - Q^2_{included}}$$

$$= \frac{0.393 - 0.464}{1 - 0.393} = -0.12$$

As a relative measure of predictive relevance, values of 0.02, 0.15, and 0.35 indicate that an exogenous construct has a small, medium, or large predictive relevance (Hair et al., 2014). The q^2 value was negative here (−0.12), suggesting that the model does not have predictive relevance.

5.5 Hypothesis testing

Supply chain resilience is still in its infancy, and Qatari organizations need to understand it in relation to eco-political risks, so that they can develop suitable strategies to mitigate these risks. This section discusses the hypotheses developed in this study to explore the concept.

Hypothesis 1: *Risk management culture has a significant relationship with supply chain resilience*

Respondents were asked to indicate their views about risk management culture as a resilience enabler in their supply chains, from 1 (strongly disagree) to 7 (strongly agree). The structural model path coefficients in Table 5.16 showed that there was a significant difference (p-value 0.047) among clusters on risk management culture. The hypothesis was therefore accepted, and the study concluded that a risk management culture significantly increases supply chain resilience to eco-political disruption.

Hypothesis 2: *Agility has a significant relationship with supply chain resilience*

In the question related to this hypothesis, respondents were asked about their perceptions of agility as an enabler of supply chain resilience. There was a significant difference ($P = 0.000 < 0.050$) among organizations, suggesting that agility was an enabler of supply chain resilience. Hypothesis 2 was therefore accepted.

Hypothesis 3: *Collaboration has a significant relationship with supply chain resilience*

In the question related to this hypothesis, respondents were asked about their views on collaboration among supply chain partners as an enabler of supply chain resilience. There was a difference ($p = 0.011 < 0.050$) between organizations about the use of collaboration to control information sharing and coordination between partners, and its effect on resilience. Hypothesis 3 was therefore accepted.

Hypothesis 4: *Integration has a significant relationship with supply chain resilience*

In the question related to this hypothesis, respondents were asked about their perceptions of the effects of integration of products, services, information, money and decision flow among supply chain partners on organization supply chain resilience. There were no significant differences ($p = 0.675 > 0.050$) among Qatari organizations. This hypothesis was therefore rejected.

Hypothesis 5: *Supply chain resilience has a significant relationship with supply chain reconfiguration*

In the question related to this hypothesis, respondents were asked about their perception of the role of supply chain resilience in supply chain reconfiguration. There was a significant difference ($p = 0.000 < 0.050$) across organizations and the hypothesis was accepted. This suggests that supply chain resilience can significantly support supply chain reconfiguration to recover from eco-political disruption.

5.6 Discussion

The objective of this study was to examine the relationships between agility, collaboration, risk management culture, and integration with supply chain resilience, and to investigate the impact of supply chain resilience on supply chain reconfiguration. The vast majority of existing models do not capture the multi-dimensionality of supply chain resilience. Previous studies have called for empirical research on models of supply chain resilience under a particular type of disruption. Some degree of progress has been made

(Ishfaq, 2012; Lam and Bai, 2016; Forbes and Wilson, 2018; Zainal and Ingirige, 2018), although much more empirical research is needed (Ambulkar et al., 2015; Adobor and McMullen, 2018; Bag et al., 2019; Ivanov and Sokolov, 2019) to develop a more thorough understanding of this complex phenomenon. The research model developed in this study therefore makes an important contribution to theory, method and practices in this field.

We used a number of processes to empirically validate the research model and support the formulation of hypotheses. The model evaluation used PLS path modeling to confirm the validity and reliability of the model.

The study results confirmed that there is a positive and significant association between risk management culture and supply chain resilience ($\beta = 0.169$, p-value = 0.047). Improvements in risk management culture can be made by enhancing agility, integration, collaboration, and reengineering (Lui et al., 2018) among supply chain partners. This leads to sharing and reduction of risk arising from supply chain vulnerabilities. This finding is also consistent with other studies on supply chain resilience and supply chain vulnerability (Wieland and Wallenburg, 2013; Soni et al., 2014; Jain et al., 2017; Lima et al., 2018; Stone and Rahimifard, 2018).

Our results also provide evidence of a relationship between agility and supply chain resilience, because the coefficient of association ($\beta = 0.396$, p-value = 0.000) was significant. This implies that an increase in agility (flexibility, visibility, and velocity) will lead to increased cooperation and ability to cope with high levels of environmental and operational uncertainty (Pereira et al., 2014; Scholten et al., 2014). Organizations will also be better able to identify changes and respond faster to them (Wieland and Wallenburg, 2013; Hohenstein

et al., 2015; Tukamuhabwa et al., 2015). This will improve the supply chain's recovery speed after a risk event (Jüttner and Maklan, 2011; Tukamuhabwa et al., 2015).

There was a positive relationship between collaboration and supply chain resilience ($\beta = 0.217$, p-value = 0.011). This is consistent with other studies that have suggested that collaboration is a precondition for developing supply chain resilience (Jüttner and Maklan, 2011; Pettit et al., 2013). Collaboration capabilities, such as collaboration activities, information-sharing, collaborative communication, mutually-created knowledge, and joint relationship efforts are likely to improve supply chain resilience (Pettit at al., 2013; Ponomarov and Holcomb, 2009; Scholten and Schilder 2015; Tukamuhabwa et al., 2015). However, this study found no evidence of a relationship between integration and supply chain resilience ($\beta = 0.036$, p-value = 0.675). This result may be because in the literature some studies suggest that a highly integrated supply chain creates risks in one link that affect the other links of the chain (Norrman and Jansson, 2004), implying that highly integrated supply chains may develop higher risk exposure. Moreover, this may be because this concept had inadequate support from relevant actors during the crisis in Qatar. Our findings echoes with the work of Wieland and Wallenburg (2012).

One of the novelties of this study lay in its exploration of a new dimension, i.e. supply chain reconfiguration. The study provided evidence of a significant relationship between supply chain resilience and reconfiguration ($\beta = 0.702$, p-value = 0.000). This implies that supply chain resilience increases the possibility that firms will be able to reconfigure their supply chain and return quickly to normal after disruptions (Ambulkar et al., 2015; Bag et al., 2018). However, the results also suggest that companies in Qatar may lack both resources

for reconfiguration and opportunities to develop resilience and re-establish the supply chain after disruption (Ambulkar et al., 2015; Bag et al., 2018; Ivanov and Sokolov, 2019; Ivanov et al., 2019).

5.7 Conclusion

As far as can be ascertained, this empirical study is among the first to address the issue of supply chain reconfiguration, and explore the role of resilience in recovering from disruptions through restructuring the supply chain. This chapter explained the development of an empirical research model to understand the relationship among the enablers of supply chain resilience and their relationship with supply chain reconfiguration. The results suggest that for supply chains operating in Qatar, supply chain resilience had a powerful influence on supply chain reconfiguration. This may provide practical guidance on the benefit of supply chain resilience and reinforcing the importance of agility, collaboration, and risk management culture in improving companies' ability to recover following disruptions in their supply chains.

The results of this chapter corroborate the findings of the ISM model and extends to test the relationship between resilience and reconfiguration. However, what are the pathways to build reconfiguration capabilities in supply chains is not well understood. In this regard, the next chapter presents a framework utilizing a multi-criteria decision model to provide supply chain managers a tool to prioritize the variables leading to supply chain reconfiguration.

CHAPTER 6: PRIORITIZATION OF SUPPLY CHAIN RECONFIGURATION VARIABLES USING BALANCE SCORECARD AND ANALYTIC NETWORK PROCESS

6.1 Introduction

In wake of variety of risks and dynamic business environment, supply chain reconfiguration has emerged as a key attribute. Several studies (Kaminsky et al. 2004; Storer et al., 2014; Varsei et al., 2014; Vidal and Goetschalckx, 1997) have described supply chain reconfiguration as a reshaping of resources. These studies considered it a strategic goal of firms and an operational competence for supply chain. In a crisis, a dramatic change in business paradigm will occur that would require restructuring or reconfiguration of the supply chain (Roh et al., 2014). Supply chain reconfiguration is not only a required attribute to manage supply chain risks, dynamic reconfiguration of the supply chain is needed to cope with changes in the demand and cost structure over time, because of variations in economic factors and the business environment (Wilhelm et al., 2013).

Balanced Scorecard (BSC) technique is one of the most widespread performance evaluation approaches, and it considers both non-financial elements and financial elements (Lu et al., 2018). BSC framework provides performance management organized into four areas or perspectives, financial, customer, internal business processes, and innovation and learning (Kaplan and Norton, 1992). Each area includes a number of leading and lagging indicators (Anjomshoae et al., 2017). Leading indicators are drivers of incremental change that affect the outcome measure while lagging indicators measure outcomes by showing the

result of the strategy (Anjomshoae et al., 2017). The four BSC perspectives are interlinked to facilitate the evaluation of corporate strategy (Modak et al., 2019). In line with BSC, supply chain management literature suggests that non-financial and financial indicators are equally important for operational management (Tseng et al., 2015).

The research presented in this chapter proposes a multi-criteria decision model to prioritize supply chain reconfiguration variables. After Introduction, Section 2 provides extant literature on balance scorecard and other issues related to the model. Section 3 proposes a systematic ANP procedure and Section 4 demonstrates the application of the proposed model to a case study. Finally, the study draws conclusions and indicates directions for future research.

6.2 Balanced Scorecard (BSC)

The balanced scorecard (BSC) is a widely used system to measure the performance of organizations across four different perspectives: financial, customer, internal business processes, and innovation and learning (Kaplan and Norton, 1992). The BSC framework was initially developed by Kaplan and Norton (1992, 1996a), as a strategic performance management tool that allows organizational managers to assess a firm's action plan and imagine possible future positions (Cebeci, 2009). Traditional financial measures often overemphasized short-term financial performance. BSC allows managers to develop a more comprehensive view of operations (Brewer and Speh, 2000; Chavan, 2009), by integrating and maintaining a balance between financial and non-financial measures, looking at the organization's long-term objectives (Hafeez et al., 2002; Wang et al., 2012). It aims to clarify

and translate the vision and strategy of the organization, and communicate and associate this with objectives and strategic measures (Pati et al., 2016; Kaplan and Norton, 1996b). It can help firms to plan goals, align strategic initiatives and improve feedback and strategic learning (Pati et al., 2016; Kaplan and Norton, 1996b).

6.2.1 Financial Perspective: The financial perspective includes traditional financial performance measures, which are related to firm profitability. Financial measures are considered to occur in one of three stages: rapid growth (early life cycle stage of business), sustain (focus on attracting investment and reinvestment) or harvest (mature phase of the life cycle) (Kaplan and Norton, 1996a). These three stages can be combined with three financial themes, revenue growth and mix (expanding product and service offerings), cost reduction/productivity improvement (lowering the direct costs of products and services) and asset utilization (reduce working and physical capital levels) (Callado and Jack, 2015; Okongwu et al., 2015).

6.2.2 Customer Perspective: The customer perspective focus on customer satisfaction and market segments. Managers monitor the performance of operational units in satisfying target segments (Modak et al., 2019). Kaplan and Norton (1996a) suggested that generic measures such as customer satisfaction, retention, acquisition, and profitability could be understood by measuring product/service attributes. Customer relationship and image and reputation could be customized to target customer groups.

6.2.3 Internal Process Perspective: The internal process perspective emphasizes identifying new processes for some of the operational activities responsible for satisfying target customers. The activities, such as value chain activities, help the business to meet

current and future needs of stakeholders (Modak et al., 2019). Common measures of value chain activity may include new products, new processes, productivity per business unit, product turnover, after-sales activity, operational cycle, suppliers, waste, flexibility, response time to customer, delay in delivery, responsiveness of suppliers, storage time, and information/integration of materials (Callado and Jack, 2015).

6.2.4 Learning and Innovation Perspective: The learning and innovation perspective focuses on the infrastructure (people, systems and organizational procedures) required to create long-term growth and improvement. The measures are related to employee satisfaction, investment in training and career growth of employees, investment in information systems or technology, employee capability, managerial efficiency, innovation management, number of complaints, and risk management (Callado and Jack, 2015; Lee et al., 2008; Tjader et al., 2014).

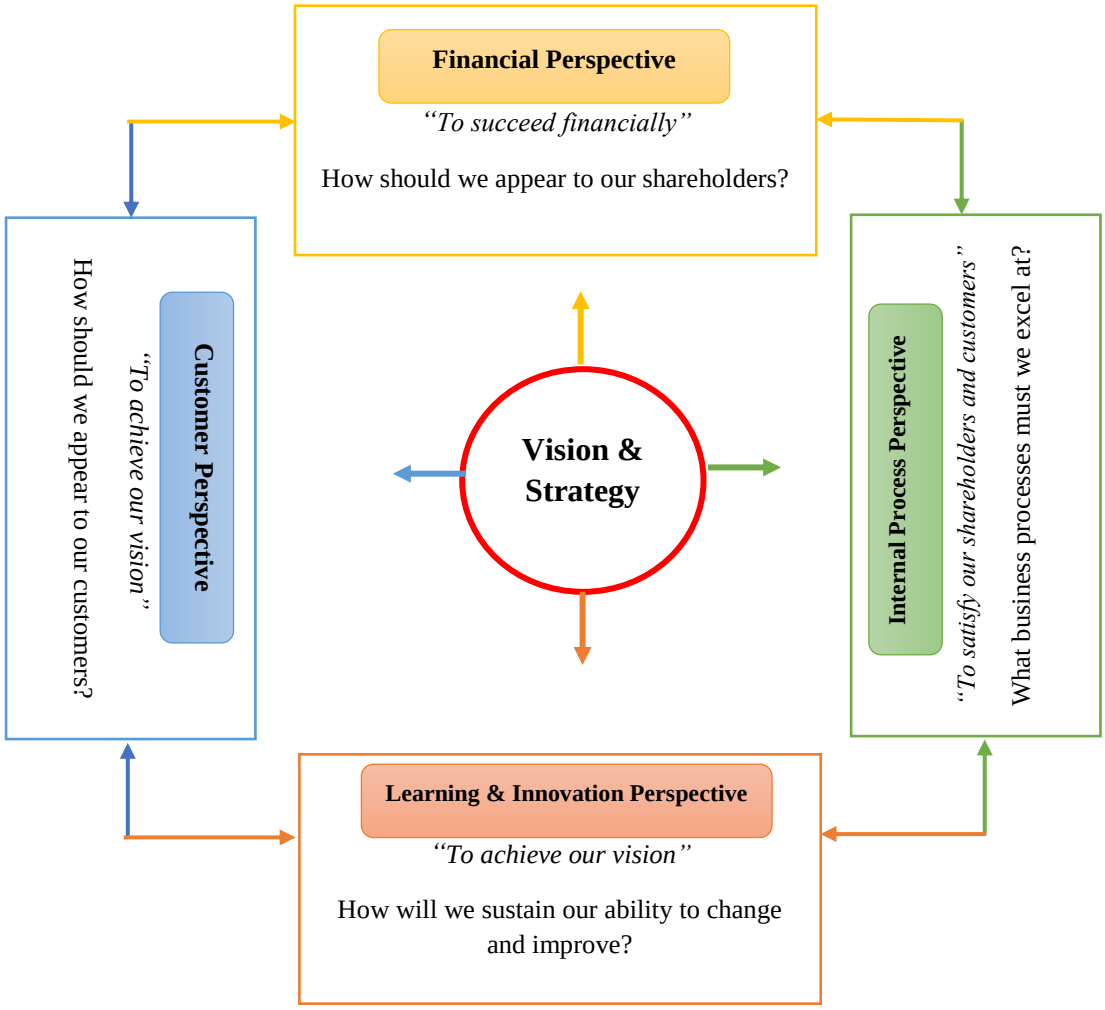

Figure 6.1 Balance Scorecards (BSC) Framework (Kaplan and Norton, 1992)

6.3 Balanced Scorecard in the Supply Chain Management

Several studies have suggested utilizing the BSC framework through the application of a multi-criteria decision making (MCDM) approach (Abran and Buglione, 2003; Lee et al., 2008; Yüksel and Dağdeviren, 2010). MCDM is a structured approach that helps to solve decision problems with multiple criteria (Majumder, 2015). It has a wide variety of

applications and provides stepping-stones toward solving any problem where a significant decision needs to be made (Ishizaka and Nemery, 2013).

A number of researchers have applied BSC methodology to study issues related to supply chain management (Brewer and Speh, 2000; Callado and Jack, 2015; Chia et al., 2009; Pati et al., 2016; Hult et al., 2008; Nouri et al., 2019; Okongwu et al., 2015; Park et al., 2005; Tan et al., 2017; Tseng et al., 2015). Studies have used the BSC to assess the performance of the supply chain (Brewer and Speh, 2000; Pati et al., 2016; Park et al., 2005; Tan et al., 2017), the roles of the supply chain (Callado and Jack, 2015), and supply chain orientation (Hult et al., 2008). The BSC framework emphasizes the inter-functional and inter-firm nature of the supply chain, recognizing the need for and increasing the chances of a balanced management approach to supply chain management (SCM) goals. However, using the BSC as a system of strategic management is complicated because there are many different strategic paths linking supply chain management practices with tangible assets and financial performance (Okongwu et al., 2015). This may lead the firm to remain focused on traditional financial measures coupled with customer satisfaction (Chia et al., 2009).

Studies about the inclusion of sustainable SCM (SSCM) in the BSC have used different dimensions. For example, Nouri et al. (2019) used financial, stakeholder, supply chain, and learning, growth, and innovation dimensions. They interviewed a panel of experts and found that the most important factors in each dimension were cost (financial), customer satisfaction (stakeholders), flexibility (supply chain), and individual capabilities (learning, growth and innovation). Tseng et al. (2015) assessed the same four options. They concluded that the stakeholder aspects received more attention than the other aspects. The top five

criteria were green design, corporate sustainability, strategic planning for environmental management, supplier cost saving initiatives and market share.

Table 6.1. Balance Scorecard in Supply Chain

Author(s)	Year	Category	Specific Aims	Performance Indicators	Sample	Methodology	Finding
Callado and Jack	2015	Supply chain roles	The evolution of supply chain performance through BSC	Two group of variables:4 SC roles variables and 49 performance indicators	121 agribusiness companies in Brazil	Survey	Customer satisfaction was the single metric present within the BSC framework for all supply chain roles
Pati Ferreira, Silva, Azevedo	2016	Supply chain performance	Evaluation of environmental performance of supply chain	Financial, suppliers, processes, learning and innovation	First tier suppliers from automotive industry	Case Study	Proposed a decision support tool to define actions to be taken in order to improve the global environment performance of the supply chain
Okongwu, Brulhart, Moncef	2015	Supply chain managemen t practices	Investigation of the casual linkage between supply chain management practices and performance	Supplier partnership, customer relationship, information sharing, information quality	450 French industrial firms	Survey	They found that there are strategic paths of different nature that links the supply chain management practices with intangible assets to financial performance
Hult, Ketchen, Adams, Mena	2008	Supply chain orientation	To examine the links between supply chain orientation and performance	customer orientation, competitor orientation, value chain orientation, supplier orientation, logistics orientation, operation orientation	129 firms	Survey	They found that supply chain capability has a direct positive effect on the four balance scorecard outcomes
Chia, God, Hum	2009	Supply chain entities	Examine what senior supply chain executives measure and how they perceive performance measurement from a BS perspective	15 variables, some of them are return on investment, gross revenue, profit before tax, cost reduction, market share, customers retention, customer satisfaction, quality of services, new services implemented per year, on time delivery, waste reduction, employee satisfaction	113 responses from logistics firms, manufacturers, IPOs, retailers	Survey	They found that firms remain focused on transaction financial measures with customer satisfaction measurement

Brewer and Speh	2000	Supply chain performance	To develop a framework for assessing supply chain performance using balance scorecard	End customer benefits, SCM goals, SCM improvement, financial benefit	2 firms (Campbell Soup, Sport Obermeyer)	Scenarios	Framework developed emphasizes the inter functional and intrafirm nature supply chain, recognizes the needs and increase the chance of balance management approach to achieve SCM goals
Tan, Zhang, Khodaverdi	2016	Supply chain performance	analyze the efficient and inefficient levels of service performance	Physical aspects, reliability, customer relationship through personal interaction, problem solving, customer perception towards service, number of customers serviced per day, profit, order processing time, complaints handled	Ten automobile dealers	Survey	They found that dealers are inefficient in learning about customer growth that help dealers to transform from inefficient into efficient.
Tseng, Lim, Wong	2015	Sustainable supply chain management	The assessment of supply chain sustainability and performance	sustainability, internal operations, learning and growth, and stakeholder	A Taiwanese electronic manufacturing focal firm	Case study	They found that the top ranking is the stakeholders aspects and the top five criteria are green design, corporate sustainability, strategic planning for environmental management, supplier cost saving initiatives and market share
Nouri, Nikabadi, Olfet	2019	Sustainable service supply chain	The assessment of supply chain sustainability and performance in service supply chains	Financial dimension, stakeholder dimension, supply chain dimension, learning, growth and innovation dimension	Interview with panel of experts	Survey	They found that the cost from financial perspective, customer satisfaction from stakeholders perspective, are flexibility from supply chain perspectives, and the individual capabilities from learning, growth and innovation perspectives are the most important factors

Park, Lee, Yoo	2005	Supply chain performance	The design of balance supply chain scorecard	Profit, revenue, cost structure, use of assets, product leadership, customer relationship, corporate image, efficiency of manufacturing process, inventory management, delivery efficiency, flexibility, new product development, sourcing leadership, collaboration with partners, purchase order transaction efficiency, intagible capital	Three SCM related	Case study	They found that the importance of the measures significantly depends on the product characteristics

6.4 Analytic Network Process (ANP) and Supply Chain Management

Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) are the most-frequently used MCDM approaches in the supply chain context (Vinodh wt al., 2011; Chen et al., 2019; Kheybari et al., 2020). AHP is a hierarchy-structured technique introduced by Saaty (1980), used to assess, concentrate, compare, and evaluate the relative importance of criteria in a decision (Vinodh et al., 2016). However, it has some drawbacks, so Saaty (1996) introduced ANP to overcome these. This is an extension of AHP that allows researchers to examine the interdependencies among different criteria (Forman, 1996; Hashemi et al., 2015). ANP can therefore assess complex interaction effects among the components within the decision criteria. This allows a better representation of complex decision problems. ANP is a comprehensive multidimensional network structure technique that allows decision-makers to assess, concentrate, compare, and evaluate the relative importance of different criteria on different components of a decision, including problem objective, criteria, sub-criteria, alternatives and their interaction with and between groups (Saaty, 2001).

ANP has been extensively used in the SCM literature. For example, it has been applied to identifying alternative characteristics of trust among buyer and supplier transactions (Agarwal and Shankar, 2003), offshoring and outsourcing decisions (Dou and Sarkis, 2010), green supply chain (Büyüközkan and Çifçi, 2012a, b; Chen et al., 2012), supply chain competition (Joshi et al., 2013), supply chain strategic planning (Choudhury et al., 2004), supply chain intelligence (Soliman el al., 2005), and supply chain risk management (Xia and Chen, 2011). In all these studies, ANP was used to examine a

minimum of three alternatives to look at the relationships between them and rank them in the decision. It therefore allowed managers to implement successful green supply chain management by prioritizing green suppliers and systems (Büyüközkan and Çifçi, 2012a, b), identify trust characteristics for an e-enabler supply chain system (Agarwal and Shankar, 2003), and identify supply chain competitiveness factors (Joshi et al., 2013). Researchers have also used ANP to select the appropriate decision for supply chain risk (Xia and Chen, 2011) providing a strategic decision model to help practitioners to identify suitable risk management tactics (Xia and Chen, 2011).

Studies have also integrated ANP with other MCDM models, including Decision Making Trial and Evaluation Laboratory (DEMATEL) to evaluate supply chain performance. Hung (2011) and Wu et al. (2017) studied the improvement of competitive advantage in supply chain planning and supply chain agility. They found that supply chain management time and flexibility were the most important components in improving competitive advantage. The Fuzzy Decision Making Trial and Evaluation Laboratory (FDEMATEL) has also been used with ANP to calculate the causal relationship and level of mutual effect, building on the green supply chain (Büyüközkan and Çifçib, 2012b; Kusi-Sarpong et al., 2016). Tuzkaya et al. (2011) used the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) to examined the Turkish white goods industry. They found that the warehousing cost was the main factor affecting collection period length and that transportation cost minimization was the most important factor for the Centralized Return Center CRC and Manufacturing Facilities MF assignments.

Other techniques have also been used with ANP to assess SCM. These include Quality Function Development (QFD) (Lam and Dai, 2015), Zero-One Goal Programming (ZOGP) (Büyüközkan and Berkol, 2011), Grey System Theory (GST, (Dou et al., 2014) Fuzzy Goal Programming (FGP) (Hung, 2011) , Data Envelopment Analysis (DMA) (Kusi-Sarpong et al., 2016), Multi Objectives Mathematical Programming method (MOMP) (Gunasekaran et al., 2010), Fuzzy Set Theory (FST) (Wu et al., 2017), and Fuzzy Analytical Network Process (FANP) (Büyüközkan and Çifçib, 2012b). All of these techniques have helped researchers and participants to solve complete decision-making problems, such as supplier selection decisions (Dou et al., 2014; Gunasekaran et al., 2010), offshoring and outsourcing for sustainable supply chain management (Dou and Sarkis, 2010), and supply chain strategic planning (Choudhury et al., 2004). A summary of the literature discussed in previous paragraphs is mentioned in the Table 6.2.

Table 6.2. Application of ANP in Supply Chain Modeling

Author(s)	Year	Category	Specific Area	Aim	Alternative Characteristics	Sample	Methodology	other techniques combined or compared	Finding
Agarwal and Shankar	2003	E-enabled supply chain	The trust between buyer - supplier transactions	To identify alternative characteristics of trust among buyer and supplier transactions	Feedback system, Trusted third party system, and Community responsibility system	Auto-Manufacturing Company	Scores from experts	Only ANP	They found that the community responsibility system favor alternative trust characteristics for successful implementation of an e-enabler supply chain
Büyüközkan and Berkol	2011	Sustainable supply chain management	The design of sustainable supply chain management	To determinate the design requirements to effectively achieve sustainable supply chain	Customers' requirements and Design requirements	Energy Sector	Case Study	QFD, ZOGP	They found that the labor education in subject like technology use and process are the most important design feature
Büyüközkan and Çifçi	2012	Green supply chain management	The evaluation of the green supply chain in Turkey	To identify a novel green supply chain framework	Organizational performance dimension, green logistics dimension, green organizational activities dimension	Ford Otosan Companies	Case Study	FANP	They found that system A received the high priority than system B and current system

Büyüközkan and Çifçi	2012	Green supply chain management	The integration of selection of supplier and green supply chain	To assess the proposed an evaluation framework for green supply chain	Organizational performance dimension, green logistics dimension, green organizational activities dimension, green supplier evaluation criteria	Ford Otosan Companies	Case Study	FDEMATEL, FANP, FTOPSIS	They found that the best green supplier is S3
Chen, Shig, Shyur, Wu	2012	Green supply chain management	The evaluation of business functions	To design a green supply chain management strategies to effectively direct business functions and activities	Green design, Green manufacturing, Green purchasing, Green marketing and services, and Green supply chain management strategy alternative	Taiwan's Leading electronics original equipment manufacturing	Case Study	Only ANP	They found that the "innovation" and "hazardous waste reduced" are the most influence factors in business functions
Choudhury, Tiwari, Mukhopadhyay	2004	Supply chain cell	Provide a model for strategic planning issues	To develop a method for achieving coordination in supply chain by taking into account production planning and logistics, leading to an effective dispatch policy	14 production locations and 22 branching/clearing and forwarding agents	Pharmaceutical company	Case Study	Only ANP	They found that the model adopt not only solve the complex and systematic decision problems but also address the exist interdependencies among non quantifiable factors associated with branching and manufacturing locations

Dou and Sarkis	2010	offshoring and outsourcing decisions	The selecting of offshoring decision alternatives	To assess and select offshoring alternatives factors affecting supplier selection, location factors, and sustainability factors	facility location factors, supplier selection factors, sustainability factors	Company A	Case Study	Only ANP	They found that the rank order for the four alternatives is not change and the values very little fluctuate.
Dou, Zhu, and Sarkis	2014	Green supplier selection	Green supplier developmen t program	To introduce a green supplier development program in order to improve supplier performance	environmental performance factors, strategic operational performance metrics, organizational factors	China pivot irrigation equipment industry	Case Study	GST	They found that the vlaue of the nine GSD programs are generally consistent
Hung	2011	Supply chain planning	The improveme nt of competitive advantage	To present a divergent supply chain planning model to enhance competitive advantage	new entrants, competitive rivalry, suppliers, consumers, and substitutes	Mobile phone company	Case Study	DEMATEL, FGP	They found that the supply chain management time is more important than the common component capacity constraint.

Hussain, Awasthi, Tiwari	2016	Sustainable supply chain management	The evaluation of sustainable supply chain management alternatives	To propose an integrate framework based on ISM and ANP to evaluate potential alternatives for sustainable supply chain management	Carbon taxing, incentives for green certification, employee training programs on sustainability, management training for corporate sustainability, IT enabled process management for sustainability, community awareness campaigning's on sustainability, mandatory fair-trade practices, employee safety at work programs, incentives for collaboration on sustainability	Not Specified	Not Specified	ISM	They found that the governmental regulation, rewards and incentives, and listening to the views of the customers are the main enablers that can achieve sustainability in supply chains
Joshi, Nepal, Rathore, Sharma	2013	Supply chain competitiveness	The prioritization of supply chain competitiveness	To examine the determinates of supply chain competitiveness in special context to its supply chain performance indicators	Cost, flexibility, quality, delivery, buyer-supplier relationship, technology, environmental factors, customer demand	Indian automotive component manufacturing industry	Case Study	Only ANP	They found that the business environment factors, such as worker's skill, globalization, and government regulations contribute the most to the overall supply chain competitiveness

Kayakutlu and Büyüközkan	2010	Supply chain effectiveness	The analyzing of supply value chain effectiveness factors	To propose a managerial decision framework for different levels of supply chain by addressing the strategic importance of competence values in supply chin effectiveness	Organizational competence, Team competence, Individual competence	Three assessor from three different companies in Turkey	Case Study	DM	They found that individual competence, in terms of learning and networking, and innovation of the team are the most important competence attributes in supply chain effectiveness
Gunasekaran, Sharif, Kirytopoulos, Leopoulos, Mavrotas, Voulgaridou	2010	Supplier selection	The evaluation of the suppliers	To provide a meta-model for supplier evaluation and order quantity allocation	service, supplier's profile, quality, other, risk	Para pharmaceutical enterprise cluster in Greece	Case Study	MOMP, AUGMECON	They found companies need to maximize the qualitative value and the market share and minimize the order cost and mean delivery time
Kusi-Sarpong, Sarkis, Wang	2016	Green supply chain management	The evaluation of mining operations	To identify and evaluate green supply chain management and its use for sustainable performance of mining industry companies	Economic performance, environmental performance, social performance	Ghana mining industry	Case Study	FDEMATEL	They found that sustainable social performance are the most important and connected factor

Lam and Dai	2015	Supply chain security	The design of logistics service providers	To propose a methodology with systematic metrics for logistics service providers to meet customer demands	design requirements and customer requirements	Medium sized of an international logistics services providers company in Hong Kong	Case Study	QFD	They found that the ANP-QFD approach can be adopted to meet customer demand for it permits a quantifiable comparison of security design requirements
Soliman , Janz, Raisinghani and Meade	2005	Supply chain intelligence	The selection of knowledge management system	To investigate the linkage between organization performance criteria and the dimensions of agility, e-supply chain drivers and knowledge management	Organization performance criteria, dimension of agility, dimensions of cost in supply chain management, dimensions of knowledge management	Global telecommunications company	Case Study	Only ANP	They found that the knowledge transfer of the most impact dimension of knowledge management on e-supply chain
Tuzkaya, Gülsün, Önsel	2011	Reverse logistics	The strategic design of reverse logistics	To design a model for a reverse logistics network	Transportation, environmental, social-political, economic, technical	Turkish white good industry	Case Study	FTOPSIS	They found that the warehousing cost is the main factor for collection period length and the transportation cost minimization is the most important factor for the CRC MF assignments.

Wu, Tseng, Chiu, Lim	2017	Supply chain agility	The improvement of competitive advantage	To develop a supply chain agility decision making hierarchical structure and explore the key drivers for leading firms to achive the competitive advantage under uncertainty	Collaboration, process integration, information integration, customer based measures, strategic alliance for eco-design in supply chain	MWT manufacturing and selling electronic company	Case Study	DEMATEL, FST	They found that the flexibility significantly impacts by process integration, information integration and strategic alliances for eco-design in supply chain
Xia and Chen	2011	Supply chain risk management	The selection of appropriate risk management method	To propose a decision making model based on the internal triggering and interactive mechanisms in an supply chain risk management	organizational performance factors, available risk operational practices, risk managerial elements, operational process cycle and product life cycle	Experts and participates in relevant supply chain management area	Questions and Interviews	Only ANP	They found that the strategic decision model is a feasible access to the suitable risk operation tactics for practitioners

6.5 Integration of BSC and ANP

A limited number of studies have used BSC with MCDM models to evaluate supply chain performance. Shafiee et al., (2014) and Moons et al., (2019) used both ANP and BSC to evaluate the performance of supply chain management to reach, sustain, and improve the logistics process. The results obtained for different supply chain performance indicators (i.e. quality, time, financial, productivity/organization) allowed participants to diagnose processes in real-world industries and propose improvement and innovation plans. Bhattacharya et al. (2014) demonstrated a green supply chain framework developing ANP to determine rank priority from comparative judgements in a UK setting. They used the Green Balance Scorecard GrBSC method to assess performance indicators for the manufacturing industry.

Modak et al. (2019) used ANP and BSC to determine the best decision for outsourcing. The approach was used to evaluate the relative benefits of a strategic alliance, outsourcing and insourcing. A study by Dev et al. (2019) applied an integrated approach combining intuitive fuzzy ANP and BSC to determine the decision criteria related to visualization of big data architecture. These criteria and sub-criteria were evaluated to give relative weights. A summary of the literature discussed in previous paragraphs is mentioned in the Table 6.3.

Table 6.3. ANP-BSC studies

Author(s)	Year	Category	Specific Aim	Performance Indicators	Sample	Methodology	Techniques	Finding
Moons, Waeyenbergh, Pintelon, Timmermans, Ridder	2019	Operating room supply chains	Evaluate the efficacy of logistics processes in operating rooms	Quality, time, financial, productivity/ organization	Hospital logistics experts and managers	Interviews	ANP, BSC	Quality is the indictor to improve the inventory management whereas productivity is the contribution factor for distribution
Modak, Ghosh, Pathak	2019	Decision making	Propose an integrated approach for selection of best outsourcing strategy	strategic alliance, outsourcing and insourcing	Coal mining organization in India	Case study	ANP, BSC	They found that strategic alliance is the best sourcing strategy followed by outsourcing and insourcing
Dev, Shankar, Gupta, Dong	2019	Big data	Propose an approach to visualize a big data architecture conceptual framework	Forecasting error, review period, lead time, order size, service level, aggregate demand	Information from RFID network	Scenarios	DES, FANP, TOPSIS	The proposed model can be used as a decision support tool by the companies to evaluate their KPIs in a real-time dynamic system
Shafiee, Lotfi, Saleh	2014	Supply chain performance	Evaluate the overall performance of the supply chain by means of the BSC and DEA model	Fifteen indicators like return on investment, gross revenue, profit before tax, saving by supplier initiatives	Iranian food industries	Case study	BSC, DEA, DEMATEL	Found that nine DMU efficient, while the other 11 DMU inefficient
Parkouhi and Ghadikolaei	2017	Supplier Selection	Propose an initial conceptual model for resilience supplier selection evaluation	Twelve variables like flexibility, quality, culture, joint growth, supplier technology	large industrial unit in wood and paper industry	Experts opinion	FANP, VIKOR	Variation in price, vulnerability, supplier's capacity limit, visibility, on time delivery most important sub-criteria in resilient supplier selection

Bhattacharya, Mohapatra, Kumar, Dey, Brady, Tiwari, Nudurupati	2014	Green supply chain	Green supply chain performance measurement framework using an intra-organizational collaborative decision making approach	Organizational commitment, eco-design, green supply chain processes, social performance, sustainable performance	Manufacturing industry in UK	Case study	CDM, ANP, GrBSc	Organizational commitment received the highest weight of performance measurement followed by sustainable performance, eco-design, green supply chain processes, and social performance, respectively

6.6 Supply Chain Reconfiguration

An increasing number of firms, both national or multinational, currently face the problem of whether and how to reconfigure their supply chain or network (Lambiase et al., 2015). Case studies suggest that changing firms or supply chains is a non-linear process requiring re-planning and learning throughout the change effort to build capacity and capability for change (Van Hoek et al., 2010). There are two parameters that determine the reconfiguration of any supply chain: financial and technology. Financial capability is the money available to invest, which is necessary to reconfigure the supply chain. It is also possible to consider different technology, such as Decision Support System (DSS) and Direct Digital Manufacturing (DDM), as a function of activity location (Lambiase et al., 2013).

There have been a limited number of studies on change within logistics and supply chains. Reconfiguration of supply chain management is generally considered across two categories: restructuring and non-restructuring. Reconfiguration of supply chain with restructuring often occurs in response to natural risks and crises (Kinkel, 2012; Osman and Demirli, 2010; Ross, 2000). Reconfiguration of supply chain without restructuring often occurs when redesigning a product, reallocating chains, or inventory allocation (Dev et al., 2014; Mondragon et al., 2018; Wei and Wang, 2010). Supply chain reconfiguration may often need to be rapid. There are therefore few studies on the reconfiguration of supply chain management during unpredictable or rare events arising from the supply chain's interaction with its environment, such as natural disasters, labor strikes, bankruptcy, fire, transportation, and terrorism. Supply chain reconfiguration requires consideration of nine characteristics:

6.6.1 The objective of reconfiguration

The objective of supply chain reconfiguration is usually either profit maximization or cost minimization (Hammami and Frein, 2014; Ross, 2000; Spicer and Carlo, 2007; Wilhelm et al., 2013). Supply chain reconfiguration needs to establish a balance between the supply chain reconfiguration cost (i.e. cost of replacing suppliers, and changing the transportation network) and supply chain operation cost (i.e. transportation cost, procurement cost, and manufacturing cost) (Guo et al., 2018). These costs can be either fixed or variable. Fixed costs are associated with facility charges including opening, closing, operating, expanding, and contracting. Variable costs mainly accrue from holding inventories and incurring backorders, outsourcing, and transportation. One study defined the objective function in terms of cash flow (Niroomand et al., 2012). It argued that reconfiguration cost and investment cost are the firm's negative cash flows and sales revenue and salvage value of removed capacity are its positive cash flows (Niroomand et al., 2012).

6.6.2 Number of echelons in the supply chain

A supply chain consists of suppliers, plants, warehouses, distribution centers, and customers Wilhelm et al. 2013). Each reconfiguration alternative involves different suppliers, production, and distribution options for raw material, finished goods, and final products (Dev et al., 2014). The performance of each echelon is unique. Each provides a specific product and is linked with a viable transportation system that allows shipment from a facility in one echelon to another elsewhere (Wilhelm et al. 2013). Environmental turbulence can force firms to relocate their plants and distribution centers to be both competitive and cost-efficient (Lemoine and Skjoett-Larsen, 2004). It is therefore difficult

to assess the number of echelons, facilities, and flows of product between facilities (Hammami and Frein, 2014).

6.6.3 Closing and opening new facilities

Redesigning supply chain may lead to the closure of existing facilities and opening of new ones. Many researchers have argued that the capacity of a facility usually remains stable over time (Canel et al., 2001; Klose and Drexel, 2005; Lee and Luss, 1987; Melo et al., 2006, 2009; Wilhelm et al., 2013). The capacity of any facility in the planning horizon cannot be contracted (Wilhelm et al., 2013). The cost of closing and opening facilities are still rarely considered. Hammami and Frein (2014) found that if the cost of closing a facility was more than 30,000 or 20,000 Euros the original site would probably be kept open. To cope with the complexity, firms need an intermediate step in the planning process. A multi-period planning horizon is a permanent stage for facility closing/opening and is necessary for capacity allocation (Hammami and Frein, 2014; Wilhelm et al., 2013).

6.6.4 Intermediate processing requirements

Intermediate product processing has a key role in redesigning the supply chain. It has recently become more important because globalization and outsourcing have increased the fluidity and complexity of supply chains (Kirkwood et al., 2005). Supply chain activities can have multiple locations for one or more activity (Kristianto et al., 2012). Intermediate products are therefore important for two reason. The first is that the final product can be kept near the customer site while the manufacturing of intermediate products is relocated elsewhere (Hammami and Frein, 2014). The second is that intermediate products can shift income by using transfer prices (Hammami and Frein, 2014).

6.6.5 Capacity relocation decision

Relocating capacity is often considered in supply chain redesign. It depends on the profitability of activities. Managers often first investigate whether it will be profitable to relocate some activities from existing to new sites (Hammami and Frein, 2014), either wholly or partially. Studies have found that including relocating capacity along with facility location, supplier selection, and physical flow size in decisions about supply chain reconfiguration can significantly improve profits (Hammami and Frein, 2014; Osman and Demirli, 2010).

6.6.6 Information technology integration

The most prominent driver behind reconfiguration is improved information and communication technology (ICT) (Lemoine and Skjoett-Larsen, 2004). Modern technology helps managers to reduce the number of suppliers (Mondragon et al., 2018). Involving ICT in reconfiguring the supply chain will increase the possibility of transferring information both geographically and between supply chain participants (Lemoine and Skjoett-Larsen, 2004).

6.6.7 Financial factors

Taxation rate, exchange rate, and transfer pricing are the main global factors considered in previous studies (Hammami and Frein, 2014). These international dimensions help to explain differences in income and expenses during reconfigurations. Hammami and Frein (2014) found that exchange rate had a greater role in activity location decisions than tax rate. Transfer pricing has been studied around both supply chain redesign and supply chain decisions. Its refer to the strategy for determining transfer price that buyer subsidiary

has to pay for selling subsidiary to a given product (Perron et al., 2010). Shunko and Gavirneni,(2007) argued that transfer pricing is a powerful tool for shifting income to subsidiaries in lower tax countries and consequence increasing after tax profit of the supply chain. More examples also support the used of transfer pricing in increasing the income from high tax to low tax countries (Shunko et al., 2014; Lakhal et al., 2005).

6.6.8 Transportation systems

Transport systems are important in reconfiguration of supply chains. The market requirement may force firms to reconfigure their supply chain to achieve customer requirements about time (Akanle and Zhang, 2008; Gosling et al., 2010; Lemoine and Skjoett-Larsen, 2004). The cost, system, and flexibility of transportation are the main factors affecting supply chain reconfiguration (Akanle and Zhang, 2008; Gosling et al., 2010; Lemoine and Skjoett-Larsen, 2004).

6.7 Proposed methodology for supplier evaluation/prioritization for supply chain reconfiguration

Supplier evaluation for supply chain reconfiguration involves simultaneous consideration of multiple criteria, and thereby requires the application of multi-criteria decision-making (MCDM). Analytic hierarchy process (AHP) and analytic network process (ANP) are the two most important and popularly used multi-criteria decision-making (MCDM) methods that aid the decision maker to select the best choice under situations characterized by having more than one criterion (or multiple criteria). In recent times, AHP due to its strict hierarchy based approach is not a favored technique in solving real world

problems that involves interdependence of criteria and sub-criteria. Therefore, ANP with its freedom of providing decision maker the choice of creating relationships among criteria and sub-criteria that simulate real world issues has emerged as a popular MCDM technique. ANP models the decision making problem as a network of criteria and alternatives grouped as clusters (Saaty, 2001). The major advantages of ANP method can be summarized as follows:

- ANP uses a network without the need to specify levels as in a hierarchy.
- All elements in the network can be related in any possible way, which means that a network can incorporate feedback and interdependent relationships within and between clusters.

Extant literature on the application of ANP (Das and Chakraborty, 2011; Giannakis et al., 2020), recommends a four step approach to model a multi-criteria decision situation. However, the last step of this suggested approach is related to the selection of an alternative. However, in our case the objective is to prioritize dimensions of supply chain reconfiguration and therefore we would adopt the three steps of the suggested methodology. These three steps are as follows:

Step 1 - Define the problem and construction of the network model:

The network model for this study including the interdependencies of criteria and sub-criteria were constructed utilizing SuperDecisions software (Version 2.8) (https://www.superdecisions.com) as shown in figure 1. In this figure it should be noted that outer dependences are indicated by arrows while inner dependences are indicated by arcs.

Step 2 - Pairwise comparisons of the clusters and elements: Similar to AHP, pairwise comparisons are also carried out in ANP to determine the relative importance weights of elements in the network based on expert judgements made using Saaty's 1-9 fundamental scale (Saaty, 1990). According to Saaty, if element *i* has one of the numbers 1–9 assigned to it when compared with element *j*, then a reciprocal value is assigned to *j*; i.e., $a_{ij}=1/a_{ji}$, where $a_{ij}(a_{ji})$ denotes the relative importance of the i^{th} (j^{th}) element. Pairwise comparisons are made with respect to clusters and within clusters. To ensure the consistency of decision maker(s) judgements, consistency index is evaluated, compared with random index to obtain the value of consistency ratio (CR). A value of CR less than 0.1 indicates the consistency of judgement in pairwise comparisons (Simwanda et al., 2020).

Pairwise comparisons under ANP model are carried out with the support of experts with the knowledge in the area under study. In the present case, five experts were consulted, three from industry and two from academics. They were physically visited to apprise them and clarify about the criteria and sub-criteria. Later, their inputs were solicited regarding pairwise comparisons to create matrices. It can be expected that the experts in the focus group would have different values of pairwise comparisons. Previous research strongly suggests using a geometric mean in deriving the final values of pairwise comparison (Simwanda et al., 2020; Giannakis et al., 2020) which was followed in the present research.

Step 3: Supermatrix formation: A supermatrix is a partitioned matrix, where each submatrix is composed of a set of relationships between two clusters. After pairwise comparisons and obtaining the local priority vectors associated with the elements, the priority vectors are entered into the appropriate columns of a matrix which illustrates the

relative influences among elements in the system. This is called the unweighted supermatrix (Simwada et al., 2020). Next step is to create a column stochastic matrix known as weighted supermatrix. Finally, this weighted supermatrix is raised to limiting powers until the weights of elements converge to stable global priority weights. The result is known as limiting matrix and the final priorities in this matrix can be used to prioritize criteria and sub-criteria that impact a multi-criteria decision model (Promentilla et al., 2008).

6.7.1 Application of the proposed methodology to case supply chain

The proposed methodology was applied to a case supply chain from retail sector. Due to eco-political risk that occurred in 2017, this supply chain had to face major disruptions. The first step is to develop the model considering the criteria and sub-criteria that can be utilized. In this case, the criteria were the dimensions of balance scorecard, namely customer, financial, internal business perspective, and innovation perspective. Further, supply chain reconfiguration dimensions were selected through a literature review and were classified under each balance scorecard dimension with the help of the experts. The network model is shown in Figure 6.2. This figure also indicates various dependencies, inner and outer including cluster dependencies.

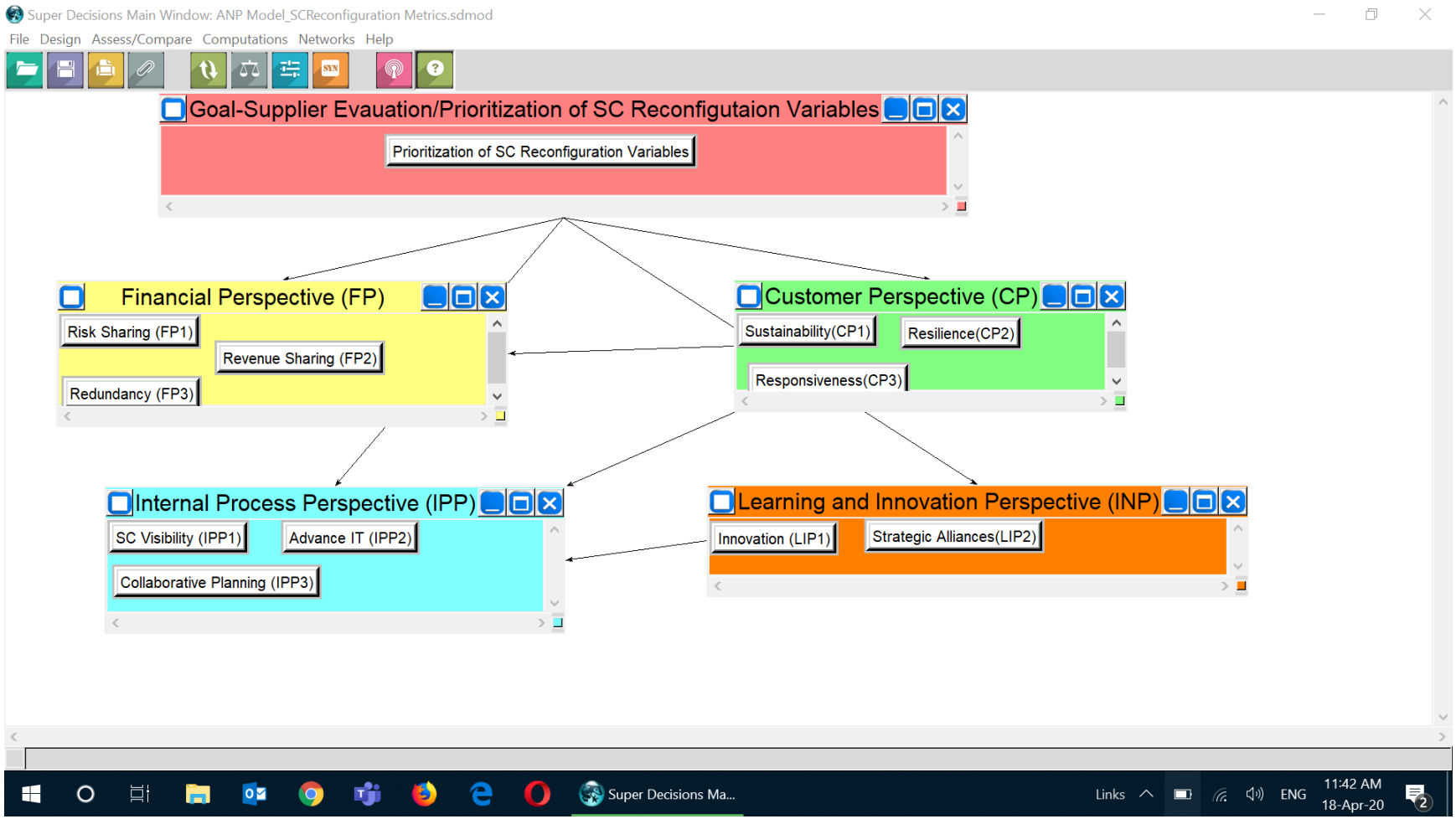

Figure 6.2. Multi-criteria Decision Model for SC Reconfiguration Variables

Pairwise comparisons: First comparison was among the criteria of balance scorecard with respect to the goal. The values of this comparison are shown in Table 6.4. The last column of the table shows the Eigen value of this pairwise comparison.

Table 6.4. Pairwise comparison of the dimensions of Balanced Scorecard with respect to Goal

	Financial Perspective	***Customer Perspective***	***Internal Process Perspective***	***Learning & Innovation Perspective***	***e-vector***
Financial Perspective	1	1/2	2	5	0.29286
Customer Perspective	2	1	3	5	0.46472
Internal Process Perspective	1/2	1/3	1	4	0.17907
Learning & Innovation Perspective	1/5	1/5	1/4	1	0.06336

CR: 0.03672

The next pairwise comparison is for each of the dimension of the balanced score card with respect to their sub-dimension. There would be four pairwise matrices representing each dimension of the balance scorecard.

Table 6.5. Pairwise comparison 'Financial Perspective Sub-dimensions' with respect to Goal

Financial Perspective	***FP1***	***FP2***	***FP3***	***e-vector***
FP1	1	1/3	3	0.25829
FP2	3	1	5	0.63699
FP3	1/3	1/5	1	0.10473

CR: 0.03703

Table 6.6. Pairwise comparison of 'Customer Perspective Sub-dimensions' with respect to Goal

Customer Perspective	***CP1***	***CP2***	***CP3***	***e-vector***
CP1	1	1/4	1/6	0.08522
CP2	4	1	3	0.27056
CP3	6	1/3	1	0.64422

CR: 0.05156

Table 6.7. Pairwise comparison of 'Internal Process Perspective Sub-dimensions' with respect to Goal

Internal Process Perspective	***IPP1***	***IPP2***	***IPP3***	***e-vector***
IPP1	1	5	3	0.63699
IPP2	1/5	1	1/3	0.10473
IPP3	1/3	3	1	0.25828

CR: 0.03703

Table 6.8. Pairwise comparison of 'Learning & Innovation Perspective Sub-dimensions' with respect to Goal

Learning & Innovation Perspective	***FP1***	***FP2***	***e-vector***
LIP1	1	¼	0.20000
LIP2	4	1	0.80000

CR: 0.0000

Finally, Table 6.9 and Table 6.10 provides pairwise comparisons that represent outer dependence, e.g. relationship between sustainability in customer perspective and strategic alliance in innovation perspective with the sub-dimensions of internal process perspective. Similarly, Table 6.11 provides outer dependence between resilience in customer perspective with the sub-dimensions of financial perspective.

Table 6.9. Pairwise comparison of 'Sustainability (CP1)' with respect to 'IPP Sub-dimensions'

Sustainability	***IPP1***	***IPP2***	***IPP3***	***e-vector***
IPP1	1	6	3	0.65481
IPP2	1/6	1	1/3	0.09534
IPP3	1/3	3	1	0.24986

CR: 0.01759

Table 6.10. Pairwise comparison of 'Strategic Alliances (LP2)' with respect to 'IPP Sub-dimensions'

Strategic Alliances	***IPP1***	***IPP2***	***IPP3***	***e-vector***
IPP1	1	2	¼	0.19981
IPP2	1/2	1	1/5	0.11685
IPP3	4	5	1	0.68334

CR: 0.02365

Table 6.11. Pairwise comparison of 'Resilience (CP2)' with respect to 'FP Sub-dimensions'

Resilience	***FP1***	***FP2***	***FP3***	***e-vector***
FP1	1	1/4	3	0.21764
FP2	4	1	6	0.69096
FP3	1/3	1/6	1	0.09140

CR: 0.05156

After all pairwise comparisons are completed and checked for consistency, the maximum eigenvalues and the corresponding eigenvectors of the pairwise comparison matrices are calculated to generate the supermatrix.

Development of Supermatrix

ANP uses supermatrix to deal with the relationship of feedback and interdependence among the criteria. The supermatrix allows a resolution of the effects of interdependence

that exists between the elements of the system. The supermatrix is a partitioned matrix, where each submatrix is composed of a set of relationships between two levels in the graphical model. If no interdependent relationship exists among the criteria, the pairwise comparison value would be 0. In contrast, if an interdependent and feedback relationship exists among the criteria, then such value would no longer be 0 and an unweighted supermatrix M will be obtained (Tseng et al., 2009). In an unweighted supermatrix, its columns may not be column stochastic. To obtain a stochastic matrix (i.e., each column sums to one), multiply the blocks of the unweighted supermatrix by the corresponding cluster priority. The supermatrix must satisfy the principle of column stochastic, which means every column should add up to 1.

Table 6.12. Unweighted, weighted and limiting Supermatrices

	Unweighted Supermatrix	Weighted Supermatrix	Limiting Supermatrix	Financial Perspective			Customer Perspective			Internal Perspective		Process	Learning & Innovation			
				FP1	FP2	FP3	CP1	CP2	CP3	IPP1	IPP2	IPP3	LIP1	LIP2	Priority Vector	**Rank**
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
FP1 Risk Sharing	0.25828	0.07564	0.08471	0.0000	0.0000	0.0000	0.0000	0.2176	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.084706	**5**
FP2 Revenue Sharing	0.63699	0.18655	0.22485	0.0000	0.0000	0.0000	0.0000	0.6910	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.224849	**2**
FP3 Redundancy	0.10473	0.03067	0.03467	0.0000	0.0000	0.0000	0.0000	0.9140	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.034673	**8**
CP1 Sustainability	0.08522	0.03960	0.03257	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.032568	**9**
CP2 Resilience	0.27056	0.12573	0.10340	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.103396	**4**
CP3 Responsiveness	0.64422	0.29938	0.24628	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.246197	**1**
IPP1 SC Visibility	0.63699	0.11406	0.12346	0.0000	0.0000	0.0000	0.6548	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1998	0.123455	**3**
IPP2 Advance IT	0.10473	0.01875	0.02340	0.0000	0.0000	0.0000	0.0953	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1169	0.023398	**10**
IPP3 Collaborative Planning	0.25828	0.04625	0.07465	0.0000	0.0000	0.0000	0.2498	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6833	0.074655	**6**
LIP1 Innovation	0.20000	0.01267	0.01042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.010420	**11**
LIP2 Strategic Alliances	0.80000	0.05069	0.04168	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.041682	**7**
Final Priority Ranking				**5**	**2**	**8**	**9**	**4**	**1**	**3**	**10**	**6**	**11**	**7**		

Table 6.12 also provides the final priority ranking for the case supply chain. It is clear that for this supply chain, responsiveness, revenue sharing, visibility are the top three variables that would impact supply chain reconfiguration.

6.8 Conclusions

In this chapter, we proposed an integrated BSC-ANP approach for evaluating supply chain reconfiguration variables. Supply chain reconfiguration variables were identified from the extant literature and were grouped under the four dimensions of balanced scorecard with inputs from experts. A major contribution of the chapter lies in its linkage of supply chain reconfiguration variables with a popular performance management framework. A key advantage of the model lies in its capability to simultaneously consider both qualitative and quantitative factors and consider their interdependencies, which is not possible to evaluate by any other statistical technique. The framework represents only one set of possible relationships and the ANP model may be enhanced through the inclusion of additional relationships. Therefore, in future studies, the robustness of the proposed model can be evaluated by considering supply chains from different sectors and including some other supply chain reconfiguration variables.

CHAPTER 7: CONCLUSION, CONTRIBUTIONS, LIMITATIONS AND AVENUES FOR FUTURE RESARCH

7.1 Introduction

This chapter summarizes the main findings of the thesis at hand. In particular, the integrative supply chain resilience and reconfiguration model developed and tested in the study has enabled a previously untested relationship to be examined. The current research therefore provides new and valuable insights to help achieve a more complete view of supply chain resilience and reconfiguration as well as resolves some of the inconsistencies of previous studies.

After summarizing and discussing the thesis findings, this chapter highlights their contributions to theory and practice. The chapter concludes with some of this research limitations that lead to identifying some avenues for future research.

7.2 General Discussion and Findings

Resilience in supply chains is an emerging field of study. However, a number of academics and practitioners have focused on understanding and managing different types of risk in supply chain resilience, because risk events have far-reaching effects. Natural and man-made risks, such as economic-political risk, can lead firms to restructure their supply chains. This restructure can consist of reducing, centralizing, or relocating plants and distribution centers, redesigning new distribution networks, and reduction of supplier bases. The implications of this reconfiguration have received comparatively little attention from

both academics and practitioners, because risk events are rare. This research therefore sheds light on the role of supply chain resilience in supply chain reconfiguration. More specifically, a model that can be used as an aid in designing supply chains as a geographic area, methodology, or resilience enablers on risk and reconfiguration has been proposed and tested.

According to Hoskisson et al. (2017), risk-taking is a critical aspect of strategic management. If managers perceive that the environment in which they are working has high risk, however their system or supply chain has low resilience they would be risk averse and their decisions would be conservative affecting the performance negatively. However, if supply chain resilience is high, managers are more likely to take chances resulting in opening of new avenues. Thereby, supply chain resilience and reconfiguration capabilities have emerged as important to improve competitive advantage and performance because managers need to take risks, in particular today's uncertain business environment. Taking risks results in the uncovering of new ways by which risk and resilience affects performance. Resilient systems encourage risk-taking at the micro or decision-making level and such risks often translate into additional benefits for the firm (Mena, 2020).

An overall objective of this thesis was to ascertain whether the supply chain resilience help in recover the supply chain after disruption and the role of resilience in reconfigure the supply chain when eco-political risk occurred. In particular, the aim was to explore the effects of risk management culture, agility, collaboration, and integration on improve supply chain resilience and reconfiguration under eco-political risk. Another objective consisted of ascertaining the resilience enablers that impact supply chain resilience

and establish relationships among them using interpretive structural modeling (ISM) under the influence of economic-political risk.

The study by Kumar and Anbanandam (2020) empirically investigated the impact of risk management culture on agility, visibility, information sharing, connectivity, and collaboration. The findings show that SC resilience of an organization is the result of interdependencies between risk management culture, agility, visibility, collaboration, connectivity, and information sharing. This study supports the findings of the questionnaire study as reported in this thesis, where risk management culture has emerged as the dominant factor in achieving resilience and reconfiguration in supply chains.

The ISM model developed in this research also established the importance of risk management culture. These findings corroborate Kumar and Anbanadam (2020) findings that organizations looking forward to improve SC resilience should focus on establishing risk awareness and reporting culture, investments in information technology tools to improve information sharing and collaboration in the SC, and improve agility of SC to counter risk events. Development of risk management culture requires firms' to train their employees to understand supply chain risks and report events that may trigger a risky event in the supply chain. Further, the extent to which risk management culture is implemented and practiced enables organizations to meet the needs of fragmented, dynamic markets, and adapt to unanticipated changes. Further, the present study provides empirical evidence that organizations have to first establish a risk management culture in their entire operations to be resilient. It establishes that to reconfigure supply chain in wake of a disruption requires combined effect of all the key antecedents as proposed in this study.

Moreover, supply chain reconfiguration has emerged as a key variable that determines the capability of supply chain to adjust itself in wake of risks or dynamic business environment. However, supply chain reconfiguration is dependent on several variables that need to be prioritized to focus resources for improvement. The final objective of this thesis was to propose a multi-criteria decision approach to prioritize the variables associated with supply chain reconfiguration.

Results from the survey revealed that risk management culture, agility and collaboration are positively affect supply chain resilience. This result is not surprising and is consistent with Jüttner and Maklan, (2011), Pettit et al., (2013), Wieland and Wallenburg, (2013), Hohenstein et al., (2015), and Tukamuhabwa et al., (2015) contention that the risk management culture, agility, and collaboration is more demanding in improving the resilience of supply chain. It also consistent with the claim that supply chain resilience significant help in reconfigure the supply chain (Ambulkar et al., 2015; Bag et al., 2018). However, this result is not supported when integration led to improve the supply chain (Wieland and Wallenburg, 2013). The possible reason for insignificant relationship may be associated with inadequate support from relevant actors during crisis in Qatar.

Another objective of the current thesis was to ascertain the inter-relationships among the enablers of supply chain resilience using ISM methodology. The model did not statistically validate the relationships between the variables. However, the model indicated that risk management culture is the highest driving power variable that impacts on the other variables such agility and integration (Liu et al., 2018). This result was supported in the model when variables such as agility, robustness, backup activity, and readiness, response

and recovery were considered as a high dependence and low driving power that influencing the resilience of supply chain under eco-political risk. Moreover, The ISM model result also suggested that supplementary variables like collaboration, information sharing, and trust have high driving power and low dependence. Chen et al., (2019) support the finding that collaboration and coordination are a core requirement for recovering from disruptions. In addition, Brusset and Teller (2017) concur that information sharing can provide flexibility and improve agility of the supply chain.

A well-prepared supply chain not only have the ability to regain the position as before the pre-disruption, but also restore the firms position to the higher level that can lead to competitive advantage. For this phase, strong market position, information sharing, velocity, public-private partnership and agility play crucial role to make supply chain resilient (Singh et al., 2019). The ISM model developed in this research and subsequently the empirical model establishes the importance of agility as a key variable affecting supply chain resilience. In this regard, Al Talib et al. (2020) suggest integrating Internet of Things capabilities that would improve flexibility and decision making process. Integration of these technologies would also enable accuracy and reliability of transmitted data and would improve supply chain ability to trach resources. In the ISM model, readiness, response and recovery emerges as a resultant action, this variable can be improved by machine learning approaches that provide SC resilience predictive capabilities to mitigate risks as the supply chain acquires self-learning capabilities (Al Talib et al., 2020).

In view of variety of risks in the business environment, organizations have realized the importance of quickly reconfiguring their supply chains. Supply chain reconfiguration is

an important and efficient strategy and existing research on supply chain reconfiguration mainly focuses on providing new reconfiguration strategies. (Tian and Guo, 2019). The ANP-BSC model presented in the present research extends the previous research by providing a tool to select the most appropriate strategy for reconfiguration. The novelty of model lies in the integration of balanced scorecard that considers financial and non-financial measures with multi-criteria decision model. The framework suggested is flexible in the sense that it can easily be modified to add new strategies that evolve over time. Based on a case supply chain from retail sector, variables such as responsiveness, revenue sharing, visibility found to be the top three variables that would influence supply chain reconfiguration. Table 7.1 summarize the major findings of the present study.

Table 7.1. Summary of Thesis Methodology and Finding

Methodology	Objective	Finding	Implication
Systematic Mapping Review	The objective of the systematic mapping review is to collate and catalogue a body of evidence to describe the state of knowledge for supply chain resilience and reconfiguration	✓ The focus in supply chain studies is on building resilience, but there is little knowledge about the role of resilience in reconfiguring supply chains. ✓ There is a clear lack of supply chain resilience to help manage risks. ✓ Disruptions that may have a catastrophic effect are often not considered important. ✓ The major reconfiguration characteristics to enable management of risks in the supply chain were understanding of reconfiguration characteristics, and allocation and reallocation of activities, facilities, inventory, suppliers and	The systematic mapping review mapped supply chains' ability to mitigate risk and reconfiguration. It proposed a model that can be used as an aid in designing supply chains as a geographic area, methodology, or resilience enablers on risk and reconfiguration. The systematic mapping review identified enablers for specified types of risk, such as economic-political risk. This allowed investigation of the role of these enablers in mitigating risk and in reconfiguring the supply chain.

		plants, production, and capabilities. ✓ The majority of the studies reviewed took place in either Europe or Asia, with none in the Middle East.	
Questionnaire - Survey	The objectives of the survey are to specified and measured the relationship between supply chain resilience and reconfiguration by identifying Qatari organizations as survey group, blockade event as economic-political risk, and four resilience enablers have a positive relationship in supply chain resilience that influence the supply chain reconfiguration	✓ The survey results suggested that there is a strong positive relationship between supply chain resilience and reconfiguration. ✓ The study found no clear relationship between integration and supply chain resilience.	This implies that supply chain resilience increases the possibility that firms will reconfigure their supply chain and return quickly to normal after disruptions. This suggests that risk management culture, agility, and collaboration are significant enablers of supply chain resilience, but integration does not add clear value to supply chain resilience.
Interpretive Structural Modelling (ISM)	The objective of the ISM is to identifying relationships among resilience enablers, which define an economic political risk.	✓ Risk management culture has an impact through activities like understanding the network, identification of disruptive and recurrent risks, making supply chain risk assessment a formal part of decision-making at all levels and continual assessment of supply chain resilience. ✓ Information sharing, trust, and collaboration among the supply chain partners have a high driving power and low dependence on other enablers. The ISM-based framework show that agility, robustness, backup capacity, and readiness, responses and recovery are required for supply chain resilience, but cannot be improved independently. ✓ Risk- and revenue-sharing, financial stability, integration, coordination and control, and multiple sourcing, linked the low-dependence variables with the high dependence	The results suggest that only certain practices, and use of particular assets and human resources will be effective. Managers who combine and enhance both integration and flexibility will probably see increased resilience in their supply chain The model provides a useful framework for decision-making on developing resilience in supply chains. Managers can use the model to ensure that they focus scarce organizational resources on the most important factors.

		variables in supply chain resilience.	
Analytic Network Process – Balance Scorecards (ANP-BSC)	The objectives of the ANP are to captures the interdependencies among the determinates, dimensions and enablers in a supply chain, and the BSC framework to provides a comprehensive structure across four perspectives to evaluate supply chain reconfiguration.	An integrated framework of ANP-BSC found that for this supply chain, responsiveness, revenue sharing, and visibility were the top three variables that would affect supply chain reconfiguration.	There may be a relationship between sustainability in the customer perspective and strategic alliance in the innovation perspective, with the sub-dimensions of the internal process perspective. There is also a relationship between resilience in the customer perspective and the sub-dimensions of the financial perspective.

7.3 Research Contributions

Finding indings revealed in the current thesis contribute to the supply chain resilience and reconfiguration literature. From a practical perspective, the analysis showed that organizations have to look beyond their boundaries. There is an urgent need to build resilience among organizations to mitigate risk in their supply chains. The result of the systematic mapping review, questionnaire survey, ISM model, BSC model, ANP model, and integrated ANP-BSC models provide new insights on the management of risk. They show that resilience in supply chains needs to be a part of any organization's overall supply chain strategy.

7.3.1 Contribution to theory

The present findings can enhance our understanding of how resilience enablers influence and guide the firms to recover their supply chain after disruptions. Showing that some disruptions led to reconfigure the supply chain to return to the normal or equilibrium

stages while other not. By conceptualizing the impacts of supply chain resilience in recovering the supply chain disruption, this research take another step towards the role of resilience in reconfigure the supply chain when a disruptive risk occurred. It emphasizes the role of risk management culture, agility, collaboration, and integration in enhancing the supply chain resilience who in turn help the firms to reconfigure the supply chain after disruptions.

Furthermore, the academic supply chain resilience and reconfiguration literature fails to move beyond theory to offer management guidance on the implication and operationalization of supply chain resilience and reconfiguration concepts. By applying systematic mapping review, certain gaps have been identified related to the number of studies, geographic area, type of research, research methods, resilience enablers, and reconfiguration characteristics in supply chains. This gaps allowed the academic and mangers attain for future research to have a complete research picture, abundance specific, and important practitioner insights.

Moreover, this research covers the area of the roles of supply chain resilience in reconfiguring the supply chain under eco-political risk based on development countries in the Middle East. The current thesis developed an integrated supply chain resilience and reconfiguration framework by investigating the interdependence between the theoretical framework of supply chain resilience and reconfiguration and the operational practices based on emergency blockade process. A questionnaire-based survey was developed from previous studies to answer the purpose of the current research. This questionnaire intends to contribute to the literature on supply chain resilience and reconfiguration by answering the question g

of how supply chain resilience help in reconfiguration of supply chain after disruption. This will be the main research question that will be answered in this study. First, it enhance our understanding of the reasons to reconfigure the supply chain by indicating linkages between supply chain capabilities and supply chain resilience, rather than relating this reconfiguration to contingency factors. Secondly, the finding of this study further our understanding of the supply chain resilience and supply chain reconfiguration of organization/supply chains. Another potential contribution would be to extend the work on this topic to a new setting and determine whether theories that predict well in one setting will be as effective as in another. Qatar, as a context of study, is unique and interesting given the recent blockade and its potential impact on the sport event, such as FIFA World Cup of 2022, and the project management, such as sports venues and Rail. In addition, Qatar received less attention among other Gulf Cooperation Council (GCC) countries (Elbanna, 2016). This study may complement our understanding of the supply chain resilience and supply chain reconfiguration in an emerging economy like Qatar. Finally, this study will examine unobserved heterogeneity using the PLS-SEM in the field of supply chain risk management.

Besides, the ISM model developed in this study makes several useful contributions in the area of supply chain risks and resilience. First, from a theoretical perspective, it enhances our understanding of the linkages between one particular form of risk, econo-political risk, and resilience enablers. Previous studies have considered the relationship between enablers and risk in general. Second, most of the previous studies have been in developed economies, so this study extends the supply chain resilience literature to a new

setting to discover whether enablers from one setting, developed economies, are also effective in another, a developing economy (Soni et al., 2014).

In addition to the ISM model, an ANP-BSC-based framework has been used to select the best approach to reconfigure a supply chain following disruptions. This multi-criteria decision-making tool may be used by academics for other decisions, including those related to management of reconfiguration in supply chains. The framework used to assess the probability and consequences of resilience enablers in a supply chain could be used for similar situations in other sectors. A major contribution of this framework lies in its linkage of supply chain reconfiguration variables with a popular performance management framework. A key advantage of the model lies in its capability to simultaneously consider both qualitative and quantitative factors and consider their interdependencies, which is not possible to evaluate by any other statistical technique. The framework represents only one set of possible relationships and the ANP model may be enhanced through the inclusion of additional relationships. Therefore, in future studies, the robustness of the proposed model can be evaluated by considering supply chains from different sectors and including some other supply chain reconfiguration variables.

7.3.2 Contribution to practice

The thesis findings has several important managerial implications. First, results are likely to inform managers about various issues related to supply chain resilience and reconfiguration. Second, it revealed that information sharing, collaboration, and trust were the major enablers of resilience in supply chains. Managers therefore need to reorient their

dealings with their suppliers and customers to improve these factors to mitigate risks and improve resilience. The survey also suggested that a combined approach of supply chain resilience with reconfiguration was a preferred strategy to manage supply chain risks. This approach will allow managers to make the necessary changes to recover from disruptions.

The significant relationship between supply chain resilience and reconfiguration will enable managers to make changes to their supply chain, including major adjustments. These changes may influence product and service offering, labor, facility operations, and leadership with other entities. One example might include using alternative suppliers and service providers to give the firm more options in the event of disruptions to the flow of products and services.

The study findings suggested that in order to create resilient supply chains, it is essential to have a risk management culture, agility, and collaboration. This would provide Qatari supply chain managers with knowledge of the enablers required for supply chain resilience. This is the starting point for establishing supply chain resilience; because it guides management decisions about supply chain reconfiguration. A risk culture can be reinforced through routine decision-making and operational processes. This will ensure that employees at all level of the firm are more likely to be aware of disruptions and take steps to learn from even small disruptions within the supply chain. This study also provides evidence that agility allows firms to absorb the impact of disruption. Managers should therefore seek to establish this capacity through human-centered leadership, continuous improvement, and culture to enable their organizations to manage and respond to real and perceived risks to their supply chains.

Cases from three sectors were analyzed using an ISM-based framework. The analysis involved the major enablers of resilience in supply chains under economic-political risk, and the hierarchical relationship between them. This tool can be replicated for other supply chains, and as would provide as a result an easy framework to understand the role of resilience in mitigating supply chain risks. The ANP-BSC framework is comprehensive in the sense that it considers all the possible processes in a supply chain that could be affected by different types of risks. This framework includes many important criteria in the management of risk in supply chains. It may therefore serve as a good aid to managers to evaluate alternatives and select the best decision for reconfiguring the supply chain during periods of disruption.

7.4 Limitations

The research was designed to address several significant gaps in the literature and provide meaningful and important insights for practitioners. However, it has some limitations, including those related to study setting, concept, methodology, and frameworks developed. These limitations do not detract from the multiple strengths of the present work and merely provide a platform for future research.

Like many other empirical studies in the area of supply chain resilience and reconfiguration, this study only covers selected issues related to the respondent companies, which represents only a segment of the population. Thus, the responses to the questionnaire reflect only the perceptions of the individuals or firms that completed the questionnaire, and therefore cannot be generalized. Moreover, responses from organizations further

downstream and upstream in the same supply chain were not sought. Furthermore, some of the findings of the thesis might be specific to Qatar, since all the study organizations work in the same political, economic, and social environment.

The research model examines the direct relationship between supply chain resilience and reconfiguration without controlling any variables such as firm size or industry type. Replicated the same relationship with a control and moderate variables are highly recommended to support the current research finding and advance supply chain resilience and reconfiguration literature.

The method used to collect data for empirical study in this research was a cross-sectional survey. This limits the ability to draw conclusions about causality. The framework for the assessment of probability and impact analysis of resilience in information, physical and financial flow has an element of subjectivity. This also limits the generalizability of the results. This study quantified resilience enablers related to economic political risk, but did not evaluate these enablers in actual settings. The models may therefore need to be verified in actual supply chain settings.

For the sake of simplicity, the study did not include subsystems and sub-subsystems, or take into account their impact to develop a more comprehensive model. Experts' help was sought to develop the contextual relationships for the ISM models, which may have introduced some element of bias. The models were also not statistically validated. A future extension of this work might apply structural equation modeling, commonly known as the linear structural relationship approach, to statistically corroborate the findings from the ISM model. In addition, it was not possible to include all possible variables in the integrated

framework for supply chain reconfiguration using ANP and BSC. The indexes were also not checked for conceptual consistency by evaluating them in other sectors.

7.5 Avenues for future research

The present study has re-affirmed the importance of resilience in shaping the firm response to disruptions. However, whilst the present study sets out to determine the overall effect of each of the four resilience enablers on supply chain reconfiguration under eco-political risk; future research could examine the effects of other supply chain resilience enablers on supply chain reconfiguration. This would provide even greater insight into why certain enablers of supply chain resilience are followed to responses to specific disruptions and others are not. Moreover, future research could also seek to replicate the current study in various dimensions of supply chain resilience and reconfiguration by integrating other type of risk, resilience enablers, reconfiguration variables, and control variables.

Furthermore, the present study has highlighted the interaction between supply chain resilience and reconfiguration under eco-political risk in private organizations in Qatar. Future research could focus on specific industries or industry sectors, or focus on certain types of organizations. The same hypotheses could also be tested in government organizations, where the effects of the risk may be less pronounced. In addition, future research could also test the framework developed in the present study, ISM model and ANP-BSC frameworks, in other sectors, beyond food, construction and manufacturing.

The present research used a single respondent from each firms. Additional data sources for the measurement of dependent variables are suggested for future research to improve the data quality.

Whilst there is a need for research utilizing large sample and multivariate analysis in order to improve the generalizability of supply chain resilience and reconfiguration, there is also the need for research to combine qualitative and quantitative design. Alternative types of data collection, such as case studies or using surveys to collect longitudinal data are also needed to claim causality of supply chain resilience and reconfiguration. The present study focus on firm level of analysis. Extending the boundaries from firm level to country level, to consider broader supply chain resilience and reconfiguration.

In this research, the quantification of issues related to resilience and reconfiguration in response to disruption has been carried out. However some of these frameworks are not evaluated for actual practical settings. Thus, it is suggested that these models may be further verified in actual supply chain settings with the help of the experts. Also in general for the sake of simplicity we have not taken into account the subsystem and sub-subsystems can be delineated and then their impact be taken into account to develop a more comprehensive model. Further, comparative data can be generated to benchmark supply chain practices to improve their overall resilience and reconfiguration capabilities.

This study explored issues related to management of risk, resilience, and reconfiguration in supply chains in Qatari organizations. This is a promising area for researchers to further explore. In the future, it may be a valuable input for future research in

this area. Finally, the ISM-based framework for modelling the enablers of supply chain resilience could be extended to include other issues in the area of supply chain management.

7.6 Conclusion

Supply chain resilience and reconfiguration have been receiving increasing attention in supply chain management research. There is a growing understanding among practitioners that any risk in a supply chain, affecting an organization anywhere in the network, may have a direct effect on the ability to continue operations, get finished goods to market or provide critical services to customers. It can therefore seriously affect the network's competitive advantage. As such, it is instrumental to understand the role of resilience in recovering from supply chain risks, and how it can help in reconfiguring the supply chain if needed. This study has made a substantial and original contribution to knowledge on supply chain resilience and reconfiguration, and provided some clear implications for managers, as well as directions for future research. It has significantly enhanced our understanding of supply chain management by clarifying some of the important relationships between supply chain resilience and its enablers, including risk management culture, agility, collaboration, integration, as well as their relationship with supply chain reconfiguration. It is hoped that this study will provide a platform for future research to replicate and extend its findings.

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APPENDIXS

Appendix A: Supply Chain Resilience Studies

Authors Names	Year	Aim	Type of Study	Population/Sample	Methodology	Resilience Enablers	Geographical Region
Hendry, L.C., Stevenson, M., MacBryde, J., Ball, P., Sayed, M., Liu, L.	2019	To investigate how local supply chains prepare for and respond to the threats and opportunities presented by constitutional change, thereby building resilience	Research Paper	14 firms in the food sector	Multiple case studies	sensing, seizing and transforming	UK
Hosseini, S., Ivanov, D., Dolgui, A.	2019	To provide a comprehensive review of the quantitative analyses of supply chain resilience	Review Paper	15 years from 2002 to 2017	systematic literature review	Agility, visibility, flexibility, collaboration, information sharing	General/ Not Specified
Bag, S., Gupta, S., Foropon, C.	2019	To investigate the function of remanufacturing capability in influencing supply chain resilience in supply chain networks under the moderating effects of both flexible orientation and control orientation.	Research Paper	150 participants completed the survey	survey	Financial factors, management factors, market factors, regulatory and environmental factors, technical factors and dynamic remanufacturing capability	South Africa
Dubey, R., Gunasekaran, A., Childe, S.J., Papadopoulos, T., Blome, C., Luo, Z.	2019	To explain the interaction effect of reduction of behavioral uncertainty on the path connecting trust and supply chain resilience and cooperation and supply chain resilience.	Research Paper	250 Indian manufacturing organizations	survey	Supply Chain Connectivity, Information Sharing, and Supply Chain Visibility, Trust, Cooperation, and Supply Chain Resilience	Indian
Dubey, R., Gunasekaran, A., Childe, S.J., Fosso Wamba, S., Roubaud, D., Foropon, C.	2019	To explain how data analytics capability under moderating effect of organizational flexibility improves supply chain resilience and competitive advantage	Research Paper	213 Indian manufacturing organizations	survey	data analytics capability, organizational flexibility, supply chain resilience, and competitive advantage	Indian

Tan, W.J., Zhang, A.N., Cai, W.	2019	To presents a conceptual model of an SCN using graph theory, considering the relationships between plants and materials	Research Paper	three case studies from real-world computer peripheral equipment manufacturing	Mathematical Model (graph-based model)	structural redundancy	Not Specified
Singh, S., Ghosh, S., Jayaram, J., Tiwari, M.K.	2019	To proposed an ontology-based decision support system to intensify the supply chain resilience during a disruption	Research Paper	seven case studies	Mathematical Model (three-echelon supply chain network)	resilience character	Not Specified
Scholten, K., Sharkey Scott, P., Fynes, B.	2019	To develop an elaborated model of SCRES learning	Case Study	28 interviews across five companies	in-depth qualitative case study	Processual Learning, Anticipative Learning, Situational Learning, collaborative Learning, Experiential Learning, Vicarious Learning	international
Mandal, S., Saravanan, D.	2019	To explores the influence of entrepreneurial, environmental, supply chain, technology, market and learning orientations in the development of tourism supply chain agility and tourism supply chain resilience	Research Paper	276 completed responses	survey	entrepreneurial, environmental, supply chain, technology, market and learning orientations	Not Specified
Ivanov, D., Sokolov, B.	2019	To advance insights into feedback-driven understanding of resilience within open system context	Research Paper	three levels of resilient SC control	Mathematical Model/ optimal control model and computational algorithm	Recovery control	Not Specified

Gligor, D., Gligor, N., Holcomb, M., Bozkurt, S.	2019	To add clarity to the multidimensional concepts of agility and resilience	Review Paper		A multidisciplinary systematic literature review	ability to quickly change direction, speed/accelerate operations, scan the environment/anticipate, empower the customer/customize, adjust	General/ Not Specified
Adobor, H., McMullen, R.S.	2018	To present a conceptual framework on resilience types in supply chain networks	Conceptual Paper	three forms of resilience: engineering, ecological and evolutionary	Complex adaptive systems perspective	Recovery and Responses	North America
Altay, N., Gunasekaran, A., Dubey, R., Childe, S.J.	2018	To examines the effects of supply chain agility (SCAG) and supply chain resilience (SCRES) on performance under the moderating effect of organizational culture	Research Paper	335 responses gathered from organizations	Survey	agility and resilience	India
Forbes, S.L., Wilson, M.M.J.	2018	To examines the impact of the two natural disasters on the wine distribution supply chain.	Case Study	five firms impacted by the Christchurch earthquakes	case study	readiness, response and recovery	New Zealand
Ivanov, D., Dolgui, A., Sokolov, B.	2018	To compute optimal recovery schedules and develop a resilience index on the basis of the minimax regret approach using an attainable (reachable) sets (AS) for supply chain (SC) design resilience quantification.	Research Paper	21 equations	Mathematical Model (Scheduling control model)	recovery actions and disruption	Not Specified

Zainal Abidin, N.A., Ingirige, B.	2018	To investigate dynamics and effects of interconnected risks among construction organizations by assessing the supply chain's critical vulnerabilities and capabilities that formulate the level of resilience in handling disruptive events in construction projects.	Research Paper	105 construction professionals from public and private organizations	Survey	vulnerabilities (Strategic vulnerability, Management vulnerability, Personnel vulnerability, Process vulnerability, Supplier/customer disruptions, Technology disruptions, Political or legal pressures, Environmental factors, Physical damage disruptions, Market pressures, Liquidity/credit vulnerability) and capabilities (Flexibility, Capacity, Efficiency, Visibility, Adaptability, Anticipation, Recovery, Dispersion, Collaboration, Market position, Security, Financial strength)	Malaysia
Sharma, S.K., George, S.A.	2018	To study the supply chain resilience of Indian truckload transportation industry, in the event of potential disasters that affect the normalcy of their services.	Research Paper	five top-level executives of companies	Graphical model (Bayesian network) + questionnaire	reactive capacity (Maintenance, Fuel price variability hedging, Skilled labor and management, Communication and coordination, Security, Insurance, Mode flexibility) and restorative capacity (Risk assessment, Budget availability)	India
Kochan, C.G., Nowicki, D.R.	2018	To present a focused review of the SCRES literature by investigating supply chain (SC) capabilities, their relationship to SCRES outcomes and the underpinning theoretical mechanisms of this relationship	Literature Review	383 articles published between 2000 and 2017	systematic literature review	Responsiveness (Agility–flexibility–sourcing, Agility–flexibility–fulfillment, Agility–velocity, Agility–visibility, Redundancy), Anticipation (Efficiency, Dispersion, Market position, Security, Collaboration, Financial strength, Revenue management, Organization culture, Anticipation), Recovery (Adaptability, Recovery)	General/ Not Specified
Bhattacharjya, J.	2018	To explore the egocentric network-based strategies used by upstream firms to ensure their own resilience when the disruptions originate with downstream partners.	Research Paper	apparel export trading company	case study	egocentric network-based strategies	India

Ivanov, D.	2018	To analyze disruption propagation in the supply chain with consideration of sustainability factors in order to design resilient supply chain structure in regard to ripple effect mitigation and sustainability increase.	Research Paper	5 market scenarios	Mathematical Model/ structured experimental design	sourcing, inventory and facility protection policies	Brazil, USA, South Africa, Italy, India
Liu, C.-L., Shang, K.-C., Lirn, T.-C., Lai, K.-H., Lun, Y.H.V.	2018	To examine the relationship between supply chain resilience and firm performance	Research Paper	253 companies in Taiwanese liner shipping industry	Survey	Reactive capabilities (risk management culture, agility, integration, and supply chain re-engineering)	Taiwan
Namdar, J., Li, X., Sawhney, R., Pradhan, N.	2018	To investigates the use of sourcing strategies to achieve supply chain resilience under disruptions	Research Paper	Scenario-based modelling	scenario-based mathematical model	procurement portfolio, collaboration and visibility, backup suppliers and a buyer's warning capability	Not specified
Lima, F.R.P., Da Silva, A.L., Godinho Filho, M., Dias, E.M.	2018	To reassess the role of supply chain resilience enablers in combating counterfeits in the medicine supply chain	Literature review	84 papers (2002-2016)	Systematic literature review	Reengineering, collaboration, visibility, innovation, SCR culture, and trust	General/ Not Specified
Adobor, H.	2018	To develop a multi-level framework that describes supply chain resilience as a higher-level construct, arising out of the coalescing of resilience at the individual, organizational, and inter organizational levels.	Literature review	Not specified	multilevel approach	Inter-firm trust and collaboration, supply chain risk management culture management, inter-partner learning	General/ Not Specified
Singh, R.K., Gupta, A., Gunasekaran, A.	2018	To identify and analyses the factors to develop the resilience in the humanitarian supply chain	Research Paper	12 factors related to resilient humanitarian supply chain	Interpretive structural modelling (ISM)	Government support and policy formulation, Strategy and capacity planning, Progress assessment of Project, Collaboration and coordination among stakeholders, Skilled and competent manpower, Application of technology and information system, Problem assessment, Integrated logistics management, Agility in processes, Timely supply of humanitarian aid, Timely inspection and	Not Specified

						quality check, Resilient humanitarian supply chain.	
Stone, J., Rahimifard, S.	2018	To identify which multidisciplinary aspects of resilience are applicable to agri-food supply chains (AFSCs) and to generate a novel AFSC resilience framework	Literature review	137 articles	Systematic literature review	Flexibility, risk aware culture, redundancy, early warning detection systems, security, efficiency, contingency plans, investing management, financial strength, leadership commitment, relationships, human resource management, business continuity, innovation, knowledge management, market position, adaptive management, collaboration, agility, visibility, adaptability, node criticality, information flow, velocity, redundancy, robustness, self-organization, rapidity, established communication lines, trust, risk management orientation, diversity, cohesion, network complexity, co-learning, bargaining power, community resources, responsiveness, buffer capacity	General/ Not Specified
Ali, I., Nagalingam, S., Gurd, B.	2017	To identify various factors involved in building resilient perishable product supply chains (PPSCs)	Research Paper	30 in-depth semi-structured interviews	Case study	proactive elements (business certifications, globalization, vertical integration, training and development, quality management) reactive elements (responsiveness to customer needs, responsiveness to competitors strategies, multi-sourcing, public - private collaboration)	Australia
Behzadi, G., Justin M., Olsen, T., Scrimgeour, F., Zhang, A.	2017	To investigate the effectiveness of both robust and resilience strategies to manage the impact of harvest time and yield disruptions	Research Paper	Zespri's kiwifruit supply chain	Mathematical Model/ Case study	robust and resilient strategies	New Zealand

Lim-Camachoa, L., Plagányi, L., Crimp, S., Hodgkinson, J., Hobday, A., Howden, S., Loechelf, B.	2017	To examine the structure of resource-based supply chains on the ability to withstand climate shocks	Research Paper	three Australian primary resource sectors (fisheries, agriculture, and mining)	Mathematical Model/ Comparative case Study	changing climate	Australia
Jain, V., Kumar, S., Soni, U., Chandra, C.	2017	To develop a hierarchy-based model for supply chain resilience	Research Paper	103 experts from Indians firms	Survey (secondary data from Soni et al., 2014)	adaptive capability, collaboration among players, trust among players, sustainability in supply chain, risk and revenue sharing, information sharing, supply chain structure, market sensitiveness, supply chain agility, supply chain visibility, risk management culture, minimizing uncertainty, technological capability among partners	India
Chowdhury, M.M.H., Quaddus, M.	2017	To develop a measurement instrument for supply chain resilience	Research Paper	Apparel industry in Bangladesh (15 in-depth interviews with supply chain decision makers in apparel manufacturing), 296 survey respondents from garment manufacturers, accessory producers and buying agents	Filed study and survey	Proactive capability, reactive capability and supply chain design quality	Bangladesh

Rajesh, R.	2017	To examine the role of technological capabilities in supply chain resilience	Research Paper	Indian electronic manufacturing industry	Case Study	Supply chain design, level of standardization, agile, supply flexibility, collaborative, postponement, enhancement, inventory, product rollover, pricing, planning,	India
Brusset, X., Teller, C.	2017	To provide insights for achieving resilience by mapping the relationships between the practices, resources, and processes over mangers controls	Research Paper	171 supply chain mangers	survey	Flexibility, external, and integration capabilities	France
Cheng, J.-H., Lu, K.-L.	2017	To examine the operating frontier, trajectory, and absorptive capability with proactive and reactive dimension of supply chain resilience	Research Paper	297 senior managers of Taiwanese manufacturing firms	survey	proactive and reactive dimensions	Taiwan
López, C., Ishizaka, A.	2017	To assess the impact of outsourcing practices on the supply chain resilience capabilities	Case Study	Single and explanatory	Case Study	flexibility, redundancy, collaboration, visibility, multiple sourcing, and management process (communication, co-operation and integration)	Not Specified
Ali, A., Mahfouz, A., Arisha, A.	2017	To make conceptual and empirical comparisons among SCRES definition, essential elements, and managerial practices, and present a concept mapping framework to seek conceptual clarity.	Literature review	103 peer reviewed journal articles (2000 to 2015)	Systematic literature review	Supply chain network design (SC configuration), flexibility, redundancy, visibility, collaboration, agility, anticipation, IT capability, robustness, supply chain risk management culture, security, knowledge management, contingency plan, velocity, coordination, integration, adaptability, market position, risk control (transfer of risk, revenue sharing), alignment, financial strength, public-private partnership, efficiency, trust, building social capital, increasing innovation, sustainability	General/ Not Specified

Mandal, S.	2017	To explore four types of organizational culture (development, group, rational, and hierarchical) on healthcare supply chain resilience, along with the moderated role of technology orientation	Research Paper	276 respondents from seven domain entities (hotels, hospital, chemistry and pharmaceutical, marketing public relations promotion, medical equipment manufacturing and surgical suppliers)	Survey	collaboration (information sharing and trust) and operational integration	India
Tukamuhabwa, B., Stevenson, M., Busby, J.	2017	To investigate the supply chain resilience in developing country (Uganda) context	Research Paper	45 interviews from 20 manufacturing firms in Uganda	Case study and Semi-Interview	Proactive strategies and reactive strategies	Uganda
Datta, P.	2017	To evaluate the accuracy of the knowledge exist in the literature on supply chain resilience and identify the possible practices adopted for securing resilience in uncertain event.	Literature review	84 Conceptual and empirical studies (1996-2016)	Systematic literature review	Supply chain risk management, agility, supply chain collaboration, supply chain understanding	General/ Not Specified
Liu, F., Song, J.-S., Tong, J.D.	2016	To address the importance of stockpiling inventory on building the supply chain resilience and	Research Paper	limiting behaviors and numerical examples	Mathematical Model	stockpiling inventory	Not Specified

Lam, J.S.L., Bai, X.	2016	To develop an original quality function deployment approach to enhance maritime supply chain resilience	Research Paper	3 container liner companies	structured interview (using questionnaire)	collaboration, flexibility and visibility, and redundancy	Singapore
Purvis, L., Spall, S., Naim, M., Spiegler, V.	2016	To explore one company's approach to translating management theories into a practical tool for the design, development and implementation of a supply chain resilience strategy.	Research Paper	One company (Innocent Ltd., is a United Kingdom-based specialist premium drink producer)	An in-depth qualitative single case	robustness, agility, redundancy, leanness and flexibility	UK
Kamalahmadi, M., Parast, M.M.	2016	To investigate the research development in supply chain resilience	Literature review	100 Publications (2000-2015)	Literature Survey review	supply chain reengineering, redundancy, flexibility collaboration, information sharing, trust, visibility, agility, velocity, supply chain risk management culture, leadership and innovation	General/Not Specified
Pournader, M., Rotaru, K., Kach, A.P., Razavi Hajiagha, S.H.	2016	To develop an assessment analytical model for resilience surrounding supply chain risks at two level supply chain system and individual tiers	Research Paper	150 middle and top level managers from 9 industry sectors in Iran	Survey	Three formative properties (readiness, responsiveness and recovery)	Iran
Chowdhury, M.M.H., Quaddus, M.	2016	To validity the measurement of supply chain resilience	Research Paper	Apparel industry in Bangladesh (15 in-depth interviews with supply chain decision makers in apparel manufacturin	Filed study and Survey	Flexibility, visibility, backup capacity, response, recovery, and collaboration	Bangladesh

				g), 272 survey respondents			
Ambulkar, S., Blackhurst, J., Grawe, S.	2015	To examine the factors that contribute to the development of firm resilience to supply chain disruptions	Research Paper	119 respondents	Survey	readiness, response and recovery	Not Specified
Chowdhury, M.M.H., Quaddus, M.A.	2015	To develop efficient resilience capabilities of Large Readymade Garment (RMG) supply chain of Bangladesh to mitigate organizations vulnerabilities	Research Paper	3 studies (apparel manufacturer, leading manufacturer, family business)	Mathematical Model/ case study	Flexibility, reserve/backup capacity, integration, efficiency, customer satisfaction & market position, financial strength	Bangladesh
Cardoso, S.R., Paula Barbosa-Póvoa, A., Relvas, S., Novais, A.Q.	2015	To explore the main characteristics a decision maker consider when design and planning resilience supply chains	Case Study	Five European supply chain	Case Study	flexibility and redundancy	Europe
Yang, Y., Xu, X.	2015	To investigate the optimal solution for the contingency tactics when facing a shortage due to natural disasters	Case Study	Rice supply chain in China	Case Study	grain supply chain resilience	China
Scholten, K., Schilder, S.	2015	T explore the influence of collaboration in supply chain resilience	Case Study	2 case studies and 16 semi-structured interviews	Case Study (with face to face interviews) and semi	flexibility, velocity, visibility and collaboration.	Netherland
Tukamuhabwa, B.R., Stevenson, M., Busby, J., Zorzini, M.	2015	To present a timely review of the available literature on SCRES based on a three stage systematic search	Literature Review	91 articles	Systematic Literature review	Flexibility, Creating redundancy, Supply chain collaboration, Supply chain agility	General/ Not specified

Munoz, A., Dunbar, M.	2015	To quantify operational supply chain resilience using a multidimensional, multi-tier me	Research Paper	manufacturing supply chain with three supply chain tiers (a manufacturer, a retailer and a customer)	Mathematical Model\experiment design	response and recovery	General/ Not specified
Gölgeci, I., Ponomarov, S.Y.	2015	To exploring the relationship between firm innovativeness and supply chain resilience	Research Paper	104 responses to the survey	survey	readiness, response and recovery	US and Europe
Jesus S., M., Koufteros, X., Hohenstein, N.-O., Feise, E., Hartmann, E., Giunipero, L.	2015	To assess the available evidence on supply chain resilience	Literature Review	67 peer reviewed articles (2003 to 2013)	Systematic Literature review	Flexibility, Redundancy, Collaboration, visibility, Agility, multiple sourcing, Capacity, Culture, inventory, Information sharing	General/ Not specified
Gunasekaran, A., Subramanian, N., Rahman, S.	2015	To draw a direct conclusions as to the various aspect of global sourcing (GS) strategies rather than report the trends and implication, global sourcing strategies in terms of complexity theory, and global sourcing strategies with supply chain resilience	Literature review	8 paper accepted from 29 papers	General Review (Special Papers)	Flexibility, Speed and responsiveness, Efficiency, Stages to manage complexities with respect to GS strategies	General/ Not specified
Urciuoli, L., Mohanty, S., Hintsa, J., Boekesteijn, E.G.	2014	To enhance the understanding in energy supply chain build resilience against exogenous security threats and the mechanisms improve the European Union	Case Study	5 case study from multiple sources on oil and gas supply chain to Europe	Case Study	Information sharing and Flexibility	Europe

Scholten, K., Scott, P.S., Fynes, B.	2014	To investigate the interdependencies between the strategic concept of supply chain resilience and the operational practitioner for management process	Case Study	Local VOAD group in EI Paso, Texas (9 interview and observation 15 member in the meeting, archival sources strategy documents)	Case Study (interview and observation, and archival sources)	collaboration	US
Pereira, C.R., Christopher, M., Lago Da Silva, A.	2014	To understand the role of procurement in identifying and managing the intra- and inter- organizational issues which impact supply chain resilience	Literature review	30 selected papers (2000-2013)	Systematic literature review	Flexibility, Redundancy, Visibility, Agility, Collaboration, Integration, Information Sharing, Financial Strength, Coordination and Control, Trust, Supply chain design, Risk Management, Company's Knowledge, Alignment, Velocity and Acceleration	General/ Not specified
Brandon-Jones, E., Squire, B., Autry, C.W., Petersen, K.J.	2014	To examine the relationships between supply chain resources (connectivity and information sharing), supply chain capability (visibility), and supply chain performance supply chain resilience and robustness	Research Paper	264 UK manufacturing plants	Survey	Visibility	UK

Golgeci, I., Ponomarov, S.Y.	2013	To investigate the relationship between firm's innovation, innovation magnitude, disruption severity, and supply chain resilience	Research Paper	114 respondents from experienced executive and full time managers in US and European firms	Scenario-based experimental and Survey	Dynamics capabilities	US and Europe
Wieland, A., Wallenburg, C.M.	2013	To explore the resilience domain (agility and robustness) and it relationships with supply chain customer value	Research Paper	270 respondents from manufacturing firms in Germany, Austria, and Switzerland	Survey	agility and robustness	Germany, Austria, and Switzerland
Johnson, N., Elliott, D., Drake, P.	2013	To examine the influence of inter organizational relationships and the social capital in building supply chain resilience	Research Paper	3 separate tiers of supply chain	Case study, interview and documentary evidence, and secondary data	Four formative capabilities (flexibility, velocity, visibility, and collaboration)	UK
Pettit, T.J., Croxton, K.L., Fiksel, J.	2013	To develop a measurement tools (supply chain resilience assessment and management)	Research Paper	7 global manufacturing and service firms and 1369 empirical items from focus group	Survey and focus groups	Flexibility in sourcing, flexibility in order fulfillment, capacity, efficiency, visibility, adaptability, anticipation, recovery, dispersion, collaboration, market position, security, and financial strength	US

Ishfaq, R.	2012	To evaluate the effect of multiple modes of transportation on the flexibility and efficiency of logistics operations, with considerations for natural or accidental disruptions	Research Paper	US transportation networks	Mathematical Model\case study	flexibility	US
Khan, O., Christopher, M., Creazza, A.	2012	To investigate the alignment between product design and supply chain, as well as it impact on firm's supply chain responsiveness and resilience	Research Paper	UK fashion retailers (FashionCo)	Case Study	product design	UK
Jüttner, U., Maklan, S.	2011	To explore the relationship between supply chain resilience and supply chain vulnerability, as well as supply chain risk management	Research Paper	First: 3 companies and their downstream and upstream supply chain process Second: interview and secondary data	Longitudinal case study (2007-2009)	Flexibility, visibility, velocity and collaboration	Europe
Colicchia, C., Dallari, F., Melacini, M.	2010	To study supply chain resilience with reference to the global sourcing process, focusing on one of the main sources of vulnerability studied in the literature: supply lead time (SLT) variability.	Research Paper	supply process of a home appliance retailer, based in Northern Italy	Mathematical Model	supply lead time (SLT) variability	Italy

Pettit, T., Fiksel, J., Croxton, K.	2010	To create a conceptual framework for evaluating and improving supply chain resilience	Literature review	8 separated focus group over two months with two to four members. Open discussion of members recent experiences with supply chain disruptions. 50 examples of vulnerabilities and 96 specific capabilities	lessons learned from supply chain disruptions	Flexibility in sourcing, flexibility in order fulfillment, capacity, efficiency, visibility, adaptability, anticipation, recovery, dispersion, collaboration, organization, market position, security, and financial strength	General/Not Specified
Ponomarov, S.Y., Holcomb, M.C.	2009	To address the knowledge gap through a multidisciplinary review of the different perspectives to identify current gaps in the supply chain resilience literature	Research Paper	Not Specified	Integrative Literature Review	Agility, responsiveness, Visibility, Flexibility/redundancy, Structure and knowledge, Reduction of uncertainty, complexity, reengineering, Collaboration, Integration, operational capabilities, transparency	General/Not Specified

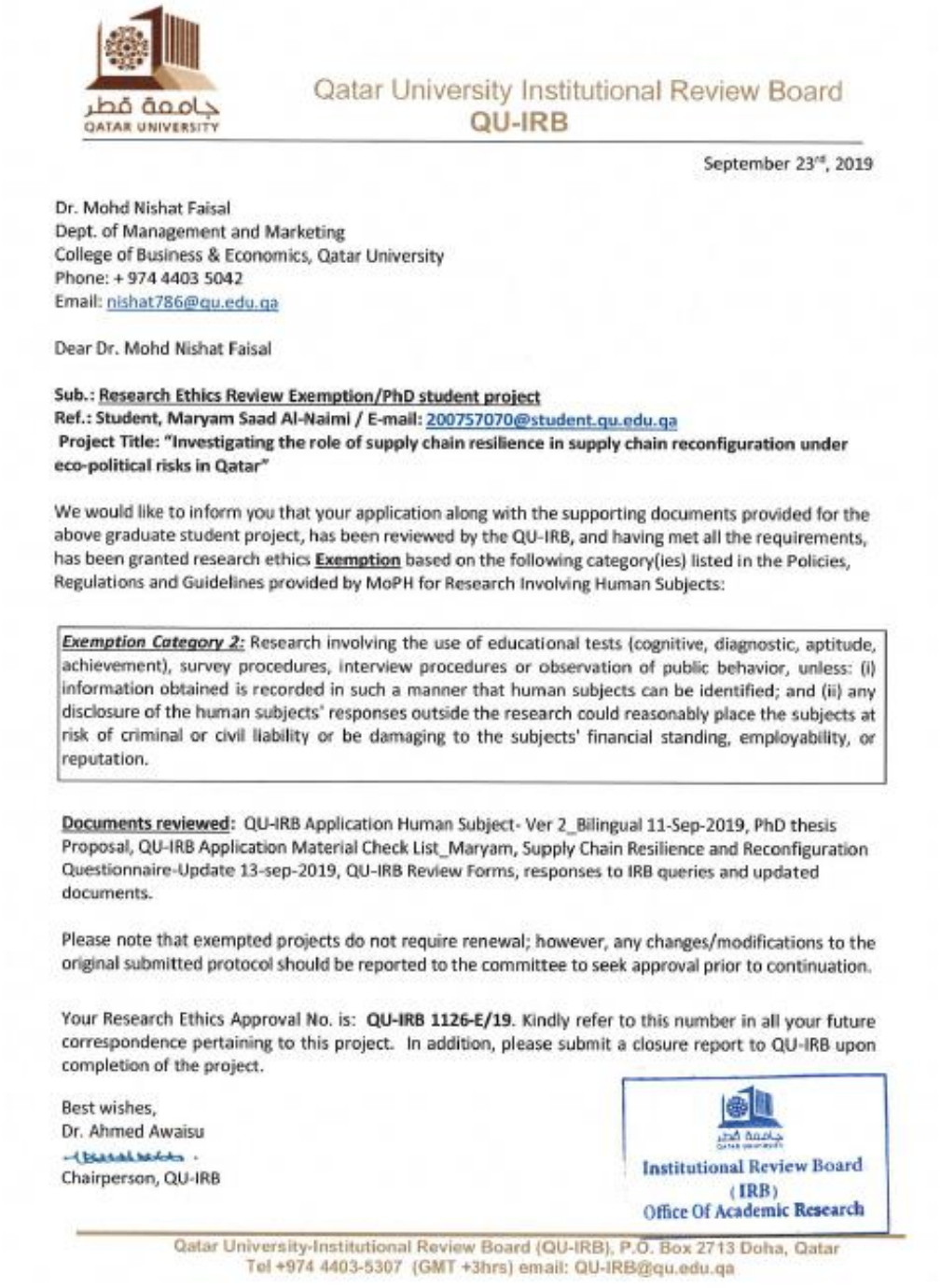
Appendix B: Supply Chain Reconfiguration Studies

Authors Names	Year	Aim	Type of Study	Population/Sample	Methodology	Reconfiguration Attributes	Geographical Region
Guo, W., Tian, Q., Jiang, Z., Wang, H.	2018	To develop reconfiguration strategies for supply chain systems for manufacturing enterprises systems	Research Paper	Case study of two scenarios	Mathematical Model (A graph-based cost model)	reconfiguration cost	Not specified
Rezaee, A., Dehghanian, F., Fahimnia, B., Beamon, B.	2017	To design a green supply chain in a carbon trading environment	Research Paper	Case study of three product types of five different states	Mathematical Model (two-stage stochastic model)	ABC reconfiguration Budget	Australia
Dev, N.K., Shankar, R., Gunasekaran, A., Thakur, L.S.	2016	To determine adaptive decisions of operational units of a mobile phone supply chain (DSS)	Research Paper	Case study of mobile phone manufacturing industry	Mathematical Model (Agent-Based simulation and decision tree learning)	supply chain structure, Inventory enablers and Information sharing mechanism	USA
Sasson, A., Johnson, J.C.	2016	To introduce an alternative where DDM coexists with and complements traditional mass production	Conceptual Paper	DDM rollout scenario			Not specified
Navin K. Dev, Ravi Shankar, Prasanta Kumar Dey	2014	To Identify the key operational enablers to be use by the practitioner while reconfiguring the supply chain network.	Research Paper	three distinct sub-operations (3 supplier, 1 manufacture, 2 warehouses, and 4 retailer)	Interpretive structural modeling approach (ISM)	information sharing, review period, lead time, lead time standard, deviation, inventory control policy, supply chain structure, and demand	Not specified
R. Hammami, Y. Frein	2014	To develop a profit maximization optimization model to redesign of global supply chains while integrating transfer pricing	Research Paper	two transfer pricing methods	Mathematical Model	Location\relocation of activities, capacity planning, selection of external suppliers, transfer pricing	Not specified

Wilhelm, W., Han, X., Lee, C.	2013	To test the solvability of different model forms to explore the dynamic facility location within a multi-period, multi-product, multi-echelon supply chain network by using different scenarios.	Research Paper	Experiment of two scenarios	Mathematical Model (traditional MIP (DSCR-T) and network based model (DSCR-N)	facility location, dynamic facility location, supply chain design, and production - distribution network design	USA
Kristianto, Y., Gunasekaran, A., Helo, P., Sandhu, M.	2012	To Improve the level of integration in inventory allocation and manufacturing process by incorporating manufacturing and product design into logistic design	Research Paper	Six part frames of office chair	Mathematical Model (Genetic Algorithms - Decision Support System and A system dynamic based computer simulation model)	Assembly planning, Demand planning, Inventory allocation	Not specified
Niroomand, I., Kuzgunkaya, O., Bulgak, A.	2012	This paper aims to explore how a firm should optimally allocate its capacity investments among dedicated manufacturing systems (DMSs), flexible manufacturing systems (FMSs) and reconfigurable manufacturing systems (RMSs) considering the capacity evolution in ramp up period	Research Paper	3 Products	Mathematical Model (mix integer programming model)	Object function, product life cycle, reconfiguration time	Not specified
Steffen Kinkel	2012	To Investigate the change of production relocation and backshoring activities patterns	Research Paper	1,484 German manufacturing companies	European Manufacturing Survey	production relocation, backshoring	German
Van Hoek, R., Johnson, M., Godsell, J., Birtwistle, A.	2010	To draw a knowledge of supply chain management domain on change in different aspects such as technical, non-technical, social, and behavioral.	Research Paper	Three case study	Case Study (Longitudinal and quasi-longitudinal)	Change items: change path, change start point, change style, change target, change roles, change levels	UK and Netherlands (Europe)
Osman, H., Demirli, K.	2010	To Provide a solution for an aerospace company to change its outsourcing strategies in order to meet the expected demand increase and customer satisfaction requirements in terms of delivery dates and amounts	Research Paper	Two policy's	Mathematical Model (A Bilinear Goal Programming Model)	Supplier selection, Distribute materials, Capabilities Allocation	Not specified

Godsell, J., Birtwistle, A., van Hoek, R.	2010	To advance the supply chain reconfiguration literature on how mange major supply chain reconfiguration by reporting the experience of major supply chain reconfiguration program from BAT's	Research Paper	British American Tobacco industry	British American Tobacco's European Supply Chain Reconfiguration Programmer	Business alignment, copy paste" solution, management roles, manage change by fact, sacred cows, unfreeze-freeze unfreeze cycle, Sales and Operations planning, and key performance indicators (KPIs)	UK

Appendix C: Approval Exemption Letter



جامعة قطر
QATAR UNIVERSITY

Qatar University Institutional Review Board
QU-IRB

September 23rd, 2019

Dr. Mohd Nishat Faisal
Dept. of Management and Marketing
College of Business & Economics, Qatar University
Phone: + 974 4403 5042
Email: nishat786@qu.edu.qa

Dear Dr. Mohd Nishat Faisal

Sub.: Research Ethics Review Exemption/PhD student project
Ref.: Student, Maryam Saad Al-Naimi / E-mail: 200757070@student.qu.edu.qa
Project Title: "Investigating the role of supply chain resilience in supply chain reconfiguration under eco-political risks in Qatar"

We would like to inform you that your application along with the supporting documents provided for the above graduate student project, has been reviewed by the QU-IRB, and having met all the requirements, has been granted research ethics **Exemption** based on the following category(ies) listed in the Policies, Regulations and Guidelines provided by MoPH for Research Involving Human Subjects:

Exemption Category 2: Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Documents reviewed: QU-IRB Application Human Subject- Ver 2_Bilingual 11-Sep-2019, PhD thesis Proposal, QU-IRB Application Material Check List_Maryam, Supply Chain Resilience and Reconfiguration Questionnaire-Update 13-sep-2019, QU-IRB Review Forms, responses to IRB queries and updated documents.

Please note that exempted projects do not require renewal; however, any changes/modifications to the original submitted protocol should be reported to the committee to seek approval prior to continuation.

Your Research Ethics Approval No. is: **QU-IRB 1126-E/19**. Kindly refer to this number in all your future correspondence pertaining to this project. In addition, please submit a closure report to QU-IRB upon completion of the project.

Best wishes,
Dr. Ahmed Awaisu
Chairperson, QU-IRB

Institutional Review Board
(IRB)
Office Of Academic Research

Qatar University-Institutional Review Board (QU-IRB), P.O. Box 2713 Doha, Qatar
Tel +974 4403-5307 (GMT +3hrs) email: QU-IRB@qu.edu.qa

Appendix D: Previous Items Measuring Supply Chain Resilience and Reconfiguration

Appendix D1: *Supply Chain Resilience Measurement Items*

Authors\Years	Scope	Questions	Cronbach Alpha	Source
Ambulkar et al., (2015)	firm resilience to supply chain disruptions	we are able to cope with changes brought by the supply chain disruption	0.89	
		We are able to adapt to the supply chain disruption easily.	0.87	
		We are able to provide a quick response to the supply chain disruption	0.75	
		We are able to maintain high situational awareness at all times.	0.6	
Brandon-Jones et al., (2014)	Supply Chain Resilience and Robustness	Material flow would be quickly restored	0.89	
		It would not take long to recover normal operating performance	0.77	
		The supply chain would easily recover to its original state	0.79	
		Disruptions would be dealt with quickly	0.7	
Cheng and Lu (2017)	Proactive dimension	Operations between you and your partner are able to continue	0.63	Brandon-Jones Et al., (2014) Wieland and Wallenburg (2013)
		Your performance does not deviate significantly from your targets	0.71	
		The supply chain between you and your partner is still able to carry out its regular functions	0.69	
	Reactive dimension	You and your partner easily adapt to the supply chain disruption	0.73	
		You and your partner are able to provide a quick response to the supply chain disruption	0.82	
Golgeci and Ponomarove (2013)	firm innovativeness and supply chain disruptions and resilience	Our firm's supply chain is able to adequately respond to unexpected disruptions by quickly restoring its product flow	0.81	
		Our firm's supply chain can quickly return to its original state after being disrupted	0.83	
		Our firm's supply chain can move to a new, more desirable state after being disrupted	0.78	
		Our firm's supply chain is well prepared to deal with financial outcomes of supply chain disruptions	0.85	
		Our firm's supply chain has the ability to maintain a desired level of control over structure and function at the time of disruption	0.82	
		Our firm's supply chain has the ability to extract meaning and useful knowledge from disruptions and unexpected events	0.73	
Liu and Lee (2018)	integration, supply chain resilience and service performance	can cope with changes brought by the supply chain disruption	0.88	Ambulkar et al., (2015)
		can adapt to the supply chain disruption easily	0.9	
		can provide a quick response to the supply chain disruption	0.92	
		can maintain high situational awareness at all times	0.84	

Mandal et al., (2016)	Supply chain resilience (RES)	Our firm's supply chain is well prepared for unexpected events	0.7	Bruneau et al. (2003), Christopher and Peck (2004) and Sheffi and Rice (2005)
		Our firm's supply chain is able to adequately respond to unexpected disruptions by quickly restoring its product flow	0.72	
		Our firm's supply chain has the desired level of connectedness among its members during disruption	0.94	
		Our firm's supply chain has the ability to maintain control over structure and function during a disruption	0.82	

Appendix D2: *Supply Chain Resilience Enablers Measurement Items*

Authers\Years	**Scope**	**Enablers**	**Questions**	**Cronbach Alpha**	**Source**
Brandon-Jones et al., (2014)	Supply Chain Resilience and Robustness	Information Sharing	Our firm exchanges relevant information with suppliers	0.82	Cao and Zhang (2011)
			Our firm exchanges timely information with suppliers	0.85	
			Our firm exchanges accurate information with suppliers	0.74	
			Our firm exchanges complete information with suppliers	0.66	
			Our firm exchanges confidential information with suppliers	0.55	
		Visibility	Inventory levels are visible throughout the supply chain	0.89	Braunscheidel and Suresh (2009)
			Demand levels are visible throughout the supply chain	0.73	
Chowdhury and Quaddus (2016)		Flexibility	We have flexibility in production in terms of volume of order and production schedule	0.74	Duclos et al., (2005); Braunscheidel and Suresh (2009); Tomlin (2006); Gunasekaran et al.,(2008)
			We produce different types of products to meet customer requirements	0.81	
			We have multi-skilled workforce to continue production	0.68	
			We have contract flexibility such as partial order, partial payment, partial shipment etc	0.8	
			We have flexibility in distribution	0.82	
			We are capable of introducing new product		
Chowdhury and Quaddus (2017)		Redundancy	We have back up capacity for machinery, parts and logistical supports	0.7	Pettit et al. (2013)
			We have buffer stock for raw material	0.74	
			We have backup energy/utility source	0.71	
		Visibility	We share information with supply chain partners	0.68	Braunscheidel and Suresh (2009); Peck (2005); Blackhurst et al. (2005); Jüttner and Maklan (2011); Pettit et al. (2013)
			We track information of different operations	0.87	
			We have business intelligence to gather information	0.68	

		Collaboration	We have collaborative forecasting of demand with supply chain partners	0.73	Braunscheidel and Suresh (2009); Pettit et al. (2013)
			We have collaborative planning & decision making practice with the SC partners	0.82	
			We invest in our suppliers plant to collaborate operations	0.79	
		Disaster preparation	We arrange disaster readiness training for overcoming crisis	0.83	
			We have resources to get ready during crisis	0.77	
			We have contingency planning for mitigating disruptions	0.71	
		Response	We can respond quickly to disruptions	0.78	Sheffi and Rice (2005); Norrman and Jansson (2004); Boin and McConnell (2007)
			We have response team for mitigating crisis	0.69	
		Recovery	We have the ability to get recovery in short time	0.62	Sheffi and Rice (2005); Christopher and Peck (2004); Holling (1973); Dalziell and McManus (2004); Rose (2004); Dalziell and McManus (2004); Martin (2004); Vugrin et al. (2011)
			We have the ability to absorb huge loss	0.73	
			We can reduce impact of loss by our ability to handle crisis	0.81	
Liu et al., 2018	The relationship between supply chain resilience and firm performance	risk management culture	The company uses different means to encourage its employees to share their knowledge about risk management	0.85	(Christopher and Peck, 2004; Jüttner and Maklan, 2011; Johnson et al., 2013)
			The company has included the subject of risk management as an important topic in new personnel training.	0.9	
			The company provides training to its employees regarding the necessary measures to take in the event of a risk incident.	0.9	
			Ensuring the proper functioning of the supply chain is every employee's top priority.	0.74	
			Risk awareness is common in our company.	0.82	
			The company believes that ''risk management" and ''job performance" are equally important	0.84	
		Agility	The company is fairly sensitive to the opportunities and threats in the business environment	0.86	
			The company can rapidly respond to the changing market.	0.89	
			The company reserves extra service capacity in response to the rapidly changing market	0.78	

			One of the company's important criteria for finding collaborative partners is their agility and ability to react.	0.76	
		Integration	The company has adopted information systems (such as ERP) to assist in information sharing.	0.8	
			Information about the operations of different departments is shared effectively in the company.	0.76	
			The company's compensation and motivation mechanisms consist of factors that promote integration.	0.77	
			The company effectively shares information about its operation with our important suppliers and/or clients	0.85	
			The company's integration with the upstream and downstream supply chain members has increased the flexibility of its operation.	0.82	
			The company has successfully integrated the clients' and/or suppliers' operations via cross-company information platforms or related activities.	0.82	
			The company can integrate clients' innovative ideas to design new services	0.799	
		Supply chain Re-engineering	The company considers its risk management ability to be one of the important criteria in the process of choosing suppliers or strategic	0.74	
			The company already has the risk management mission statements or strategies in writing	0.87	
			The company already has specific departments or teams to deal with issues related to supply chain risk management.	0.92	
			The company has already included the item of risk management performance in personal KPIs.	0.84	
			The company has allocated more resources to deal with incidents related to supply chain risks.	0.87	
Mandal (2012)	Supply chain resilience	Supply chain design/Re-engineering	Supply chain strategies are balanced between cost and vulnerabilities	0.86	(Christopher Peck, 2004)
			Maintain optimum capacity	0.72	
			Maintain optimum inventory	0.79	
			Create a supply chain information infrastructure	0.68	
			Integrate business processes	0.55	
		Supply Chain Agility	Usage of many channels to detect and keep aware of changes in supply/demand	0.88	(Li et al., 2009; and Rouis, 2010)
			Reconfigure supply chain resources in a timely and flexible manner to respond to changes in supply/demand	0.83	
			Usage of many channels to detect and keep aware of changes in supply chain daily execution	0.77	

			Reconfigure supply chain resources in a timely and flexible manner to respond to changes in daily supply chain execution	0.57	
		Supply Chain Collaboration	Information sharing on price changes, supply disruptions, etc.	0.91	(Simatupang and Sridharan, 2004)
			Joint planning on promotional events, product assortment, etc.	0.89	
			Joint decision making on optimal order quantity, inventory requirements, etc.	0.73	
			Incentive availability to both suppliers and customers	0.75	
Mandal et al., (2016)	Supply chain resilience capability	Integrated logistics capabilities (ILC)	Our firm's logistics capabilities are suitably integrated at its supply chain level		
			Our firm's logistics activities are suitable integrated with suppliers' logistics activities	0.79	
			Our integrated supply chain logistics capabilities are characterized by excellent distribution, transportation, and/or warehousing facilities	0.88	
			Our inter-organizational logistic activities are closely coordinated	0.76	
		Supply chain collaboration (COLL)	Our firm works jointly with its key suppliers for achieving mutual goals		
			Our firm develops strategic objectives jointly with our supply chain partners	0.78	
			Our firm shares rewards and risks evenly with our supply chain partners	0.72	
			Our firm jointly works with its key supply chain members for mutual benefits	0.72	
		Supply chain visibility (VIS)	Our supply chain members have the information for monitoring and changing operations strategy	0.8	
			Our supply chain members have access to inventory, order status information for forecasting	0.85	
			Our supply chain members have the necessary information system for tracking goods	0.83	
		Supply chain flexibility (FLEX)	Our firm's supply chain can adjust supplier's order quantity to mitigate a disruption	0.82	
			Our firm's supply chain can adjust delivery time of supplier's order for mitigating a disruption	0.81	
			Our firm's supply chain can adjust production volume capacity in response to a disruption	0.88	
			Our firm's supply chain can adjust its delivery schedules for coping with disruptions		
		Supply chain velocity (VEL)	Our firm's supply chain can rapidly deal with threats in our environment	0.87	
			Our firm's supply chain can quickly respond to changes in the business environment	0.97	

			Our firm's supply chain can rapidly address opportunities in our environment	0.78	
Wieland and Wallenburg (2013)	Explore the resilience domain	Communication	We provide each other with any information that might help us	0.65	Chen et al., 2004
			Exchange of information takes place frequently and in a timely manner	0.83	
			We keep each other informed about events or changes that may affect the other party	0.75	
			We give each other feedback about our performance	0.7	
		Cooperation	No matter who is at fault, problems are joint responsibilities	0.65	Morris and Carter, 2005
			One party will not take unfair advantage of a strong bargaining position	0.75	
			We are willing to make cooperative changes	0.91	
			We do not mind owing each other favors	0.68	
		Integration	We have full access to joint planning systems	0.8	
			We synchronize our production plans	0.67	
			We carry out joint electronic data interchange	0.62	
			We have knowledge of inventory mix/levels	0.77	
		Agility	Adapt manufacturing leadtimes	0.63	Wieland and Wallenburg, 2012; Swafford et al., 2006
			Adapt level of customer service	0.82	
			Adapt delivery reliability	0.85	
			Adapt responsiveness to changing market needs	0.76	
		Robustness	For a long time, our supply chain retains the same stable situation as it had before changes occur	0.71	Wieland and Wallenburg, 2012
			When changes occur, our supply chain grants us much time to consider a reasonable reaction	0.73	
			Without adaptations being necessary, our supply chain performs well over a wide variety of possible scenarios	0.92	
			For a long time, our supply chain is able to carry out its functions despite some damage done to it	0.8	

Appendix D3: *Supply Chain Reconfiguration Measurement Items*

Authers\Years	Scope	Questions	Cronbach Alpha	Sources
Ambulkar et al., (2015)	Resource reconfiguration to supply chain disruptions	We realign our firm resources and processes in response to environmental changes.	0.62	
		We reconfigure our resources and processes in response to the dynamic environment	0.92	
		We restructure our resource base to react to the changing business environment.	0.74	
		We renew our resource base in response to the changing business environment	0.67	
Wei and Wang (2010)	Supply chain reconfigurability	We can successfully reconfigure supply chain resources to come up with new productive assets	0.94	Pavlou & El Sawy, 2006).
		We can effectively integrate and combine existing resources into novel combinations in this supply chain.	0.95	
		We are able to engage in resource recombinations to better match the product-market areas in this supply chain.	0.94	

Appendix E: Measurement Items (Survey)

Dear Respondent,

We would like to invite you to participate in this research study titled "Investigating the role of supply chain resilience in supply chain reconfiguration under eco-political risks in Qatar" and approved by QU-IRB board under the reference number QU-IRB 1126-E/19

The purpose of the study is to investigate the relationship between supply chain resilience and supply chain reconfiguration. This study involves surveying a random sample of 200 employees who have an experience in operations management and working in private, government, and semi-government in Qatar.

The survey should not take more than 10 minutes of your time. The information collected will be kept strictly confidential. Your participation is completely voluntary and anonymous, however this is entirely optional. You may withdraw from this study at any time.

For further information or concerns about the study, please contact Dr. Mohd Nishat Faisal, Associate Professor of Management at College of Business and Economic, Qatar University, Phone Number: 44035042, E-Mail: nishat786@qu.edu.qa, P.O. Box 2713, Doha, Qatar

Please indicate that you have read, understood and if you agree to participate. If you wish to participate, kindly click on Yes

Yes NO

Thank you for your valuable time.

A. General Questions:-

1. **Gender**
   - □ Male
   - □ Female

2. **Nationality**
   - □ Qatari
   - □ Non-Qatari

3. **Level of Education**
   - □ High School
   - □ Undergraduate Degree
   - □ Graduate Degree
   - □ Any Additional Qualification

4. **Age**
   - □ 25 – 35
   - □ 36 – 46
   - □ 47 – 57
   - □ 58 – or Above

5. **Years of Experience**
   - □ Less than 5 Years
   - □ 5 – 10
   - □ 11 – 15
   - □ 16 – 20
   - □ More than 20 Years

6. **Job Level**
   - □ General Manager
   - □ Procurement Staff/Manager
   - □ Operation Staff/Manager
   - □ Supply Chain Staff/Manager
   - □ Other, Please Specify …….

7. **Type of Organization**
   - □ Private
   - □ Government
   - □ Semi-Government

□ Other, Please Specify ……

A. Supply Chain Resilience:-

Supply chain disruptions are unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain (Craighead et al., 2007). Thus, the supply chain resilience is the ability of a system to return to its original state, within an acceptable period of time, after being disturbed (Christopher and Peck, 2004).

(Please answer each row.)	**Strongly Disagree**						**Strongly Agree**
	1	**2**	**3**	**4**	**5**	**6**	**7**
We are able to cope with changes brought by the supply chain disruption	□	□	□	□	□	□	□
We are able to adapt to the supply chain disruption easily	□	□	□	□	□	□	□
We are able to provide a quick response to the supply chain disruption	□	□	□	□	□	□	□
We are able to maintain high situational awareness at all times.	□	□	□	□	□	□	□
Our firm's supply chain is well prepared to deal with financial outcomes of supply chain disruptions	□	□	□	□	□	□	□
Our firm's supply chain can move to a new, more desirable state after being disrupted	□	□	□	□	□	□	□
Our firm's supply chain has the ability to maintain a desired level of control over structure and function at the time of disruption	□	□	□	□	□	□	□
Our firm's supply chain has the ability to extract meaning and useful knowledge from disruptions and unexpected events	□	□	□	□	□	□	□
The company uses different means to encourage its employees to share their knowledge about risk management	□	□	□	□	□	□	□
The company has included the subject of risk management as an important topic in new personnel training	□	□	□	□	□	□	□
The company provides training to its employees regarding the necessary measures to take in the event of a risk incident	□	□	□	□	□	□	□
Risk awareness is common in our company	□	□	□	□	□	□	□

The company is fairly sensitive to the opportunities and threats in the business environment	☐	☐	☐	☐	☐	☐	☐
The company can rapidly respond to the changing market	☐	☐	☐	☐	☐	☐	☐
Our supply chain members have the information for monitoring and changing operations strategy	☐	☐	☐	☐	☐	☐	☐
Our supply chain members have the necessary information system for tracking goods	☐	☐	☐	☐	☐	☐	☐
Our firm exchanges relevant information with suppliers	☐	☐	☐	☐	☐	☐	☐
Our firm exchanges timely information with suppliers	☐	☐	☐	☐	☐	☐	☐
Our firm exchanges accurate information with suppliers	☐	☐	☐	☐	☐	☐	☐
We have collaborative planning & decision making practice with the SC partners	☐	☐	☐	☐	☐	☐	☐
The company has adopted information systems (such as ERP) to assist in information sharing	☐	☐	☐	☐	☐	☐	☐
The company effectively shares information about its operation with our important suppliers and/or clients	☐	☐	☐	☐	☐	☐	☐
The company's integration with the upstream and downstream supply chain members has increased the flexibility of its operation	☐	☐	☐	☐	☐	☐	☐
The company has successfully integrated the clients' and/or suppliers' operations via cross-company information platforms or related activities	☐	☐	☐	☐	☐	☐	☐

B. Supply Chain Reconfiguration:-

Supply chain reconfiguration is the ability of a system to reshape the resources by business and operatives into new operational competencies (Storer et al., 2014).

(Please answer each row.)	**Strongly Disagree**						**Strongly Agree**
	1	**2**	**3**	**4**	**5**	**6**	**7**
We reconfigure our resources and processes in response to the dynamic environment	☐	☐	☐	☐	☐	☐	☐
We can successfully reconfigure supply chain resources to come up with new productive assets	☐	☐	☐	☐	☐	☐	☐

We can effectively integrate and combine existing resources into novel combinations in this supply chain	□	□	□	□	□	□	□
We are able to engage in resource recombination's to better match the product-market areas in this supply chain	□	□	□	□	□	□	□

The End