Causal Model and Analysis of International Garments Supply Chain Resilience with Partners in Germany, Pakistan and Turkey

Doctoral Thesis

Lehrstuhl Wirtschaftsinformatik

Wirtschafts- und Sozialwissenschaftliche Fakultät

Technische Universität Dortmund

in the fulfilment of

the requirements for the Degree of

'Doktor der Wirtschaftswissenschaften'

by

Muhammad Khushnood

from

Karak, Pakistan

Dortmund, Germany 2014

The Board of Examiners:	Prof. Dr. Richard Lackes
	JProf. Dr. Grigory Pishchulov
	Prof. Dr. Jack E. Wahl
Date of Oral Examination	October 29, 2014

Dedicated to

My Parents,

Taranum,

Hannia &

Bilal

Acknowledgements

This work in its final form is the result of independent research project funded by the Higher Education Commission (HEC) Pakistan through German Academic Exchange Service (DAAD) for a period of four years at the department of Business Information Management (Wirtschaftsinformatik) at the faculty of Business, Economics and Social Sciences (Wirtschafts- und Sozialwissenschaftlichen) Technical University (technische universität) Dortmund, Germany.

I am indebted to many people for their direct or indirect support and encouragement that made the completion of this research work successfully possible. I would like to gratefully acknowledge the HEC Pakistan for their financial support. I am thankful to DAAD for their unceasing supportive role throughout the study period. I am greatly thankful to Professor Dr. Richard Lackes for his supervision and guidance throughout the research. I am thankful to Junior Professor Dr. Grigory Pishchulov for his guidance and supervision. I am thankful to Professor Dr. Jack E. Wahl for his academic comments and suggestion on the topic. I would like to extend my thanks to Professor Dr. Peter Reusch for his unceasing support and guidance, during my studies in Dortmund, Germany.

I also owe thanks to the colleagues in the department of Business Information Management for their support. Special thanks to Dr. Markus Siepermann for is guidance and support. I thank Mr. Erik Frank, Mr. Stefan Springwald, Miss Esther Berndt, Mr. Tobias Anton, Miss Katharina Stehling, and all the colleagues for their support and motivation. I am also thankful to Miss Marion Nölle for guidance and support regarding matters related to administration.

I am thankful to Mr. Asif Sarwar, business owner of Aisf Sultan Trade Impex Sialkot, Pakistan for his help in data collection and providing logistics. I am also thankful to Mr. Kashif Raza, owner of garments business in Hagen Germany for his role in data collection from Turkish garments manufacturers ad German customers through personal contacts.

I am also thankful to my colleagues in Dortmund including Dr. Mudassar Razzaq, Dr. Shafqat Hussain, Dr. Rashid Mehmood, Dr. Kamran Usman, Dr. Masood Hussain and Dr. Shafaq Hussain for their academic and motivational support in Dortmund, Germany. Special thanks to my friend and colleagues in Pakistan including Dr. Zeeshan Khattak, Dr. Sammar Abbas and Dr. Bilal Shams for their encouragement to take academic career in management studies and throughout support later on.

Last but not the least, I would like to express my heartiest thanks to my family for their care, love and support during my studies. Special thanks to my wife Taranum for her kind support, understanding, patience and cooperation. I would extend special thanks to my children Hannia and Bilal for their presence that have been the constant source of energy and motivation.

Dortmund, November 9, 2014 Muhammad Khushnood

Abstract

Supply chain resilience is an approach that assesses the ability of supply chain processes to respond to disturbances and maintain its functioning. The approaches like supply chain risk management and supply chain vulnerability are proactive in nature and consider the probability of disruption that may occur and cause variance in functioning of supply chain process. The remedial measures are suggested and incorporated in supply chain process plan and even contingency measures are suggested in case of the unexpected changes. The concept of supply chain resilience, while considering the probability of disruption and sensitivity of the process, also takes into account the actual event of disruption. It even goes beyond this point and considers the effectiveness of adaptive capability of the firm that tends to the adverse effects of disruption. Adaptive capability determines whether a process, encountered by disruption, has finally overcome the adverse effects or is unable to recover and sustain disturbances. This, in turn, determines the functioning level maintained by process. The whole phenomena is termed as supply chain resilience - considering adaptive capability of the process, the probability of and sensitivity of process disruption and the sustained or achieved functioning level of the process.

The risk or vulnerability to disruption is determined by the organizational and environmental factors that affect supply chain process. The environmental factors are location dependent and are unique for different countries. Therefore, in order to evaluate the ability of supply chain process carried out in a location with unique condition, it is essential to have knowledge of the local environment factors and organizational structures. These are considered by managers while deciding location of facilities so as to reduced variability and ensure reliability. However, a main weakness of the approach is failure to capture the role of adaptive capability and retention of function or service level despite the volatile local conditions and organizational issues. The possibility of exploiting the competitive advantages is only decided upon the risk or vulnerability profile of a locality while the aspects of adaptive capability and ultimate functioning of supply chain process are overlooked. These aspects are included by the concept of resilience

presented in this study. The inherent complexities of supply chain resilience framework demands more insight into the processes through structural equation model and empirical analysis.

In this work, survey of international garments supply chain is conducted to test validity of the measurement model and structural model through structural equation modeling method. Measurement model is called outer model and structural model is called as inner model in Partial Least Square Structural Equation Modelling (PLS SEM) context[1]. As the methodology used in this study is PLS SEM, respective terminology will be used henceforth. Validity of the formative outer model is tested through defined criteria. Mediation, interaction moderation, and multi-group moderation techniques are used to test the influence of adaptive capability and disruption vulnerability on supply chain processes and in turn on overall resilience of the supply chain that influences supply chain risk costs. Open system approach was adapted to supply chain process that transforms, through a purposeful designed structure, the input that is sourced from environment into required output. The input for garment manufacturing process is raw material, workers, machines and utilities and for transportation process are freight forwarding services, transportation infrastructure, and administrative procedures and shipping modes. The output of manufacturing is to produce required quantity of garments with specified quality and the transportation ensures the delivery of the produced garments to customers within the quality and quantity demand. The on time manufacturing and transportation measures the overall resilience of supply chain that is influenced by manufacturing and transportation resilience. The budgeted cost measures the conformity to cost limits planned for manufacturing and transportation process that are influenced by the overall resilience of supply chain. Unexpected changes in the environment and supply chain structure cause variations in the quality, quantity, time, and cost limits due to disturbances in process input and operations. The availability, accessibility and reliability of these inputs and later on the operations are determined by the local

[1] Hair, Ringle, & and Sarstedt, 2011, p. 141

conditions as well as the supply chain entity structure. In this study, cross cultural comparative survey is designed to study garments manufacturing process in Pakistan and Turkey and the subsequent transportation process in Pakistan, Turkey, and Germany with unique country conditions.

The most significant contribution is that the role of adaptive capability of supply chain process is observed with more of proactive rather than the often considered reactive nature. The use of adaptive capability results as a response to disruptions for the first time as a reactive strategy and then it is followed as a proactive strategy until the occurrences continues. In the absence of disturbances, the use of adaptive capability is redundant. Again the frequent usage of adaptive capability by supply chain process is indicative that the conditions are very volatile. However the presence of adaptive capability does not let the effect to penetrate and sustain the effects of disruption. Organizations with meager resources have not enough adaptive capability that even by using all of its resources the level of disturbances remains high. The effect of disruption vulnerability, caused by either internal or external causes, negatively affects resilience but the introduction of adaptive capability leads to a complex relationship among disruption vulnerability, adaptive capability and the dependent variable of resilience. The occurrences of disruptions may be very frequent but the effect may not cause such frequent disturbances due to use of alternate sources, resources and measures. In practice, the prevailing approach to adaptive capacity is proactive that later on turns out to be reactive as shown in Figure 5. This study considers the practical approach because of the fact that the survey of the garments manufacturers and freight shippers had practical orientations.

An important contribution of this study is the outer and inner models that are developed for to measure the concept of supply chain resilience and test empirically the constructs. Lackes et al. has developed optimization model for when and which alternate methods are to be used to handle the variances in the plan of supply chain process[2]. The impact of country conditions on supply chain processes

[2] Lackes, Siepermann, & Khushnood, 2012, pp. 398-408

are demonstrated and measured through disturbances in the process input. The assumption is that natural and human induced disasters and accidents affect the input to supply chain process including natural, human, technological and infrastructural resources. The other contribution of this work, presented in the descriptives part, is the evidence that supply chain resilience in countries with high risk or vulnerability profile is at par with those in low risk or vulnerability profile that shows that adaptive capability is important determining factor of the process function or service level with the objective to accomplish the objectives.

A major contribution of this work is the development of outer model to capture the concept of supply chain resilience for garments supply chain processes across different countries with unique conditions. The outer model is validated by empirical data by methods researchers. The causal model of the supply chain processes is realized through inner model. Causal model for supply chain resilience, to the best of my knowledge, has been used for the first time. The results of the causal analysis shows that supply chain process input is prone to disturbances in location with high risk or vulnerability profile. The adaptive capability first reactive, in role of dependent variable, turns into proactive approach where it adapts the role of moderator and mediator that influences the actual occurrence of disturbances in the input and operations of supply chain processes. This leads to renewed relationship that is the high the adaptive capability, the lower shall be the disturbances in the input to the supply chain process. The instance of such facilities that experience high occurrence of disturbances despite using adaptive capacity to the full are those with meager resources that does help to respond effectively to disruptions that affect the supply chain process. This suggests that it is the adaptive capability that influences the functioning level of the supply chain process performed by supply chain partner facility located in location with unique conditions. The outer and inner models are validated and overall the results are in good agreement with the theoretical model and empirical data.

Table of Contents

Table of Figures

Table of Tables

List of Abbreviations

APTMA	All Pakistan Textile Mills Association
C&A	Clements and August
CB	Covariance Based
DMAIC	Define, Measure, Analyze, Improve and Control
EU	European Union
GDP	Gross domestic product
H&M	Hennes & Mauritz
IBM	International Business Machine
MAC	Manufacturing Adaptive Capability
MDV	Manufacturing Disruption Vulnerability
MR	Manufacturing Resilience
PCGA	Pakistan Cotton and Ginning Association
PHMA	Pakistan Hosiery Manufacturers Association
PLS	Partial Least Squares
PRGMEA	Pakistan Readymade Garments Manufacturers & Exporters Association
SC	Supply Cain
SCGR	Supply Chain Global Resilience
SCRC	Supply Chain Risk Costs
SEM	Structural Equation Modeling
Smart PLS	Smart Partial Least Square
SPSS	Statistical Package for Social Sciences
TCMA	Turkish Clothing Manufacturers' Association
UK	United Kingdom
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
UNISDR	United Nations International Strategy for Disaster Reduction
US	United States
USDA	United States Department of Agriculture

VIF	Variance of Inflation Factor
WTO	World Trade Organization

1 Introduction to the Research

International supply chain offers opportunity to avail the resources of countries with abundant endowment factors, low cost raw material, human resource and factors of production including utilities, infrastructure, industry and market. The incentives for deciding on facility location includes tax rates, tax free zones, duty free exports and imports, weak currencies and environmental relaxations[3].The current trend in sourcing of clothing by big brands, wholesalers and retailers is from the developing countries with low cost raw material, labor and other factors of production[4].

International supply chain has also inherent risk that may affect the operations of the processes. Countries have unique attributes that determine the conditions of natural, human, infrastructural, political, economic and social environments. The ever changing environment or its sub dimensions pose risk of disturbances besides the opportunities. Vulnerability to natural disasters, such as floods, earthquakes or human caused disasters, is distributed across the countries of the globe without any pattern. It does not differentiate between developed or developing or less developed countries. However, adaptive capability, defined by country condition and situation supply chain, of a country determines the ability of supply chain entity to resist, sustain, absorb, adapt or eliminate to disruptions. For example floods affect the cotton crops and the resources of the irrigation department would determine whether the damage is either prevented or alternate water courses were used to ward off the flood. The same is true for supply chain business partnering facilities carrying out one or the other supply chain processes like procurement of raw material, manufacturing of component parts or products and transportation between centers and stages. These process may be highly vulnerable to disturbances in a location with volatile environment, the ultimate function of the process will depend on the adaptive capability that enables the business

[3] Ferdows, 1997, p. 73

[4] Hussain, Figueiredo, & Ferreira, 2009, p. 12

facility to respond to disruptions. In this work, international supply chains have been studied to investigate the conflicting relationship of adaptive capability and vulnerability with functioning of the supply chain. It is also to explore whether country specific conditions are the sole determinant of supply chain process resilience or it is rather the adaptive capability of supply chain process that enables it to respond to disruption and maintain required functioning. The example of garment manufacturers and exporters in Pakistan and Turkey are studied to find the relationship between manufacturing process resilience and unique country conditions. Similarly, transportation form garment manufacturers in Pakistan and Turkey to garment customers in Germany is surveyed to explore the relationship between transportation process resilience and specific conditions of the country.

1.1 Background and Context of the Research

Like all systems - individual, organizational, social, political, economic, physical and natural- supply chain facilities relies on other systems for input to raise and maintain the structure and also sustain the operations[5]. At the same time, these are all exposed to risks of disruptive events from within as well as outside the system[6] that interrupt the normal flow of goods, services and information within the Supply chain partner facility or across the supply chain. The conditions of these systems are unique to locations and thus countries have been classified as developed, developing and less developed in terms of infrastructure by The World Bank[7]. Reliability is the major concern of supply chain organizations and location related factors are identified and assessed both for opportunity and risks while deciding on establishing a facility, contracting a franchise, merger and acquisition, outsourcing or sourcing from suppliers. The primary concern of the managers is the reliability of supply chain. While the disruptive events are unexpected and free of time and space, ideal situation of no disruptions cannot be real.

---

[5] Von Bertalanffy, 1972, p. 414

[6] Christopher & Peck, 2004, p. 3

[7] The World Bank, 2013, p. Country Ranking

Therefore, the concept of living by disruption is suggested by researchers and practitioners through strategies of operational buffers[8], proactive mitigation[9] measures and reactive contingency[10] actions. Christopher defines resilience as the ability of the system to regain the pre-disturbance state or even achieve improved state after struck by disturbance[11]. Resilience is the property of the surrounding systems as well as supply chain firm itself to respond to turbulence and discontinuities. For example if a location has large number of raw material suppliers, the ability of the supply chain firm to respond to variations is greater than in a location with few suppliers. However, availing alternate modes of operation is determined not only by availability and possibility but also by the firm's capability to switch and that is to be managed within minimum time and cost.

Country indices on human, infrastructural, social, political, economic and natural conditions are well developed by reputed organizations and individuals like UNDP, The World Bank, The Heritage Foundation, and UNISDR. Pakistan, Germany and Turkey belong to different categories based on cultural and natural conditions. Germany is among the developed countries while Pakistan and Turkey are placed in the category of developing countries. For the period 2008-2012, on average the annual percentage growth rate in gross domestic production are 2.384, 0.704, and 4.624 for Germany, Pakistan and Turkey respectively[12]. The trade, economy and income indices for Germany, Pakistan and Turkey are 0.867,

---

[8] Chopra & Sodhi (2004, p. 55) suggested mitigation strategies for example adding capacity, inventory and increasing suppliers to cope with risk of disruptions. However, Giunipero & Eltantawy, (2004, p. 699) observed the movement from risk buffering to risk management as the later approach is a continuous process that needs appropriate coping measures against every emerging situation. He pointed out that traditional buffering is a static approach with fixed measures that is not sufficient and efficient.

[9] Peck, et al. (2003, p. 45) Peck et al. suggested mitigation measures that are taken against risks on the basis of SC-process analysis to reduce the occurrences of disruptions. The approach is continual and handles risk on individual basis considering the probability and severity.

[10] Hiles and Barnes (2007, p. xxiii) mention alternative modes to continue the operation of processes that are influenced by a disruptive event and pose a potential loss to the SC-facility or supply chain as a whole.

[11] Christopher & Peck, 2004, p. 2

[12] The World Bank, 2013, p. World Development Indicators

0.479 and 0.726 and human development indices are ranked at 5th, 146th and 90th respectively[13]. The infrastructure is sufficiently developed for Germany, inadequately developed for Pakistan and moderately developed for Turkey including means of transportation, water resources, and electricity supply and information technology[14]. While the vulnerability profiles of Germany and Turkey are comparatively low, Pakistan has been ranked with high risk or vulnerability profile due to war and political instability in the region for decades. The ongoing war against terrorism since 2001, the earthquake in 2005 and the flood in 2010 have negatively affected the conditions and resulted in extensive losses in terms of human and economy[15]. The neighboring wars, political instability, insufficient state institutions has left the country with huge human and property losses, insecurity of life and business, increased business risks, frequent cases of extortion, shift of investment, limited mobility, lack of basic utilities like power, water and transport and even the lack of mental peace and harmony among the masses of the country[16]. In comparison to Germany and Turkey, the frequency of human induced disruption acts, natural disasters and accidents are high including attacks, strikes, fires, accidents, floods, droughts, and earthquakes, landslides causing damages to human, cultivation and physical infrastructure.

Like other developing countries, for Pakistan and Turkey the textile value chain has shown growth since the establishing of WTO in 1995 that left off the textile export quotas. On the contrary, Germany being an industrialized country, sources the textile products from developing countries like China, Bangladesh, India, Pakistan and Turkey to name some of the countries. Textile industry is a major contributor in the economy of developing countries. The contribution by textile

---

[13] UNDP, 2012, p. Human Development Index Ranking

[14] The World Bank, 2013, p. World Development Indicators

[15] Pakistan Economic Survey, 2012-2013, p. i

[16] Pakistan Economic Survey, 2012-2013, p. i

and clothing sectors are 8.5 percent[17] and 6.5 percent[18] in the GDP of Pakistan and Turkey respectively. Pakistan is the fourth and Turkey is the eighth leading grower of cotton in world. However, both the countries do not register among the leading exporters of cotton for the reason that they are also leading consumers of cotton after china and India. Rather, Pakistan and Turkey import cotton to meet their consumption requirements. Pakistan and Turkey have reported among the top five countries in cotton yarn production[19] and among top ten countries in the export of both textile and clothing[20].

Due to the stated volatile conditions in developing countries, supply chain partners are perceived as unreliable due to constant exposure to disruptive events. Most of the big brands, wholesalers and retailers like Nike, Adidas, H&M, and C&A are based in industrialized countries. The major concern of these garments chains is the reliability of the suppliers. The perceptions of developing countries are based on the frequency of negative occurrences, labor conditions, working environment, environmental and other indices. Potential competitive supply sources are overlooked due to notoriously risky environment of developing countries. There are other considerations to be made for example the performance of specific sector, the resilience of the input to the process, required infrastructure of the sector in general and of supplier in particular. A location with clothing value chain having large number of cotton growers, ginneries, weaving mills, processing mills, clothing manufacturers ensure availability of alternatives during disruptions at any level of the chain. However equally important is the ability of the firm to utilize the alternative to reduce occurrences of potential disruption losses by carrying on the operations at required functioning level. Supply from countries with volatile conditions may be as reliable as elsewhere because of the

[17] Pakistan Textile Journal, 2012, p. 1

[18] Turkey Clothing, 2013, p. 2

[19] International Cotton Advisory Committee, 2013, p. 2

[20] World Trade Organization, 2014, p. Databases

resilience of a facility is based on the external opportunities and internal abilities to avail alternate mode of operations in the face of negative events.

This study presents an approach assuming that supply chain resilience is the result of interplay between disruption vulnerability and adaptive capability of a firm. In order to assess these relationships, three analytical dimensions are proposed that are not incorporated appropriately by the existing frameworks of supply chain resilience. The dimensions are adaptive capability, occurrences of disruptions and the resultant resilience for supply chain processes. The overall resilience is proposed through a concept of supply chain global resilience resulting from resilience of supply chain processes. Furthermore, cost aspect of supply chain is represented with the construct of supply chain risk cost. For empirical investigation of the proposed framework of supply chain resilience, it is necessary to gather data on supply chain processes in locations with unique conditions.

1.2 Aim and Scope of the Research

The aim of the study is to investigate the influence of adaptive capability and disruption vulnerability on resilience of supply chain processes. The resilience of supply chain processes affects the overall resilience of the chain that has influence on overall risk cost of supply chain. It is presumed that location with its resources offers opportunity to adapt alternate resources and methods to continue functioning while on the other hand volatile conditions poses vulnerability to disruptions. For this purpose, manufacturing and transportation processes of international garments supply chain with partners in developing and industrialized countries are surveyed for the purpose of empirical investigation. Pakistan has more volatile conditions as compared to Turkey and Germany in the of backdrop of wars, conflicts, inefficient state institutions to cope with natural and human disturbances and accidents, incapacity of the infrastructure to cater the energy, water, transportation and communication needs of the country. In this study, garments supply chain resilience is viewed as the reliability of the supply chain to continue its functioning through use of adaptive capability, despite disruptions posed or actually caused by natural disasters, political upheavals, infrastructure collapses, governmental policies and regulations, market uncertainties, economic crisis and internal breakdowns and capacity constraints of the partner firms.

The concept of resilience is defined by scholars with different perspectives to fit to the disciplines like psychology, ecology, sociology and others. The general agreement and focus among researchers is that resilience is the ability to restore the original state after disturbance[21]. The existing frameworks to study supply chain resilience are segmented, informative or prescriptive in nature and approach. The conceptual and methodological challenges have been avoided and a holistic framework to measure and analyze the concept is unattended so far.

In this study, the concept of supply chain resilience is defined as the ability of supply chain processes to continue their functioning after disruption occurs. The disruption is attended by adaptive capability through use of alternate mode of operations. Three important aspects of resilience are mentioned in the definition. One; the ability of supply chain process to respond to undesired turbulent change resulting from negative event for example machine breakdown, utility supply discontinuity, shortage of human resource, or stock out of raw material; second; the occurrence of disruption after using adaptive capability as a response to disturbance; third; the resulting resilience of the supply chain process. The negative events can be either organizational or locational factors that affect supply chain processes from procurement to final delivery of the products as discussed later. The study aims to research the impact of country specific conditions on supply chain resilience. For this purpose the answer to the following questions will be researched whether:

Does disruption vulnerability and adaptive capability influence resilience of supply chain processes?

[21] Ponomarov & Holcomb, 2009, p. 132; Christopher & Peck, 2004, p. 2 & Falasca, Zobel, & Cook, 2008, p. 596

Does the resilience of supply chain processes influence the overall resilience of supply chain?

Cross sectional surveys of international garments supply chain with partners in Pakistan, Germany and Turkey have been conducted to empirically answer the research question. Comparative research design is used to examine the effects of country conditions on overall supply chain. Two approaches were used to study the role of location conditions. One; supply chain stages are followed from manufacturer to customer to see the effects of different condition on different stages of supply chain process. For this purpose, the garments manufacturing and transportation processes are studied across Pakistan and Germany to find which stage of the supply chain process is unreliable due to weak resilience. Second; the same process in different locations is compared to investigate the functioning of process in different conditions. For this purpose garments manufacturing process is studied in Pakistan and Turkey and transportation process is studied across Germany, Pakistan and Turkey in order to compare for reliable manufacturing and transportation in different environments.

1.3 Outline of Thesis Structure

The thesis is organized into two main parts of theoretical foundation and empirical analysis shown in Figure 1. The theoretical part presents introduction to study, theoretical background and conceptual framework of supply chain resilience. The introduction part, in chapter1, presents the area of interest, background and context to the research, aims and scope of research and the outline of thesis structure. Chapter 2 is dedicated to the theoretical background of the study tracing back the development of the concept of resilience with different perspectives of psychology, ecology, sociology and in the field of management specially the recently focused supply chain resilience.

Supply chain management in general and international supply chain management in particular are discussed with regard to the competitive advantages and associated challenges. The conceptual framework of supply chain resilience is developed in Chapter 3 by identifying the constructs of resilience, the respective measurement indicators and the causal relationship among the constructs.

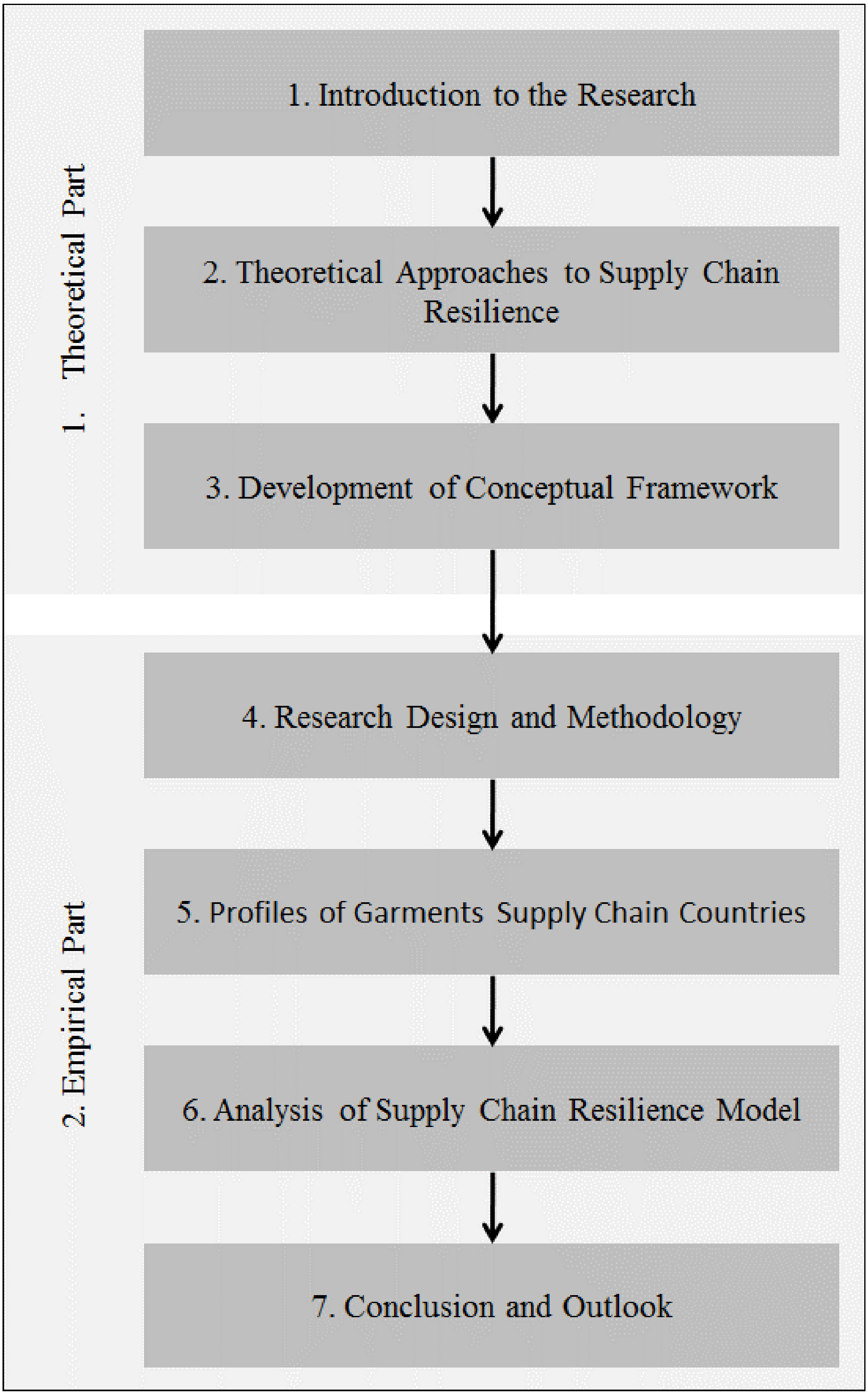

Figure 1 Outline of the Thesis

The empirical part presents the research design and methodology, contextual background to the study of international garments supply chain, analysis of supply chain resilience model and conclusion. Chapter 4 provides research design and methodology to guide the empirical testing of the proposed supply chain resilience framework. As the study considers international garments supply chain across countries, it is thought essential to present the country attributes of the supply chain partners in Chapter 5. Analysis of the theoretical model is through evaluation of outer model and testing of structural relationship among the constructs in Chapter 6. The study summarizes the results and offer conclusion in the last chapter 7, with recommendations for future research in the area of supply chain resilience.

2 Theoretical Approaches to Supply Chain Resilience

The major themes of supply chain are supply chain risk management, supply chain vulnerability and supply chain resilience since the term supply chain has been in vogue during the last couple of decades. The relationship among these themes have been the subject of debate in many articles. It is important to understand the nature of supply chain, the themes of risk, vulnerability and resilience for clear understanding of the concepts. For this purpose, section 2.1 presents the fundamentals of supply chain, discusses international supply chains with emphasis on the trade-offs between competitive advantages and inherent complexities, and mentions the issues in international supply chain management. Section 2.2 provides the theoretical perspectives of resilience in general and supply chain resilience in particular. Section 2.3 provides the summary of the chapter and suggests the processes of resilience as the basis for supply chain resilience framework, discussed in the following chapter.

2.1 Introduction

The term supply chain management was first used by consultants, Oliver and Weber, in their work titled as 'Supply-chain management: logistics catches up with strategy' published in Outlook in 1982[22]. Supply chain and the associated concepts owes its evolution to contributions in many other streams in literature over the last three decades as shown in Figure 2. The term supply chain became popular with the publication of Houlihan titled as 'International Supply Chains: A new Approach' in 1988. Houlihan realized that the compartmentalized functions with conflicting objective did not work very well and there is need to follow a new approach of supply chain management to manage the key functions in an integrated process manner[23].

[22] Lambert, Cooper, & Pagh, 1998, p. 2

[23] Houlihan, 1988, p. 23

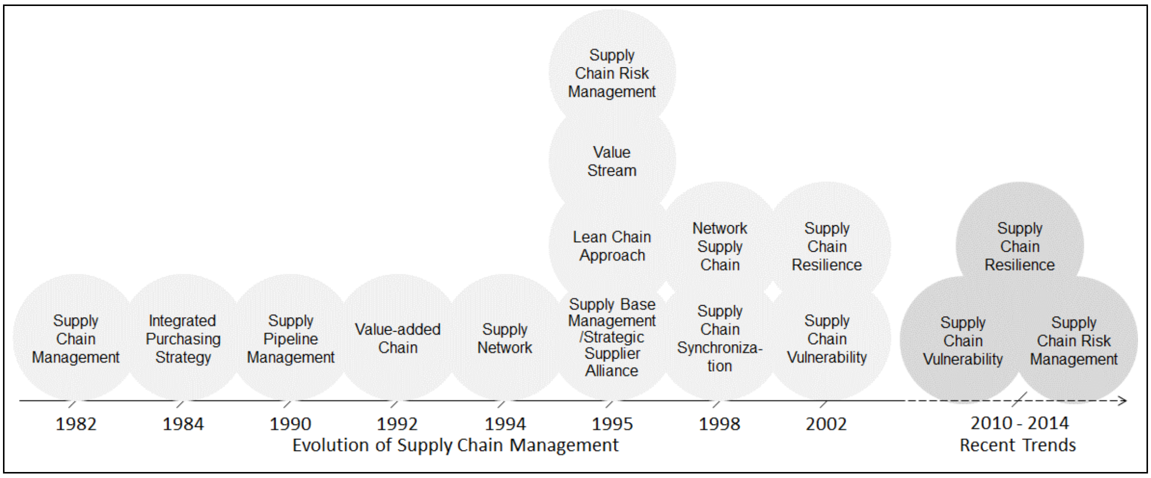

Figure 2 Evolution of Supply Chain Concept[24]

The term supply chain management after its early appearance in literature has been the focus of discussion under different titles. Hugos captioned this fact as 'nothing new... just a significant evolution' on Logistics and Operation Management[25]. The term has been in vogue under different streams like integrated purchasing strategy, supply pipeline management, value added chain, strategic supplier alliance, value stream and others. Supply chain risk management has surfaced and dominate the literature since mid-1990s. The concepts of supply chain vulnerability and supply chain resilience were added gradually in the early 2000s after large scales natural and human induced disasters. The large scale natural disasters, accidents and human induced negative events during the last couple of decades have emphasized the aspects of risk, vulnerability and resilience. However Cooper et al. emphasized that supply chain management is not merely an extension of logistics but rather it is a standalone and more comprehensive term[26]. Supply chain involves a number of business entities and coordinates the activities of designing new products and services, acquiring raw material from primary or secondary supply sources, making of components, manufacturing goods and services, distributing to retailers and providing to end customer as shown in Figure 3

[24] Croom, Romano, & Giannakis, 2000, p. 68 / Christopher & Peck, 2004, p. 2

[25] Hugos, 2011, p. 3

[26] Cooper, Lambert, & Pagh, 1997, p. 2

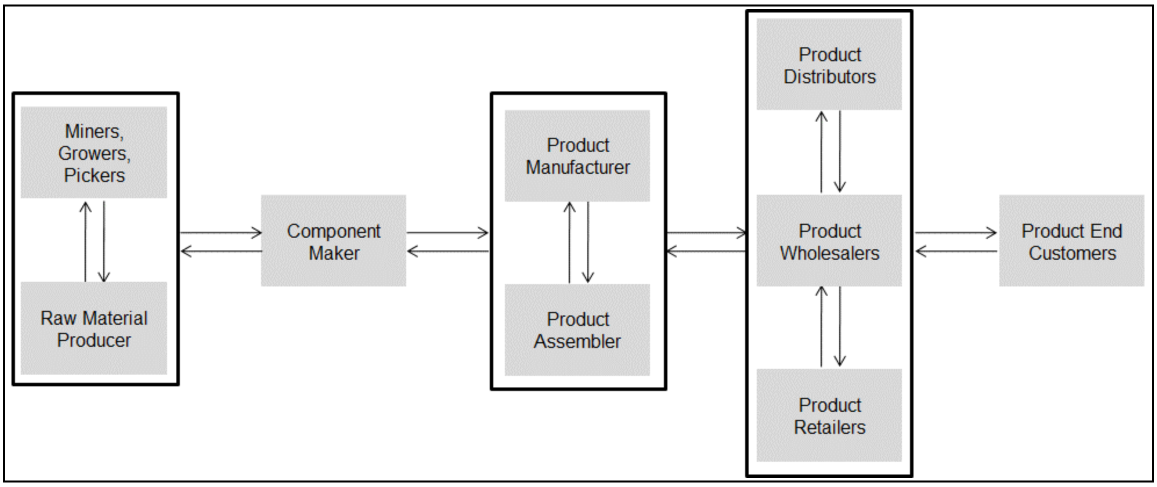

Figure 3 Supply Chain Interaction Model[27]

Supply chain entities interact for flow of goods, information and funds. Supply chain management strives at 'coordination of production, inventory location and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served[28].' For this reason supply chain stages coordinate to ensure that the processes are synchronized and work for the attainment of objective that is to provide the required quantity of products according to specifications, on scheduled time and at minimum costs[29] from original supplier to end customers. Suppliers, manufacturers, distributors and retailers coordinate in a way to ensure the objective of supply chain management. The decision involved in supply chain management are about supply, production, inventory, distribution, transportation and location of facilities[30]. Information about the specification of products, required quantities, scheduled time and cost are needed for making these decisions. Furthermore, in search for competitive advantage, location of facilities are decided on the basis of information on endowment factors like quality, availability, accessibility and cost of raw ma-

[27] Swaminathan & Sadeh, 1998, p. 607 / Lambert, 2008, p. 114

[28] Hugos, 2011, p. 4

[29] Cutting-Decelle, et al., 2000, p. 75

[30] Hugos, 2011, pp. 5-6

terial and processing activities with consideration for infrastructure and other factors of production[31].

The challenges to supply chains are both from operational and locational perspectives. While Houlihan observed that the functional approach among business entities affect the responsiveness due to conflicting objectives[32], the literature during the first decade of twenty first century was mainly focused on location of facilities. Operational and locational challenges pose challenges in managing supply chains. Supply chain operations include procurement, production, distribution and coordination and contract related issues. Various factors are considerate while making decision about supply chain operations.

Procurement decisions are about deciding on how much and when to acquire raw material leads to many a conflicting objectives. For example the quantity for whole year will be purchased at discount rate but this would cause inventory costs. On the other hand, just-in-time approach would be inherent with stock out risks and subsequent repercussions. The sourcing policy may be adapted as single source, dual source or multiple sources each with merits and risks.

Production decisions are related to production plans that are to be decided regarding types of product, their respective quantities and schedules[33]. The challenges faced in production are production capacity, quality and quantity of products and variation in product types. The production policies of make-to-order and make-to-stock have tradeoffs in terms of stock out and inventory costs.

Distribution decisions on type, quantities, schedule and transportation are made so as to cater the needs of all facilities i.e. wholesalers or retailers and the cus-

---

[31] Prasad & Sounderpandian, 2003, p. 241

[32] Houlihan, 1988, p. 23

[33] Hugos, 2011, p. 3

tomers[34]. Excess inventory, stock outs and redundant transportation pose challenges to distribution decisions.

Coordination and contracts decisions are related to supply chain operations that are challenged by conflicting objectives of processes carried out by partnering business entities, variations in customers demand in terms of type of products, and quantity of products[35]. The reaction of supply chain partners, mode of coordination, rights and liabilities are clearly stated and documented in order to save variability, loss of customer and expensive litigations.

Location challenges are inherent in the locational conditions where supply chain processes are carried out. It is critically important to decide on the location of a facility either owned by the organization itself or by supplier. The domestic and international locations have the tradeoff among stock out and inventory, low cost and longer lead time and reliability and variations. In pursuit of competitive advantage, supply chains have experienced a great spread across international locations in many industries including automobile, computer and apparel industries[36]. Location poses threat as well as offer opportunities. The tradeoff is between locations threats and opportunities is complex and need deeper understanding and investigation than the bare information based on raw facts and figures. The research question of the study is concerned with the effects of location conditions on supply chain resilience.

2.1.1 International Supply Chain Management

The process of globalization coupled with developments in information and transportation technologies has changed the world into a global market. Additionally, as the industrialized countries experienced increase in costs of labor and other factors of production, the search for locations to gain competitive ad-

[34] Hugos, 2011, p. 3

[35] Houlihan, 1988, p. 16

[36] Taylor, 1997, p. 1 / Tang & Musa, 2011, p. 25

vantage resulted in shifting of facilities to developing countries including China, India, Turkey, Malaysia, Bangladesh, Pakistan in Asia and Brazil and other countries in Latin America. With globalization, enterprises are forced to establish global supply chains or production networks of their own or to be the part of such arrangements[37]. The decision about sourcing or manufacturing domestically or internationally is motivated by many factors like tariff and trade concessions, low cost direct labor, capital subsidies, and reduced logistic costs[38]. However, international supply chains also pose serious challenges like transportation costs or longer lead times[39]. They inherit issues of currency exchange rates, economic and political instability, and regulatory environment of the country. Different local cultures, languages, and practices influence the business processes such as demand forecasting and material planning. The countries with underdeveloped transportation and communication infrastructure, inadequate workers skills, supplier availability, supplier quality, equipment, and technology make the coordination of supply chain relationship difficult[40].

International supply chains are spread over distances and cause longer lead time, variability in delivery and increase in transportation costs[41]. Furthermore, countries, institutions, organizations and individuals are all subject to different and continuous changes in the environment. The severity and frequency of adverse effects can be different arising within or outside the system, including disasters as well as small uncertainties[42]. Dalziell and McManus proposed that resilience is the product of vulnerability and adaptive capability[43]. The process input is vul-

---

[37] Jaehne, Li, Riedel, & Mueller, 2009, p. 2013

[38] Ferdows, 1997, p. 82 / Meixell & Gargeya, 2005, p. 533

[39] MacCarthy & Atthirawong, 2003, p. 797

[40] Meixell & Gargeya, 2005, p. 539

[41] Prater, Biehl, & Smith, 2001, p. 826

[42] Bhamra, Dani, & Burnard, 2011, p. 5375

[43] Dalziell & McManus, 2004, p. 7

nerable to the infrastructural, technological, human, economic, social, political and natural conditions. The conditions of location are supposed to determine the reliability of supply chain. The research aim of the study is to examine the relationship for deeper understanding of the phenomena of supply chain resilience.

2.1.2 International Supply Chain Risks

Risk is the chance of occurring of a disruption[44]. The usual meaning of risk represents a venture, a danger or the possibility of a loss, as well as the possibility that a negative occurrence of some sort will occur. The exclusive focus on risk as a purely negative factor is defined in the literature in terms of pure risk, or as risk in the narrow sense[45]. The risk manifests itself – in the case of occurrence – as property loss, loss of profits, etc. Risk is mainly the uncertainty of what will occur in the future. For the quantitative determination of risks, the possible developments are set in relation to a reference value. Almost all recent scientific publications define risk as the possibility that, due to uncertainty about future events, the realized value and the plan size differ negatively. Analogous to that, the positive deviation is called a chance[46]. The risk depends on the potential difference between the realized and the target value.

Supply chain risks are related to material flow, financial flow, and informational flow[47]. Risks are triggered, on the one hand, by risk events such as natural events for example storms, severe weather, strikes, congestion, and other whereas on the other hand, there are correlations between the specific business factors, such that the difference of one factor implies a ratio variation in other key figures. Thus, between risks there exists a complex cause-effect network[48]. From a business

---

[44] Tse & Tan, 2011, p. 141

[45] Rücker, 1999, p. 30

[46] Rücker, 1999, p. 32

[47] Tang & Musa, 2011, p. 27

[48] Heise, 1975, pp. 1-33

point of view, risks can affect the factors of time, quantity, quality and costs or price[49]. In many cases these factors are also interrelated.

Globalization has made the supply networks more and more vulnerable to risks due to geographical and structural complexity leading to loss of production capacities temporarily affecting the performance of the whole supply chain. Kleindorfer & Saad classify supply chain risks, on the basis of their sources, into operational contingencies, natural hazard, and political instability[50]. Chopra & Sodhi categorize risks into natural and man-made disasters, supply risks, systems, forecast, intellectual property, inventory, and capacity risks[51]. Manuj & Mentzer develop types of risks as supply risks, operational risks, demand risks, security risks, financial risks, political risks, competitive risks, and resource risks[52].

Supply chains are inherent with issues of conflicts of objectives not only among the functions of business units but also the among the business units that are working under constraints of quality, quantity, schedule and budget. It is important to note that on the bases of information received, a preceding upstream business facility supplies input to the following downstream facility. The interfaces among the partnering facilities are bottle neck points and breakdown at an interface affects the following interfaces. The dependencies add complexities to supply chain especially when the facilities are located at long distances. The cause and effect chain is at work in case of discontinuities that may begin at a facility by variation in quality, quantity, schedule or budget as shown in Figure 4.

---

[49] Siepermann, 2008, p. 65

[50] Kleindorfer & Saad, 2005, p. 54

[51] Chopra & Sodhi, 2004, p. 54

[52] Manuj & ^f, 2008, p. 138

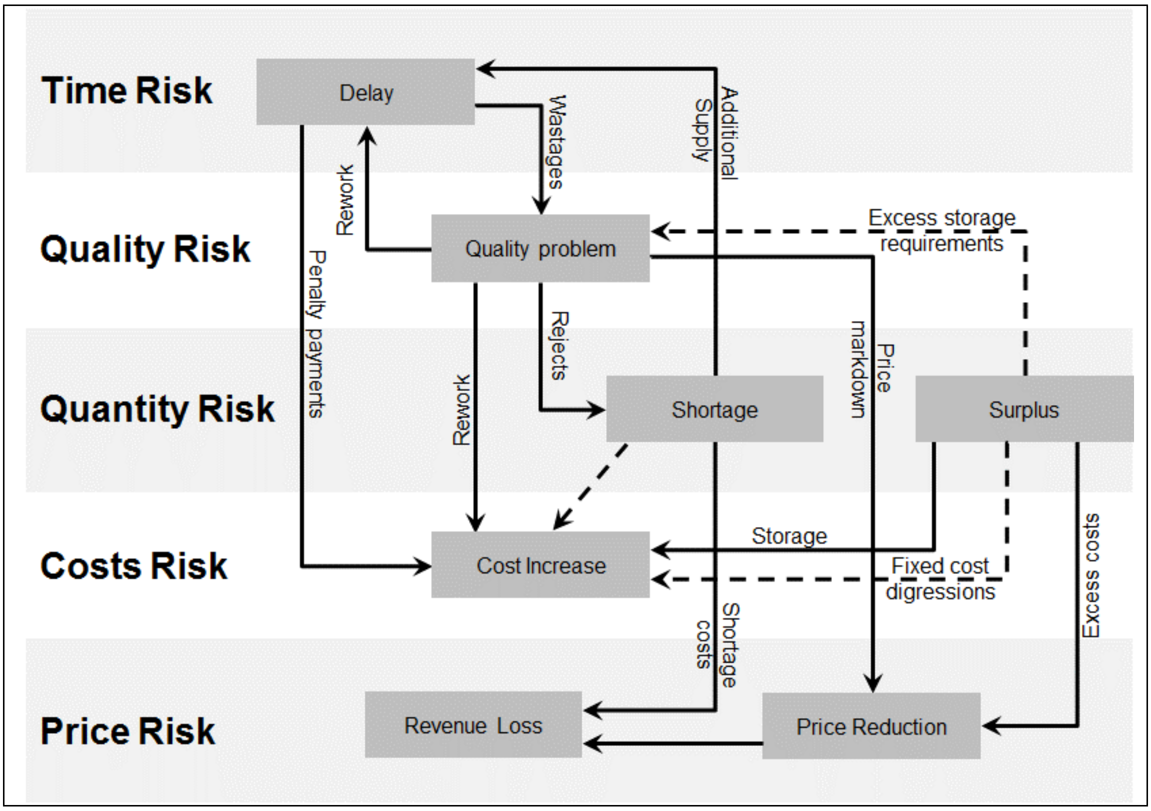

Figure 4 Risk Cause and Effect Chain[53]

Supply chain concept has recognized the importance of relationships among organizations driven by economic globalization. The decision to locate company owned facilities or supplier based resources has been of strategic importance[54]. The risk factors considered are foreign exchange risk, government interventions, political risk, economic risk, legal risk and natural disaster risks[55]. Prasad and Sounderpandian classify factors, with regard to country of location, into endowment factors, cultural factors, arbitrage and leverage and government incentives[56]. They suggested that in order to meet quality, quantity, schedule and cost targets, the country, industry and firm strategies are important to ensure smooth running of procurement, processing and distribution processes. Meixell and Gargeya pointed out issues dealt in literature like tariffs and duties, non-tariff trade

53 Lackes, Siepermann, & Khushnood, 2012, pp. 398-408

54 Dou & Sarkis, 2010, p. 567

55 Dou & Sarkis, 2010, p. 567

56 Prasad & Sounderpandian, 2003, p. 242

barriers, currency exchange rate, corporate income tax, transportation time, inventory costs and worker skill availability[57]. Schoenherr identified contract specifications, purchase risk, supplier responsiveness and procedural rigor in international supply chains[58]. Lowe et al. enlisted the issue related to international supply chain including design capacity, labor costs, quality control, waste treatment, utilities, supplies, packaging cost, duty rates and currency exchange rates. Colicchia et al. were concerned with transportation aspect of international supply chain including travel, ports and process related issues[59]. The travel related issues considered are weather and sea condition, traffic during sea carriage, accidents during haulage, and breakdowns of road vehicles. Issues related to ports are ports clogging, custom clearance, weather and strikes. The processes related issues considered are missed vessel boarding, shortage of container, limited capacity of vessels, incomplete custom document or bills. Supply chain processes are thus exposed to many risks that may lead to variability. The concept of resilience has been presented as a bulwark against such sanctions. The following section presents the different approach to resilience and the emergence of supply chain resilience concept.

2.2 The Concept of Resilience

Among researchers, the term resilience has been the part of discourse when it comes to risk, vulnerability and adaptive capability[60]. The term has different aspects that assigns complexity to the term and has been defined with emphasis on one or the other aspect. Manyena tabulates definitions of resilience that are standalone and complete concept in itself[61] while separately mentions others that

---

[57] Meixell & Gargeya, 2005, p. 539

[58] Schoenherr, 2009, pp. 1-25

[59] Colicchia, Dallari, & Melacini, 2010, p. 685

[60] Gallopín, 2006, p. 293

[61] Manyena, 2006, p. 437

suggest resilience as a complementary role to risk and vulnerability[62]. The term has been defined by focusing on either the ability to recover or on the aspect of disaster. This has been further complicated by the fact that resilience has been defined from individual, organizational, social, and ecological perspectives that fall in the domains of different disciplines like psychology, sociology and ecology[63].

Resilience has gained popularity in organizational and management fields like disaster management with physical and economical risk considerations. Supply chain resilience has been one of the major themes in supply chain management overshadowing the related themes of supply chain risk management and supply chain vulnerability. Given to the fact that resilience has been considered by many disciplines with diverse perspectives, resilience is a complex concept. For this reason, the concept of supply chain resilience still offers the room for a well-developed framework as well as associated indicators that could be empirically tested.

The earliest appearance and use of term resilience is traced back to the studies of physics, ecology, or psychology. Resilience from psychological perspective appeared in the work of Norman Garmezy titled 'Competence and adaptation in adult schizophrenic patients and children at risk' in the year 1973. It was the same year that an important publication on ecological resilience titled ' Resilience and stability of ecological systems' was authored by Crawford Holling[64]. Since then the term resilience has been in vogue and extended to social resilience. Resilience has been the core issue in the areas of emergency management, sustainable development and supply chain risk management since the early 1990s. Resilience has been discussed in vulnerability literature with the perspective that resilience is merely an aspect of vulnerability. To this point of view, resilience is the ab-

---

[62] Manyena, 2006, p. 441

[63] Bhamra, Dani, & Burnard, 2011, p. 5384)

[64] Holling, 1973, pp. 1-23

sence of vulnerability. However, the concept of resilience is more comprehensive and stretches beyond vulnerability. The following section presents different perspectives of resilience so as to understand the multidimensionality and its multidisciplinary usage of the term.

2.2.1 Psychological Perspective

The study of resilience is traced back to the fields of psychology and psychiatry. Resilience has been adapted to explain the ability to recover from disruption. The indirect reference to the term is suggested by terms of competence and adaptation in the writings of Norman Garmezy. The study of Norman Garmezy mentions social abilities for example communication, team work, team member and leadership and non-social abilities for example language, cognitive, and assertiveness while investigating parent-child relationship in case of psychological illness. These abilities are used as resources that enable the individual to respond to the surrounding human environment by accepting the norms and additionally exhibiting flexibility to adjust to unexpected and potentially disruptive conditions[65]. The work by Werner and Smith titled 'Vulnerable but invincible: A study of resilient children' works out difference between vulnerability and resiliency and searches for the causes of coping capabilities of children who well survived exposures to poverty and diseases despite the fact that they even lacked in support from parent for one or the other reason[66]. The differentiation between vulnerability and resilience is of great interest for this study as it presumes that supply chain processes are vulnerable but may be resilient to cope with volatile conditions.

2.2.2 Ecological Perspective

The publication of Crawford Holling titled ' Resilience and stability of ecological systems' elaborate the term resilience while discussing the behavior of ecological

---

[65] Garmezy, 1973, p. 187

[66] Werner & Smith, 1982, pp. 153-154

systems during disturbances[67]. Contrary to completely deterministic view of world where the properties of ecosystems are affected by random events, Holling suggests the random events are outside the system as well as internal to system. He identifies stability and resilience as the behavior of such systems in the situation of disturbance. In case of temporary disturbance, the stability enables the system to restore the pre-disturbance stage. He emphasized that a system is said to be more stable when fluctuations are less severe and restorations are faster. The second behavior of the systems, in the case of disturbance, is called resilience and is defined as 'a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationship between populations or state variables'.

The characteristics of resilience assume less stable state where disturbances are high. However the ability of the system to absorb disturbance and demonstrate change to adapt to disturbance is said to be very high that help the system to maintain its functioning. Holling stresses that 'a system can be very resilient and still fluctuate greatly, i.e. have low stability'[68]. The variations in state of a system are invoked by internal or external change agents that result in disturbances. The system's ability to absorb these shocks and restore to the desired state determines the resilience of that system. The differentiation between stable and resilience is studied. Supply chain operations in volatile locations may not be stable but resilient is supported by the concepts of stability and resilience.

The term of resilience is further developed by later researchers in ecology studies for example Walter Westman[69], Carpenter et al.[70] Folke et al.[71] and others. A notable development was the work of Walker et al. that broadly defines social eco-

[67] Holling, 1973, p. 14

[68] Holling, 1973, p. 17

[69] Westman, 1986, pp. 5-19

[70] Carpenter et al., 2001, pp. 765-781

[71] Folke, 2006, pp. 253-267

logical resilience as 'the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain the same function, identity and feed backs'[72]. The random events mentioned are ecological, economic, social, political conditions that stresses the system. Walker et al. mentions two related concepts of adaptability and transformability where the former refers to the collective capacity of the human actors in the system to manage resilience and the later term refers to 'the capacity to create a fundamentally new system when ecological, economic, social-political conditions make existing system unstable'[73]. The reference to collective capacity of the human actors to respond to surrounding system introduces the concept of resilience from ecology to social system. The retention of function is of key importance for this study that incorporates it as a construct of supply chain resilience framework. Turner et al. perceives resilience as one of the components of the vulnerability framework besides exposure and sensitivity[74]. They emphasize the concept of entitlement that is the possession of resources that determine the system's ability to maintain different sensitivities to perturbations and stressors. The coping capacities of social units are also different that enables to respond to harm. The framework view the human and biophysical conditions as capital and endowment factor constituting the sensitivity of the system in the framework of vulnerability. The concept of possession of resources contributes to this study as it assumes the organizational and locational resources as alternative means in case of disruption at the regular sources.

2.2.3 Social Perspective

Adger draws a parallel to ecological resilience while defining social resilience as 'the ability of groups or communities to cope with external stresses and disturb-

---

[72] Walker et al., 2004, p. 2

[73] Walker et al., 2004, p. 7

[74] Turner, et al., 2003, p. 8075

ances as a result of social, political and environmental changes[75]. The term ecological system is extended to social system where individual humans are the building units instead of plants and animals habitats. Adger refers to changes in the surrounding systems including social and environmental as sources of disturbances in a community. However, the disturbances from within the community are overlooked while defining resilience from social perspective. This theme in resilience has been of greater interest for organizations involved in community development like United Nations that works for improving the life conditions of communities through different organs like UNICEF, UNESCO, UNDP, UNISDR and others. United Nations International Strategy for Disaster Reduction defines resilience as ‘the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is measured by the degree to which a social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures’[76]. The definition mentions the elements of resilience that are adaptive capacity, level of functioning, and the exposure to hazards. The study includes theses aspects in supply chain resilience framework.

2.2.4 Vulnerability Perspective

Resilience has been debated as whether it is a distinct concept or a complementary term to vulnerability. Vulnerability has been considered by many researchers as the absence of resilience and vice versa[77] while others believe resilience as a sub dimension of vulnerability[78]. Adger observed that resilience of a system is not standalone concept rather it is related to vulnerability and adaptive capability

---

[75] Adger, 2000, p. 163

[76] ISDR, 2004, pp. 16-17

[77] Manyena, 2006, pp. 436-437

[78] Gallopín, 2006, p. 301

of social and ecological environments[79]. Timmerman observed that vulnerability and resilience were frequently used for the analysis of social economic characteristics of system but specific description of the terms was nonexistent[80]. He sums up the discourse of his monograph with defining vulnerability as level of negative reaction to disruptive event by a system. The degree and quality of the adverse reaction by the system depends on magnitude of hazardous event and the capabilities of the system. Whereas resilience measures the capacity of system to absorb and recover from the effects of disruptive event.[81] Vulnerability assesses system for the degree of shock whereas resilience is more of a follow-up that system manages the shock through absorption or recovery. This concept supports the view of supply chain resilience as an event driven process chain presented in Figure 5.

2.2.5 Supply Chain Perspective

The term supply chain and its resilience perspective are relatively new in management studies compared to logistics, operations management, crisis management, disaster management and disaster recovery planning that were established concepts in management disciplines[82]. With focus on business process improvement, supply chain management cared about expediting the flow of goods and services by the coordination of logistics, operations and marketing cross functionally as well as cross organizational[83]. The paradigm shift from internal functional self-interest to inter organizational coordination observed that in order to ensure focus on customer 'supply chains allow goods to be produced and delivered in right quantities, to the right places, at the right time in cost effective man-

---

[79] Adger, 2000, p. 349

[80] Timmerman, 1981, p. 3

[81] Timmerman, 1981, p. 21

[82] Christopher & Peck, 2004, pp. 1-4

[83] Christopher & Peck, 2004, p. 2

ner'[84]. The nicer idea of supply chain poses challenge when the organizational objectives are in clash with supply chain objectives, in the first place. Supply chain has to ensure material, informational, and financial flows with objectives of 'right products, in the right quantities, at the right place, at the right moment at minimal cost'[85].

There are numerous challenges to supply chain objectives implied in domestic, international, physical, human, political, economic, social and natural. Events like Fuel protests in 2000 and outbreak of foot and mouth disease in 2001, followed by large scale economic disruption in UK, emphasized the fact to investigate in the area of supply chain vulnerability. The famous study conducted, by Centre for Logistic and Supply Chain Management at Cranfield School of Management in 2002, came up with definition of supply chain vulnerability as 'an exposure to serious disturbances arising from risks within the supply chain as well as external to the supply chain'[86]. The following study was titled as 'Supply Chain Resilience' conducted in 2002-2003 that led to the popularization of the term supply chain resilience. During early 2000s, the focus was on external and large scale disasters that later on shifted to both external and internal and large and small scale disruptions[87]. Christopher and Peck identifies five categories of supply chain risk that are process risk, control risk (internal to firm) demand risk, supply risk (external to firm) and environmental risk (external o supply chain)[88].

Supply chain resilience has been evolved out of the concepts of supply chain risk and supply chain vulnerability as the term was mentioned at the conclusion of report on supply chain vulnerability conducted at Cranfield University in 2003. This work addresses the issue of risk in such a way that overshadow the concept

---

[84] Christopher & Peck, 2004, p. 1

[85] Cutting-Decelle, et al., 2000, p. 75

[86] Peck, et al., 2003, p. 2

[87] Chopra & Sodhi, 2004/ Sheffi & Rice, 2005/ Kleindorfer & Saad, 2005

[88] Christopher & Peck, 2004, p. 4

of resilience because the work is primarily concerned with the drivers of supply chain vulnerability. Supply chain vulnerability is related to the process, dependencies, networks and environment in which the supply chain operates. The study is thus diagnostic that how to diagnose and workout the improvement of resilience[89]. Later studies continues with the same approach to prescribe measures for building resilience. Christopher and Rutherford suggested six sigma for handling the disruptions and made a comparison of robust and resilient supply chain. The approach to resilience is evading and indulged in process control through quality management tools like DMAIC to define, measure, analyze, improve and control[90]. The approach to directly define and grasp supply chain resilience has been over looked. The question of how to create resilience is addressed but the question of how to measure the supply chain resilience is not attended.

The elaborative, diagnostic and prescriptive approach to supply chain resilience continued in the following studies. Sheffi and Rice, in an attempt to ponder on the resilient enterprise from supply chain perspective prescribes redundancy and flexibility as solution to recover quickly from disruptions and the work continues to elaborate the stages of disruption, vulnerability assessment, cost of redundancies and concluded with the business case for investing in flexibility[91]. Similarly, Falasca et al. identify determinants of resilience within supply chain as the number and dispersion of supply chain partners, the interconnectedness between the partners and the number of critical partner in the supply chain[92]. The approach is remedial in nature instead of measuring the resilience of supply chain.

The approach to supply chain resilience so far used is not holistic. This fact is realized by Ponomarov and Holcomb who observed that supply chain resilience literature was not only scarce but scattered and focused on description of the

---

[89] Peck, 2006, p. 210

[90] Christopher & Rutherford, 2004, pp. 24-28

[91] Sheffi & Rice, 2005, pp. 41-48

[92] Falasca, Zobel, & Cook, 2008, p. 598

concept in the first place[93]. The later studies that followed were informative and used to cover one or the other aspect of supply chain resilience such as flexibility, agility and reliability discussed separately with gape for a holistic conceptual view. Researchers have searched for link between supply chain resilience and logistic capability. The hypothesis they presented is to find the cause and effect relationship where logistic capability enables supply chain resilience that lead to sustainable advantage. They point out that logistics and supply chain related capability enable performance that leads to competitive advantage. The general proposition they put is that the better the logistic capability the greater the supply chain resilience. The researchers are concerned with explaining supply chain resilience as consisting of readiness, response and recovery stages and that resilience depends on control, coherence and connectedness of logistic capability. However the attempt to have a holistic approach to resilience was restricted to logistic capabilities that enables the supply chain to be responsive to disruption vulnerabilities. Logistic capability is an aspect of resilience that is treated in the resilience model.

The work by Colicchia et al. studies supply chain resilience in global sourcing context and prescribes certain mitigation strategies and contingency measures[94]. The mitigations strategies are included in the plan like pre-booking of containers, bonded warehouses, custom inspection at the port of destination and ensuring shipping priorities with the service provider. The contingency actions include measures such as avoiding the intermediary ports, use of sea and air service mix and use of airfreight for non-containerized goods. The study has mainly focused on the transportation stage of supply chain and that is related only to the segment from port of origin to port of destination. The supply chain resilience framework is only limited to transportation stage of supply chain.

93 Ponomarov & Holcomb, 2009, p. 32

94 Colicchia, Dallari, & Melacini, 2010, p. 684/668

Among the later literature, Pettit et al. proposed conceptual framework of supply chain resilience that was based on the concept of vulnerability and the ability to respond to vulnerability[95]. Forces of change create supply chain vulnerability and management control create supply chain capability. The hypothesis is that supply chain resilience increases as capability increases and vulnerability decreases. The main factors of vulnerability are turbulence, deliberate threats, external pressures, resource limits, sensitivity, connectivity and supply or customer disruption. Whereas the main factor of capability are flexibility, sourcing, fulfillment, resources, efficiency, visibility, adaptability, anticipation, recovery, dispersion, collaboration, organization, market position, security and financial strength in the supply chain resilience framework. The balance between vulnerability and relevant capacity can directly improve resilience. Pettit et al proposes that 'excessive vulnerabilities relative to capabilities will result in excessive risk; excessive capabilities relative to vulnerabilities will erode profitability; and supply chain performance improves when capabilities and vulnerabilities are more balanced.'[96] The response capability matching the vulnerability will help in maintaining the service level that aims to provide products to customers according to the requirements of quality, quantity, time, and cost. The study has mentioned two factors of supply chain resilience. The ultimate objective of maintaining resilience is not included. Furthermore, the constructs of vulnerability and capacity need to be operationalized so that they may be empirically studied.

Researchers were aware of the fact that the approach to supply chain resilience is from the perspective of creating it within itself[97]. The literature is prescriptive and focused on certain aspect. The literature serves thus the purpose of presenting a general overview of the concept. Blackhurst et al. based their framework of supply chain resilience on the concepts of system theory and resource based view of firms. The framework considers supply chain resilience as a firm's ability to

[95] Pettit, Fiksel, & Croxton, 2010, p. 6

[96] Pettit, Fiksel, & Croxton, 2010, p. 7

[97] Blackhurst, Dunn, & Craighead, 2011, p. 385

recover from disruptive event as defined by Sheffi and Rice[98]. The major dimension of supply chain resilience identified are supply resiliency enhancers and supply resiliency reducers. Supply resilience enhancers consist of human capital resources, organizational and inter organizational capital resources, and physical capital resources whereas supply resilience reducers considered are flow activities, flow units and source of flow units. Blackhurst et al. derive supply resilience framework through qualitative study with generalization that 'enhancers of firm's resiliency are attributes that increase a firm's ability to quickly and efficiently recover from a disruptive event.' Whereas a firm's resiliency reducers have the opposite effect and are defined as attributes that decrease a firm's ability to quickly and efficiently recover from a disruptive event.'. There are four situations assumed as result of interaction between enhancers and reducers. In case of both high reducers and enhancers the supply chain is said to be volatile. The supply chain is referred to as sensitive when both the reducers and enhancers are low. Supply chain is vulnerable in case of high reducers and low enhancers. The situation where reducers are low and enhancers are high is termed as resilient supply chain.[99]. Blackhurst et al. believe that 'the framework and matrix are versatile in that they are not industry specific and can be employed and determine the level of supply chain resilience in certain segments of supply chain (i.e. for particular countries or regions of world) or for specific product flows (i.e. critical items)'[100]. The remark is interesting in the context of this study because it investigates supply chain resilience across countries and for the products of garments industry.

The works of Ponomarov et al., Pettit et al., and Blackhurst et al. are qualitative and exploratory with the purpose of theory building. The empirical generalizations from these studies are yet to be tested. Pettit suggests that 'this exploratory research must be followed by empirical validation. Feedback to date from limited

---

[98] Sheffi & Rice, 2005, pp. 41-48

[99] Blackhurst, Dunn, & Craighead, 2011, p. 386

[100] Blackhurst, Dunn, & Craighead, 2011, p. 386

brands and other firms has been very positive and suggests great potential for the supply chain resilience framework. Empirical evaluation of the resilience definitions and concepts presented here is required by academics and practitioners to provide validation. Large-scale testing will be required to confirm propositions.'[101] Blackhurst et al. suggests that the framework presented in their work is 'versatile in that they are not industry specific and can be employed to determine the level of supply resiliency in certain segments of supply chains (i.e., for particular countries or regions of the world) or for specific product flows (i.e., mission-critical items)'[102]. Additionally they also comment that considering all generalizations in single study could become extremely complex and may result in lengthy survey instrument such that to be difficult for implementation. The study proposes a holistic framework to analyze supply chain resilience and for the purpose of empirical analysis operationalizes the constructs by assigning indicators.

The above discussion regarding resilience has been concluded as depicted as event drive process chain as shown in Figure 5.

In a situation when a system is hit by an adverse event either external or internal, the immediate response of the system would be to resist or absorb the effects of such events and maintain its pre-disturbance condition. However when the adverse events crosses the resistance and absorption threshold of a system, the functioning of the system is disturbed. In this case the system alternate means and ways are adapted to respond. As a result the system either recovers to its earliest position or transformed according to the new condition. The system continues its functioning and may deliver services until hit by another change event. The system when hit persistently and continuing its functioning on additional means may lead to state where the service ceases to continue.

[101] Pettit, Fiksel, & Croxton, 2010, p. 13

[102] Blackhurst, Dunn, & Craighead, 2011, p. 386

As shown in Figure 5, the resilience of a system is manifested by the ultimate provision of services to itself or the target recipients.

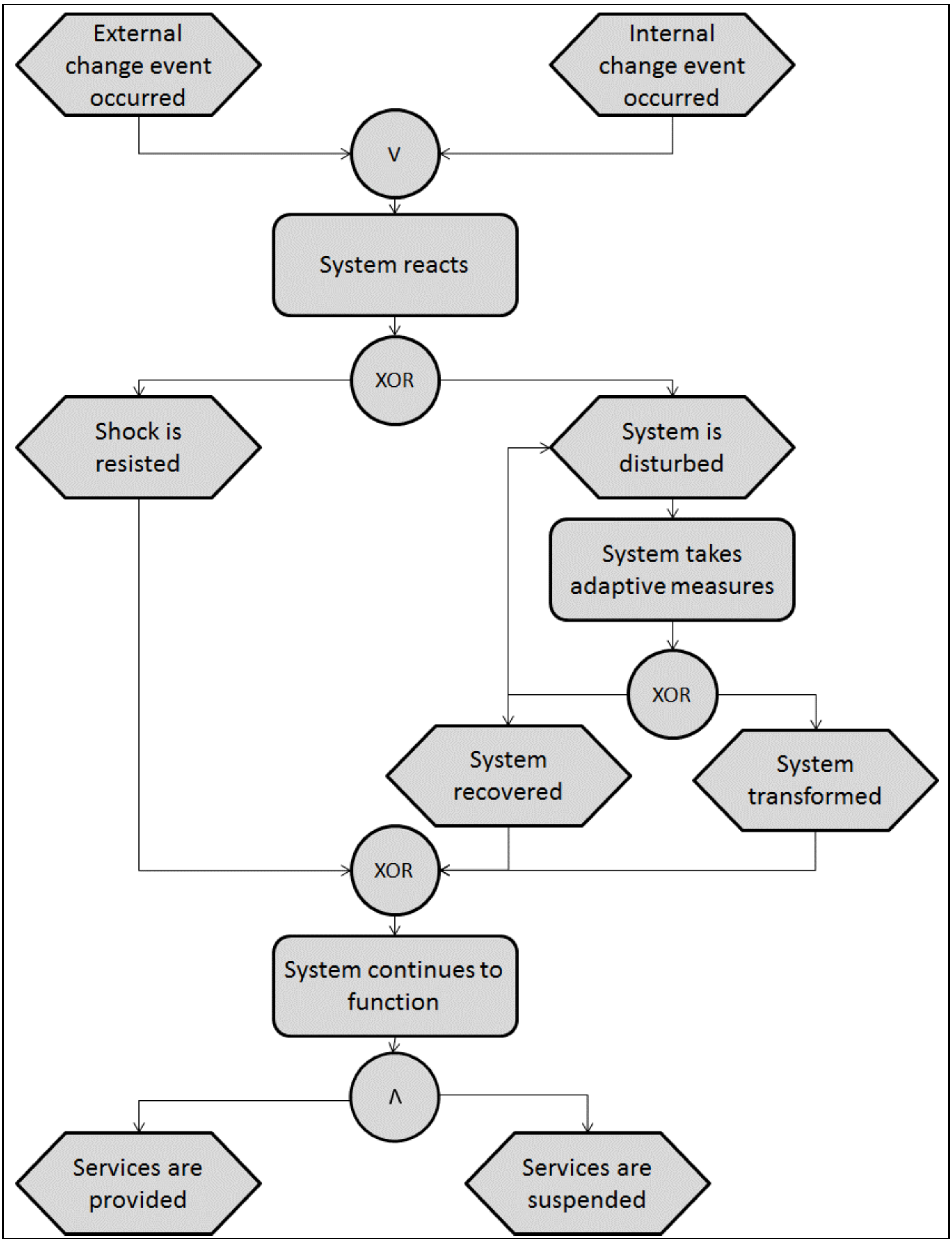

Figure 5 Event Driven Process Chain for Resilience

In this case, a system is resilient when it continues its functioning either by resistance, absorption, recovery or transformation when a change event occurs both internal and external to the system. From the preceding discussion, the main determinants of supply chain processes resilience are summarized. The overall purpose of this work is to develop and enhance the understanding of supply chain resilience and to test and analyze the outer model and inner model across supply chain located in different countries and with different conditions. The work seeks to find out the extent to which different country settings and partnering facilities have an impact on the supply chain stages operations. The empirical testing aim at providing real time operational evidences on the effects of country conditions on supply chain stage resilience.

The risk profile of countries is mentioned only as a contextual setting to the supply chain processes because the measurement of risk is beyond the scope of this work. Event driven process chain for resilience helps to capture the complexity of the concept and is used for presenting the research framework in the next chapter.

2.3 Summary

This chapter provides an introduction to the concept of supply chain resilience, its dynamics, and important issues. The context of international supply chain poses operational and locational challenges. The ever changing environment poses risks to regular functioning of supply chain operation. The drivers of supply chain risk are related to supply chain entity, supply chain, and environment. Volatile conditions and organizational issues determine disruption vulnerability of supply chain processes carried out in specific location and by certain supply chain entity.

The theoretical background to supply chain resilience has been presented in detail by tracing back how the term resilience came in psychological discourse. The term was later on used in ecological, sociological and other disciplines. Supply chain resilience has been in vogue especially after the large scale natural and human caused disasters in the beginning on this century. The chapter is concluded by explaining resilience with event driven process chain as shown in Figure 5, in order to develop clear understanding of the concept of resilience.

3 Development of Conceptual Framework

The discussion in the previous section was aimed to develop understanding of the concept of resilience and that with the perspective of supply chain. It is also important to consider the fact that international supply chains are geographically dispersed with different stages carried by facilities located in countries with varied cultures. The reliability of supply chain depends on the resilience of its segments collectively that in turn is dependent on firm's organizational and locational factors. With these considerations, conceptual framework is developed for analyzing international supply chain resilience in the context of locational attributes of partnering facilities. Section 3.1 presents introduction to supply chain frameworks in the light of discussion in chapter 2 and proposes framework for this study. In section 3.2, existing frameworks of supply chain resilience are discussed with focus on describing the constructs of disruption vulnerability, adaptive capability, and resilience. Section 3.3 presents extended supply chain resilience with constructs. Section 3.4 research hypothesis as suggested in the extended supply chain resilience model. Section 3.5 operationally defines the constructs by assigning indicators to the constructs of extended supply chain resilience model so that the model could be empirically investigated. Section 3.6 describes extended supply chain resilience model in the context of structural equation model. Indicators are discussed against the criteria for establishing their nature in section 3.7. Section 3.8 of the chapter concludes the discussion and mentions the necessity to define research design and methodology to collect data for the indicators so that the international garment supply chain resilience model shall be empirically tested.

3.1 Introduction

This study considers resilience in its entirety and considers that internal and external change events exposes system to disturbances. When such a change event occurs, the system either resists or succumb to disruptions. The proactive stage of resilience is overpowered and the operations of a system are not running as planned. To the rescue of the system alternative additional resources are injected leading to various situation of either full recovery, partial recovery, or no recovery. As an outcome of interplay among disruption events, adaptive capability, minimizing disruptions and the resultant resilience of system are the different stages of resilience process as shown in Figure 5. Ultimately, resilience is exhibited by the resilience of the function. The definition given by Ponomarov and Holcomb is more appropriate for this study that describes resilience as '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'[103]. If respond to disruption is the adaptive capability of a system, the occurrence of discontinuities of process input, operations and output is the measure of resilience. With this approach adaptive capability of a system is first defined that is used in the advent of disruption, depending on the frequency of change agents challenging the process. The use of adaptive capability is expected to reduce the occurrence of disruption and ensure desired functioning level. Though the system itself is challenged by internal and external disruptive events, the resilience of system ensures that alternative operations are readily available and used to reduce the occurrence of process discontinuities and the desired resilience is maintained.

3.2 Existing Supply Chain Resilience Frameworks

The works of Ponomarov et al., Pettit et al., and Blackhurst et al. propose supply chain resilience models. Their works are qualitative and exploratory with the purpose of theory building. The works provide basic necessary theory of supply chain resilience.

---

[103] Ponomarov & Holcomb, 2009, p. 131

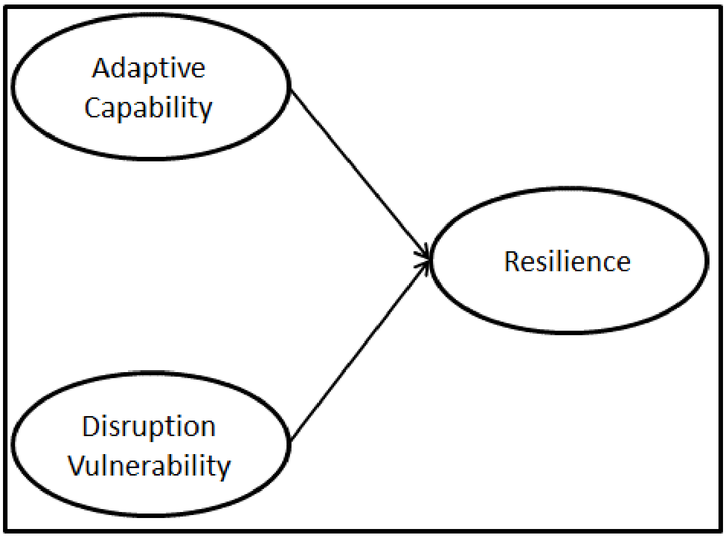

Figure 6 Existing Framework of Supply Chain Resilience[104]

The consensus among supply chain resilience researchers is that it is multidimensional construct with supply chain process vulnerability, adaptive capability and resilience.

3.2.1 Adaptive capability

Adaptive capability is invoked when a system is hit by change event and the functioning is adversely affected[105]. While many researchers looked into supply chain for resilience through agility, responsiveness, visibility, flexibility, redundancy, reduction of uncertainty[106], adaptive capability considers alternative resources and methods within the supply chain unit, among the supply chain entities and the location from which the supply chain process extract input. The alternate resources and methods are called into action in the face of disruptions in order to save the actual occurrence of process discontinuities, reduce the adverse effects if after all discontinuities do occur or help the process to resume normal operations in case of severe effects of disruption[107]. Resilience is termed as more

[104] Pettit, Fiksel, & Croxton, 2010 and Blackhurst, Dunn, & Craighead, 2011

[105] Ponomarov & Holcomb, 2009, p. 132

[106] Christopher & Peck, 2004 / Chopra & Sodhi, 2004

[107] Pettit, Fiksel, & Croxton, 2010, p. 6

proactive in practice than the commonly stated concept with emphasis on response or reaction to disruption[108]. Developing supply chain firms adaptive capability is one aspect, the location of the supply chain firms may offer many an alternate resources and approaches to tackle the situation of disruptions. Supply chain entity itself and surrounding environment with all its resources and capital help to gain sourcing, production and disruption flexibility[109]. The framework of resilience by Blackhurst et al. includes physical, human and organizational capital and resources as enhancers of supply chain resilience. Adaptive capability is different from coping capacity of system as the former is invoked in case disruption over powers the inbuilt response capacity of system. Adaptive capability is acquired through the use of other resources that help system back to desired functioning. Adaptive capability is used only in such situation and is not suggested to be used under normal conditions because this would lead to redundancy and diminish the profit[110].

3.2.2 Disruption Vulnerability

Supply chain vulnerability is the tendency to disruption of processes related to input resources, operations or the entity responsible for carrying out the operations[111]. This is system based approach to grasp the concept of supply chain vulnerability. The discontinuities may occur in inbound or out bound logistics, supply of raw material and production operations caused by internal or external change event. Vulnerability represents the system sensitivity to both internal and external disruptive events which deviates the system from its standard working conditions and is manifested in terms of damages to performance due to the intrinsic system incapacity to react to change event[112]. While risk management is

[108] Waters, 2011, p. 189

[109] Pettit, Fiksel, & Croxton, 2010, p. 19

[110] Ponomarov & Holcomb, 2009, p. 132

[111] Pettit, Fiksel, & Croxton, 2010, p. 19

[112] Albino & Garavelli, 1995, p. 73

preparedness for possible losses so as the vulnerability with additional consideration for the structural capacity to cope with the disturbance that determine sensitivity or preparedness for eventualities by incorporating provisions in planning the activities.

3.2.3 The Resilience

Supply chain resilience is unanimously defined at least in terms of the restoration to early state[113], recovering to normal performance[114] or maintaining continuity of operations at the desired level of structure and function[115] after the system is being affected by disruptive event. The objective of supply chain process is to provide 'the right products in the right quantities, at the right place at the right time and at the minimum cost'[116]. Supply chain firm aims at ensuring quality of products, at competitive prices and shorter lead times[117]. In locations with high volatile situation arising from internal or external change events, supply chains are trying to maintain the required resilience through risk management and vulnerability reduction through proactive and reactive approaches with the ultimate aim to ensure the required amount of products, with specified quality, within scheduled time and at minimum cost.

Supply chain resilience frameworks by Petite et al. and Blackhurst et al. postulate that there is negative relationship between vulnerability and resilience and that there is positive relationship between adaptive capability and resilience. Supply chain process is affected by external, internal, chain or network environments. Adaptive capability of a firm or chain moderates and mediates the effect of vulnerability on resilience that demonstrate resilience. These frameworks provide

---

[113] Christopher & Peck, 2004, p. 2

[114] Falasca, Zobel, & Cook, 2008, p. 596

[115] Ponomarov & Holcomb, 2009, p. 131

[116] Cutting-Decelle, et al., 2000, p. 75

[117] Prasad & Sounderpandian, 2003, p. 244

constructs of vulnerability, capability and resilience. The limitation is that resilience is suggested as a part of supply chain resilience that is contradictory to measure resilience by itself. Again, the studies are focused on vulnerability and capability but none of the studies have discussed the construct of resilience. There is no clear consideration of the factors representing construct of resilience. In order to address the gap, this study suggest service level as the outcome of disruption vulnerability and adaptive capability.

This study aims at developing the construct of resilience such that it is measurable and could be empirically tested. A fully operational model will help to investigate the research question that asks the impact of country condition on international supply chain resilience.

3.3 Constructs of Extended Resilience Model

In case of international supply chain, the processes are spread over different geographical location. The unique locational conditions affect the input, operations and output of processes across the supply chain stages. For the purpose of operationalization this study define supply chain resilience as the cumulative effect of processes carried by supply chain firms located in different countries with unique conditions[118]. Country specific conditions affect supply chain process segment resilience. However firms located in countries with turbulent conditions are still part of international supply chains. For this the objective of the investigation is to find whether international garments supply chain processes show differences in resilience for firms located in different countries.

International supply chain spreads over geography and processes of procurement, manufacturing and distribution are carried across countries each with different conditions. Countries have unique attributes exhibited by the natural, physical, human, social, political and environmental conditions[119]. The assumption of the

[118] Dou & Sarkis, 2010, p. 571

[119] Meixell & Gargeya, 2005, p. 533

study is that country conditions influence the resilience of supply chain processes (Figure 7). Each stage of supply chain is both thriving and disturbed by the attribute of location. In case of international supply chain with partners located in different countries will be affected by the conditions of the country of location.

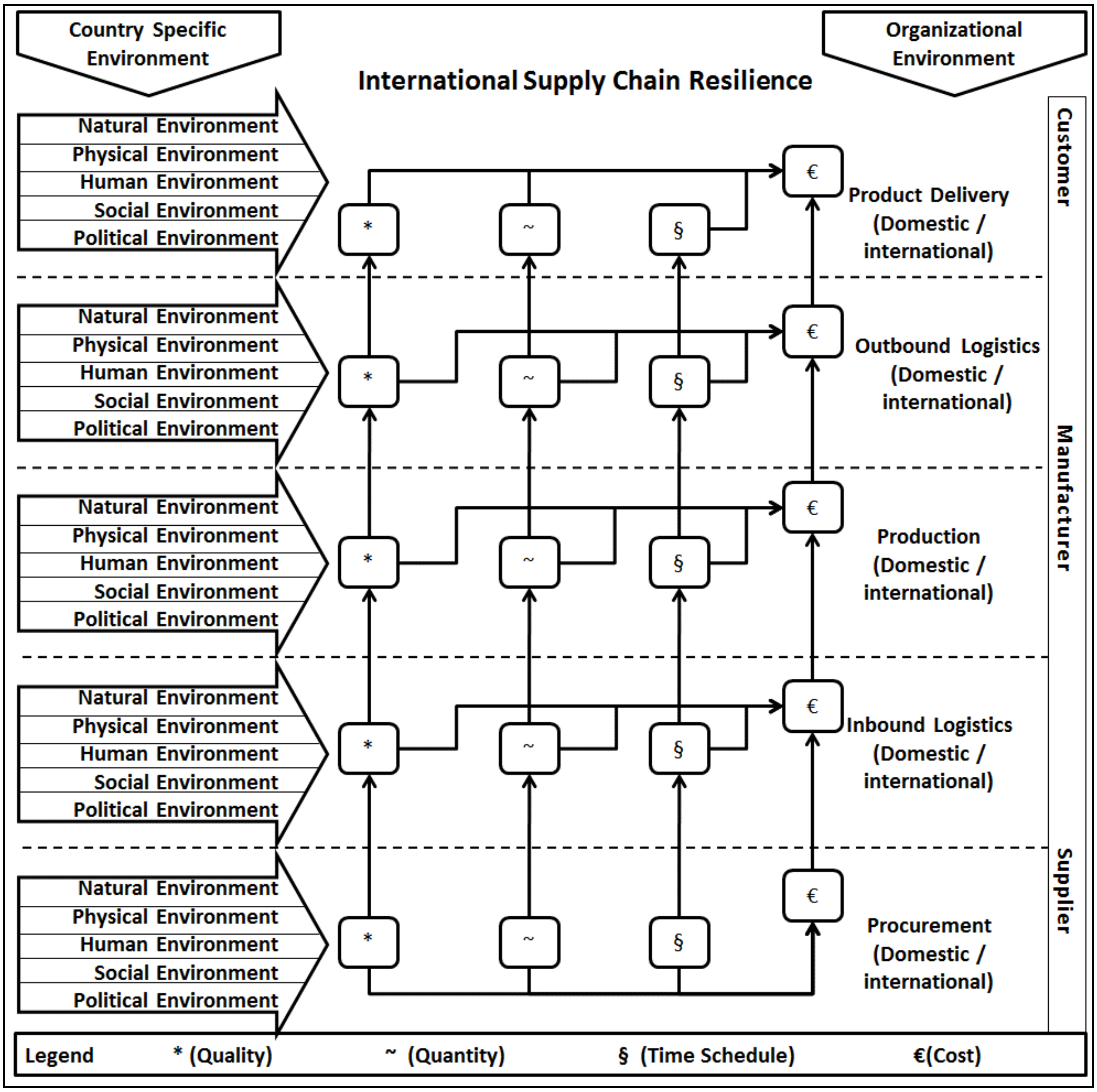

Figure 7 Cause-Effect Chain for International Supply Chain

Garment manufacturers located in Pakistan and Turkey supply garment to Europe besides other destinations like American, Australian and African markets. Pakistan and Turkey have different conditions and are expected to have different effects on manufacturing process. Similarly the process of transportation is studied in Pakistan, Turkey and Germany with different conditions and are expected to have different effects on transportation process. A supply chain process takes input for its operations and the firm's location determine the availability, reliability and cost aspects of the process input given to the unique conditions.

As shown in Figure 7, the country specific environment effects each stage of supply chain. The organizational environment defined by coping capacity and adaptive capability also has effects on respective stage of supply chain. These former stage of supply chain is input to the next stage also effect carries the effects with it. Thus the overall resilience of supply chain is determined by the resilience at every stage of the chain. It is also depicted in Figure 7 that each stage has quality, quantity, schedule and cost aspect to be considered. The quality of process affects the quantity to be processed and both quality and quantity of stage affect schedule of processing. The cost of processing depends on quality, quantity and schedule of processing at the stage level. These aspects at a stage have effects on the aspects of following stage in supply chain. The ultimate purpose is to optimize in such a way that costs are minimized and profit is maximized.

The framework suggests that resilience of supply chain process is influenced by adaptive capability and disruption vulnerability. The resilience of supply chain processes in turn affect the global resilience of supply chain that influence the cost of supply chain. In order to investigate the above stated objectives two measurement instruments for manufacturing and transportation were developed. The manufacturing instrument was designed to collect data on manufacturing adaptive capability, manufacturing vulnerability and manufacturing resilience of the firm. Similarly, the transportation instrument is in parallel to manufacturing instrument as far as the constructs are concerned. However given to difference in the nature of operations, required input resources and output service aimed at are different.

The general framework of supply chain resilience has been extended for the purpose of empirical investigation in this study. The scope of study is limited to the study of manufacturing and transportation stages. In this context, the existing model of resilience, as discussed earlier, has been extended over the processes of manufacturing and transportation as presented in Figure 8.

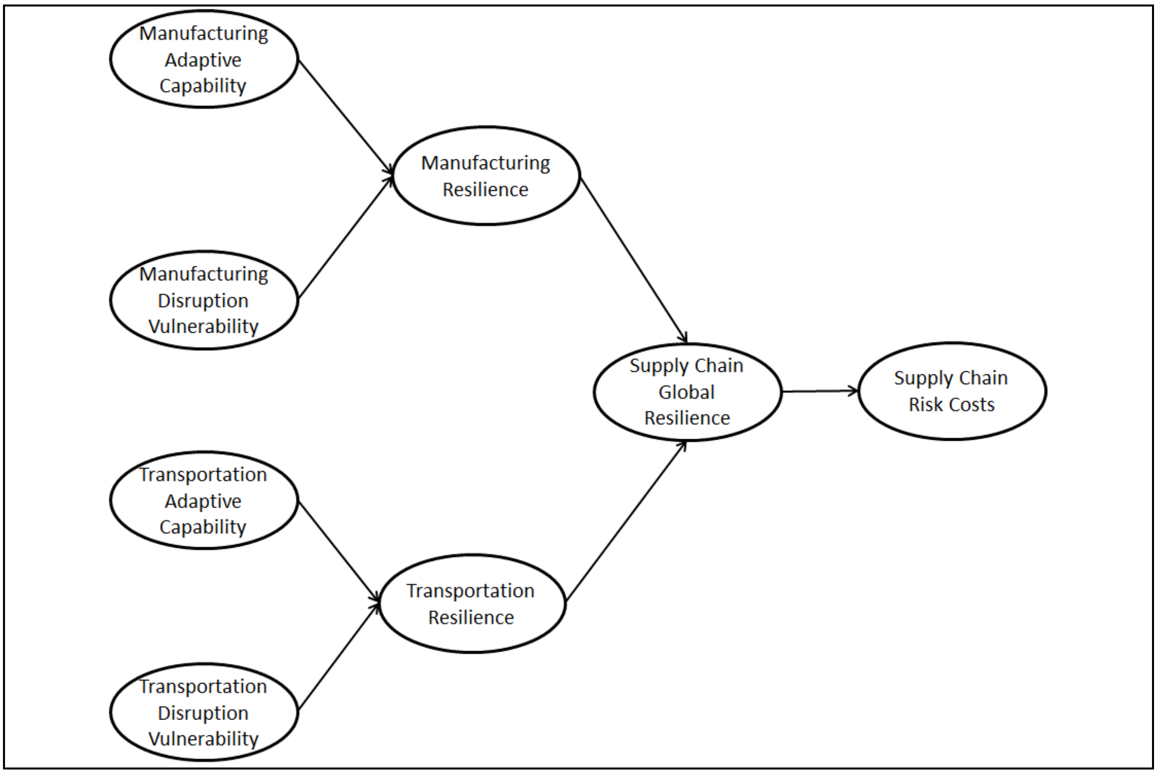

Figure 8 Constructs of Extended Resilience Model

The extended model suggests the constructs both for manufacturing and transportation of adaptive capability, disruption vulnerability and resilience respectively. The overall resilience is represented by supply chain global resilience and supply chain risk costs.

3.3.1.1 Manufacturing Adaptive Capability Construct

The construct of manufacturing adaptive capability (MAC) represents the alternate resources and methods that can be adapted in case of the process is hit by either internal or external disruptive event. The organizational and locational opportunities provide the ability to respond to disturbances. Location with number of raw material suppliers, availability of workers, and multitude of manufacturers are some of the possibilities to adapt to new situation without incurring substantial costs.

3.3.1.2 Manufacturing Disruption Vulnerability Construct

Manufacturing Disruption Vulnerability (MDV) captures the situations where the process of manufacturing is disturbed by disruptive events. Manufacturing process depends on number of inputs that are processed into products. The disturbance in input sources and operations cause variability in manufacturing.

3.3.1.3 Transportation Adaptive Capability Construct

The construct of transportation adaptive capability represents the ability of the process to respond to disturbances caused by disruptive events. Possibility of using alternate means and methods of transportation constitute the adaptive capability of the process. The location with number of transportation methods and routes help develop readiness to respond to disturbances.

3.3.1.4 Transportation Disruption Vulnerability Construct

The construct represents the situations when the process of transportation is disturbed. The modes of transportation and routes are exposed to disturbances and leads to process variation. Vehicle breakdown, routes closures, weather conditions are potential issues.

3.3.1.5 Manufacturing Resilience Construct

The construct of manufacturing resilience (MR) represents the functioning of process after being affected by manufacturing vulnerability and treated by adaptive capability. It considers the service level of manufacturing process.

3.3.1.6 Transportation Resilience Construct

The construct represents the service level of transportation process that continues functioning after being affected by disruptive event and attended by adaptive capability.

3.3.1.7 Supply Chain Global Resilience Construct

Supply chain global resilience represents the overall reliability of supply chain and result of the constituent processes carried out by respective entities. In this model the overall resilience is resultant of manufacturing and transportation processes.

3.3.1.8 Supply Chain Risk Costs Construct

The construct of resilience of supply chain risk cost represents the cost objective of supply chain. Variation in supply chain processes causes increase in costs. Supply chain global resilience influences the overall costs.

Thus the study extends the existing model of supply chain resilience. The extended model has the constructs of manufacturing adaptive capability, manufacturing disruption vulnerability, transportation adaptive capability, transportation disruption vulnerability, manufacturing resilience, transportation resilience, supply chain global resilience, and supply chain risk costs. The extended model suggests causal relationships among construct that are discussed in the following section.

3.4 Research Hypothesis

The structural equation model of extended supply chain resilience suggests direct relationship and additionally the model is analyzed for more complex relationship for mediation and moderation.

3.4.1 Direct Effect Hypothesis

The research question is to investigate the influence of disruption vulnerability and adaptive capability on supply chain resilience. The relationships among constructs are proposed in the inner model. The direct relationship between variables is suggested in Figure 9.

Disruption vulnerability is supposed to negatively affect supply chain process resilience. This means that with disruption vulnerability frequently hitting manufacturing or transportation process, owing to organizational situation or location conditions, the frequency to meet quality and quantity objective will be lower and so the manufacturing or transportation resilience. Low manufacturing resilience would mean that the required quality is not often maintained and there are more rejects due to quality issues. Additionally, the required quantity will not be often produced due to disruptions. The situation is stated as hypothesis H1a

(Table 1). Similarly low transportation resilience would mean that losses are frequently experienced during the process and the process fell short of shipping the required quantity more often. This relationship is given in hypothesis H1b (Table 1).

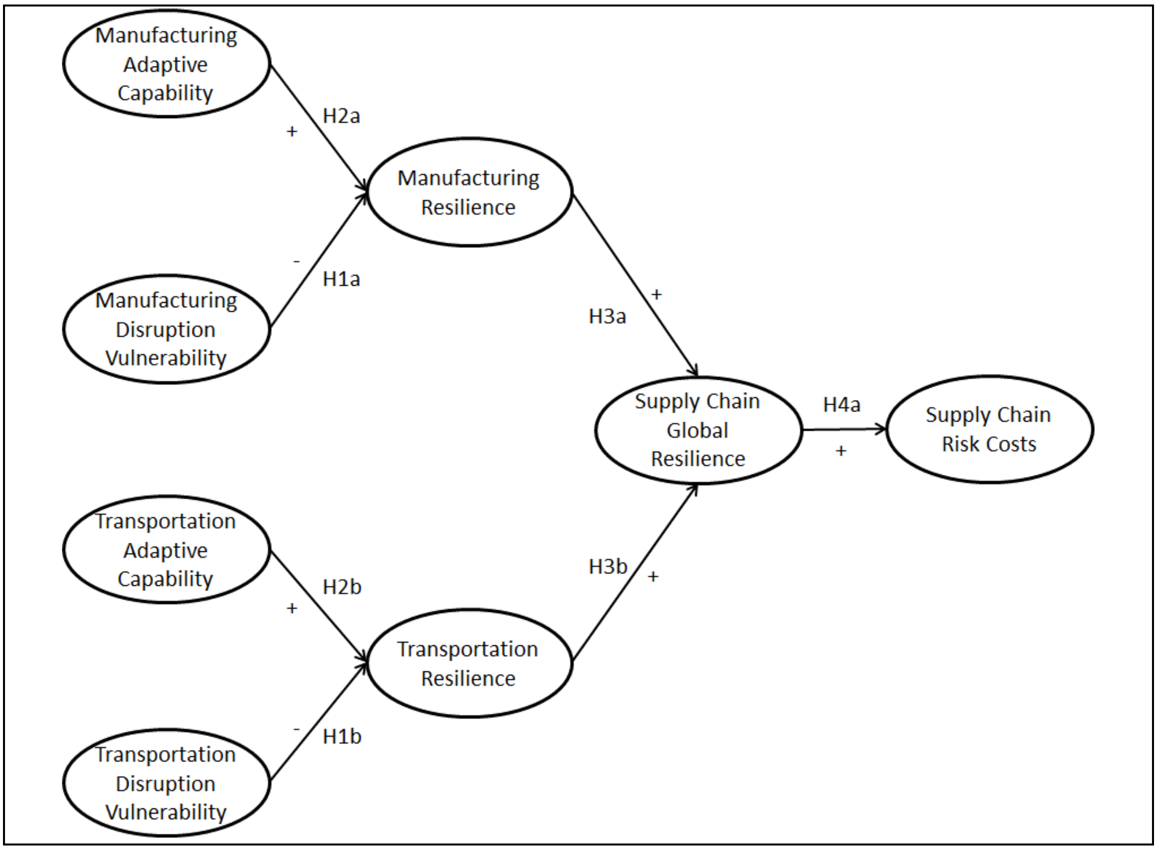

Figure 9 Proposed Direct Causal Relationship

Adaptive capability is expected to have positive effect on supply chain process resilience. Supply chain entities with ability to use more often adaptive capability, as a response to frequent disruptions, contribute positively to resilience. In case of disturbances in manufacturing process, use of adaptive capability is expected to positively affect manufacturing resilience suggesting that required quantity is produced with fewer quality issues. The situation is proposed as hypothesis H2a and similarly, the situation is suggested as hypothesis H2b for transportation process shown in (Table 1).

Supply chain global resilience suggest that the required products are produced in required quantities with minimum rejects and on schedule time. With frequent quantity and quality issues the timely production will often experience production delays. Timely production represents the construct of supply chain global resilience. The situation is theoretically proposed as hypothesis H3a as below.

Table 1 Research Hypotheses Related to Direct Relationship

Theoretical Generalization	Hypothesis
1. Disruption vulnerability negatively affects supply chain process resilience.	H1a. Manufacturing disruption vulnerability negatively affects manufacturing resilience.
	H1b. Transportation disruption vulnerability negatively affects transportation resilience.
2. Adaptive capability positively affects supply chain process resilience.	H2a. Manufacturing adaptive capability positively affects manufacturing resilience.
	H2b. Transportation adaptive capability positively affects transportation resilience.
3. Supply chain process resilience positively affects supply chain global resilience.	H3a. Manufacturing resilience positively affects supply chain global resilience.
	H3b. Transportation resilience positively affects supply chain global resilience.
4. Supply chain global resilience negative affects supply chain risk costs.	H4. Supply chain global resilience negatively affects supply chain costs.

Similarly, the products are to be transported to the customer in required quantities with minimum product losses and on schedule time. Resilience of transportation process positively affect supply chain global resilience. With fewer occurrences of quantity limitations and product losses during transportation will suggest timely delivery of products to customer. The situation is captured in hypothesis H3b stated in Table 1.

The relationship between supply chain global resilience and supply chain risk costs suggest that frequent production and transportation delays will increase the occurrence of additional cost. The more the on time production and transportation is accomplished the lesser will be the risks of cost. The situation is stated as hypothesis H4 in Table 1.

As a variation of supply chain resilience model, the relationship, in a more complex way, suggests mediation and moderation among the variables.

3.4.2 Mediation Effect Hypothesis

Mediation relationship suggests that an independent variable influences dependent variable through another independent variable. It is possible that the direct effect between predictor and outcome variable is affected by a third independent variable[120]. The middle variable works as mediator for example the effect of disruption vulnerability is mediated by adaptive capability that determines the resilience of a supply chain process. In the absence of adaptive capability, as there are firms that do not have the possibility to use alternate sources or methods, the disruption vulnerability will affect the resilience adversely. The presence of mediating variable is therefore deemed as necessary for alleviating the effect of independent variable on dependent variable. The independent variable assumes the role of predictor, the middle intervening variable is referred to as mediator, and the dependent variable is termed as outcome variable. The phenomena is called as mediated effect in causal modeling. The intervening intermediate variable operates as dependent variable for the predictor variable and adopts the role of independent variable for the outcome variable as shown in Figure 10.

[120] Hair J. F., 2009, pp. 751-755

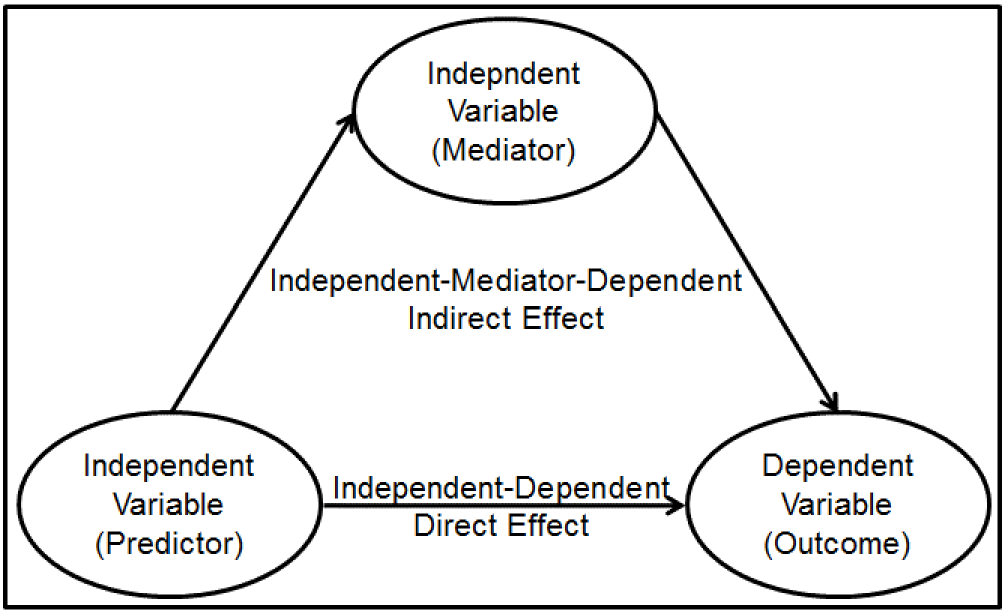

Figure 10 Mediation Causal Effect

The empirical conditions for mediation are that predictor variable is significantly related to the mediator variable, the mediator variable is related to the dependent variable, and that the relationship between predictor variable and outcome variable diminishes with inclusion of middle intervening variable in the model[121].

Mediation can be full, partial, inconsistent, or no mediation. Full mediation is a situation when the direct effect between independent and dependent variable turns non-significant with the introduction of mediator whereas the relationship between independent variable and mediator and mediator and dependent variable is found significant. In partial mediation, the relationship between predictor variable and outcome remains significant. In case of inconsistent mediation, the relationship between predictor and outcome variable changes sign from positive to negative or negative to positive. In case of no mediation situation, there is no relationship between mediator and outcome variable[122].

Mediation suggests that disruption vulnerability affects resilience of supply chain processes through the variable of adaptive capability as presented in Figure 11.

---

[121] Little, et al., 2007, p. 208

[122] Hair J. F., 2009, pp. 751-755

The proposed mediation and moderation are stated as hypothesis 5 and hypothesis 6.

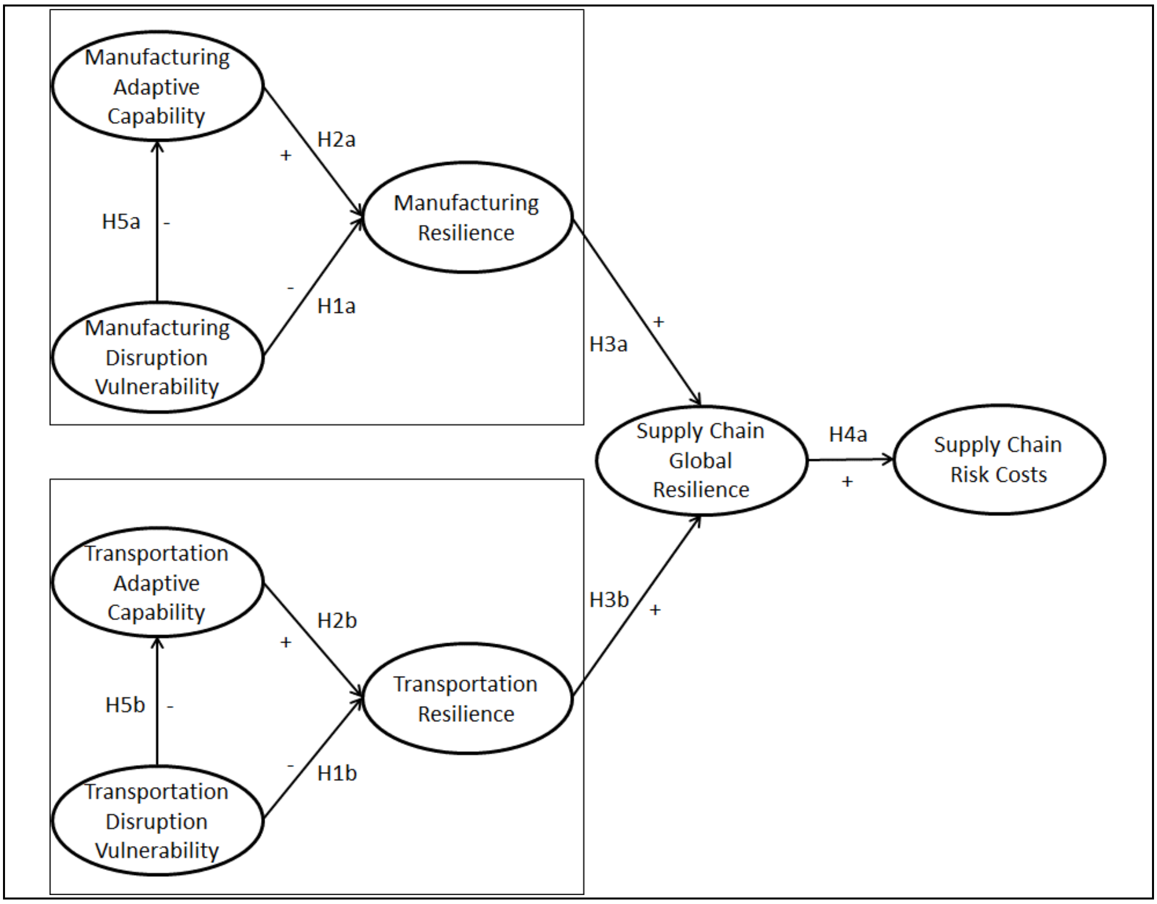

Figure 11 Proposed Mediation Causal Effect

As mentioned, besides direct effect, the interplay between independent variables is also suggested. A proposition in this regard is that effect of disruption vulnerability is mediated by adaptive capability. In the absence of intervention by adaptive capability, the resilience is expected to be low in the case of frequent disruption vulnerability. The situations for manufacturing and transportation are proposed in hypotheses H5a and H5b as shown in Table 2.

3.4.3 Moderation Effect Hypothesis

Moderation is a complex causal relationship where an independent variable changes the relationship between another independent variable and dependent variable as show. The variable that causes change in the relationship is termed as moderation variable. Moderation variable is also called relationship changer. The independent variable whose relationship is changed is the mediated variable. The dependent variable is the outcome variable. The moderating influence is modelled by devising a new variable as a product of moderating and moderated variables. In the process of assessing moderation, the effects of moderating and moderated variables on outcome variables are estimated. The interaction term is added to the model then and tested for significance. In case the effect of interaction variable is significant, the effect of moderated variable on outcome variable is said to be dependent upon the level of moderating variable. This means that low level of moderator would have low change effect and high level of moderator would have high change effect[123].

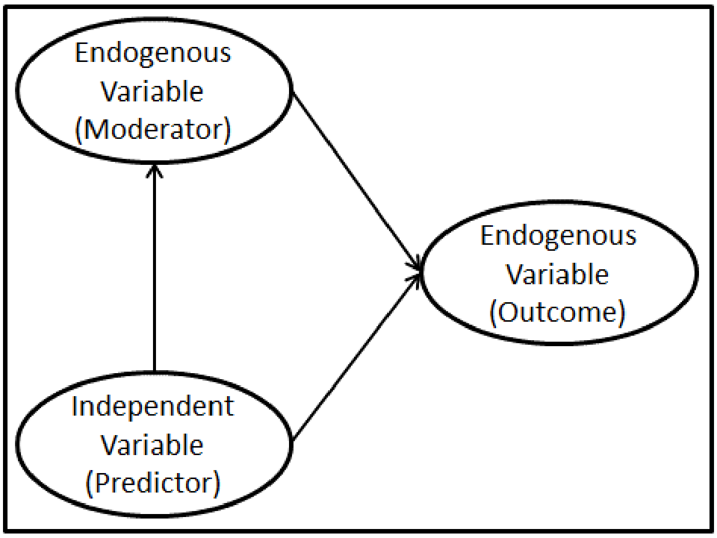

Figure 12 Moderation Causal Effect

Supply chain resilience model has adaptive capability as moderating variable that is used to moderate the effect of disruption vulnerability on supply chain resilience. The general proposition is that adaptive capability dampens the negative relationship between disruption vulnerability and supply chain process resilience.

Similarly, another proposition is that adaptive capability plays the role of moderator implying that the effect of disruption vulnerability on resilience of supply chain processes is dampened as shown in Figure 13.

[123] Little, et al., 2007, p. 216

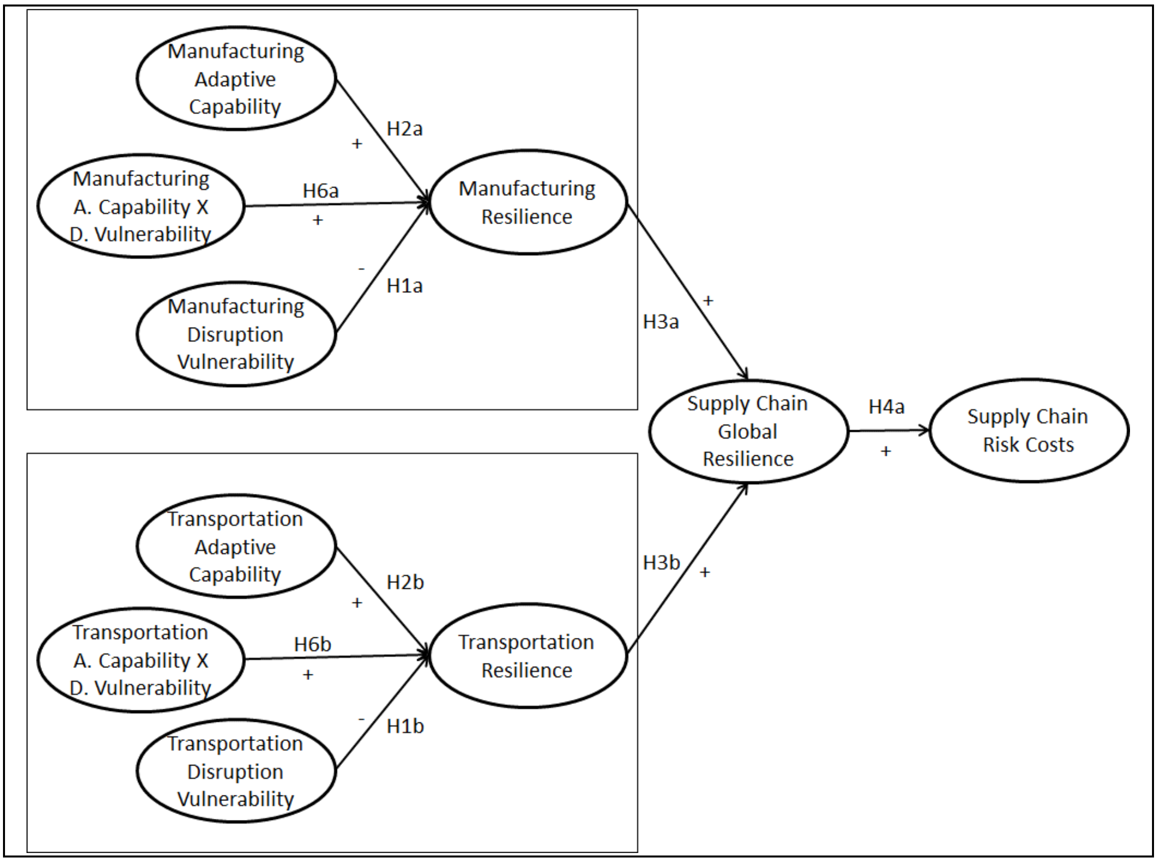

Figure 13 Proposed Moderation Causal Effect

It is also suggested that the variable of adaptive capability changes the relationship of between disruption vulnerability and supply chain process resilience. The negative relationship is expected to be dampen by adaptive capability. The situation is theoretically presented in hypotheses H6a and H6b as shown in Table 2.

Table 2 Research Hypotheses Related to Complex Relationship

Theoretical Generalization	**Hypothesis**
1. Adaptive capability is supposed to play as mediator between disruption vulnerability and supply chain process resilience.	H5a. Manufacturing adaptive capability negatively mediates the negative relationship between manufacturing disruption vulnerability and manufacturing resilience.
	H5b. Transportation adaptive capability negatively mediates the negative relationship between transportation disruption vulnerability and transportation resilience.

2. Adaptive capability is supposed to change the relationship between disruption vulnerability and supply chain process resilience.	H6a. Manufacturing adaptive capability dampens the negative relationship between manufacturing disruption vulnerability and manufacturing resilience.
	H6b. Transportation adaptive capability dampens the negative relationship between transportation disruption vulnerability and transportation resilience.

The hypothesis suggested by the extended model of resilience has been stated in the above section. The constructs are unobserved variables and need observed variables so that these could be estimated for analysis and hypothesis testing. For this purpose, the respective indicators of the constructs of international supply chain resilience model are detailed in the following section.

3.5 Indicators of the Model

The hypothesized model of international supply chain resilience has the constructs of manufacturing disruption vulnerability, transportation disruption vulnerability, manufacturing adaptive capability, transportation adaptive capability, manufacturing resilience, transportation resilience, supply chain global resilience, and supply chain risk costs. Manufacturing and transportation resilience are dependent variables determined by the independent variables of adaptive capability and disruption vulnerability of the respective processes. Supply chain ensures the flow of material from source, through different stages, to end users in right form and amount, on time and at minimum cost. The complexity of products, processes and supply chain designs have inherent risk of disruptions both internal and external.

Supply chain global resilience is the ability to maintain the overall process by using adaptive capability to control disruptions in the face of disruption vulnerability. Supply chain global resilience is influenced by manufacturing resilience and transportation resilience. Supply chain global resilience has influence on supply chain risk costs. The dependent variables of supply chain process or stage resilience contribute to overall supply chain resilience. The feedback is used for reengineering and redesign of processes, chains and network of supply chain. It is important for supply chain as whole and particularly for the supply chain processes under investigation.

The constructs of the extended model of supply chain resilience are unobserved variables that requires indicators to help measurement and analysis of the theoretical relationships among constructs. The indicators are assigned to the constructs are presented in the following Figure 14.

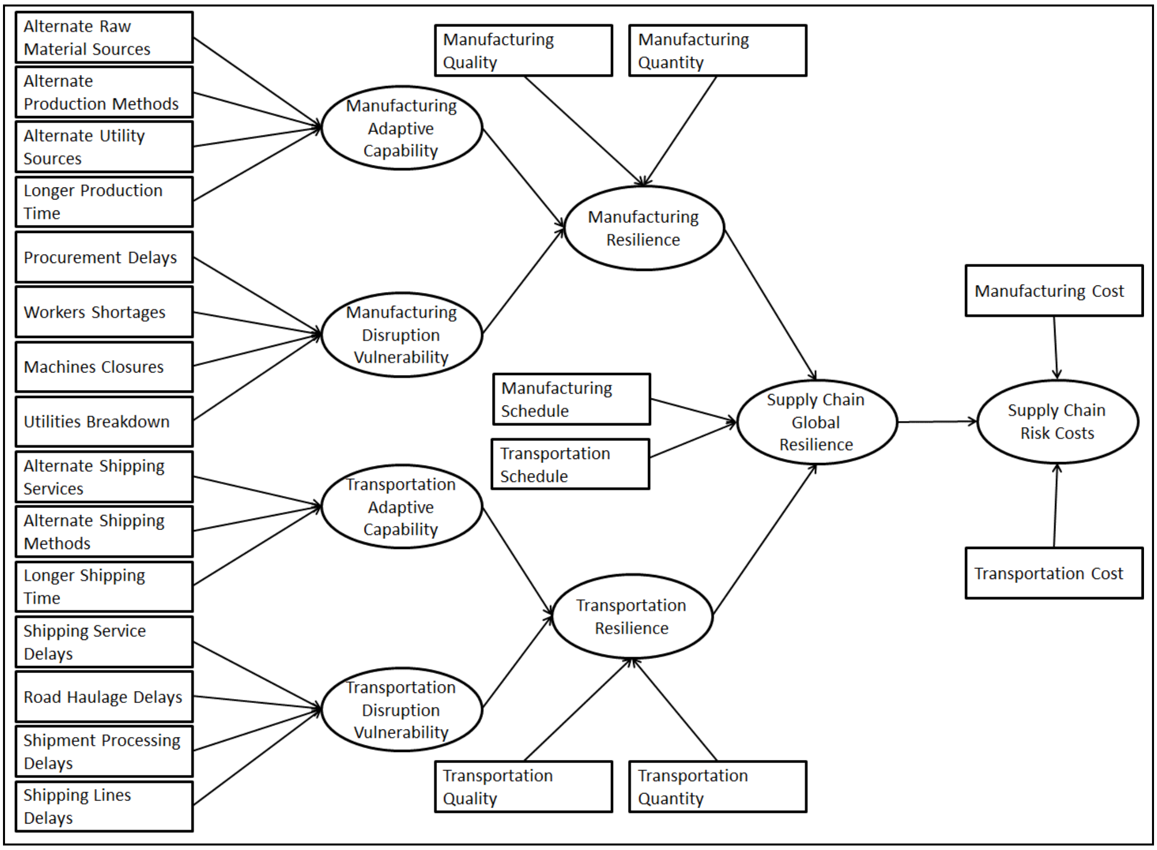

Figure 14 Indicators of Constructs of Extended Resilience Model

The concepts presented in Figure 7 are used as basis for developing indicators for constructs in the model. The conceptual framework is laid on the basic definition of process that is input is transferred into product and that serves as input to another process. Supply chain transform raw material into semi-finished and subsequently finished product that requires a number of resource inputs like supply of raw material, human resource, energy resource, machine and technological resource, utilities and transportation resources. Supply chain stages are planned in terms of quality, quantity, schedule and cost and are exposed to disruptions caused by internal, network related or environmental adverse events. Supply chain processes are carried out subsequently to deliver right product at right time and to the right customer. The indicators are assigned to the construct variables as shown in Figure 14. The following section discusses in detail the indicators for all the constructs of the model.

3.5.1 Manufacturing Adaptive Capability Indicators

Adaptive capability is the firm's ability to respond to disruptions and intervene in order to prevent the potential disturbances. Firm's ability is inherent in the structure and resources of organization as well as the external environment. From the perspective of firm production capacity, own power plant, and standby unit give flexibility, agility and adaptability in case of disruption. On the other hand multitudes of supporting industries help to switch to other suppliers of raw material in case of disruptions.

1) Alternate Raw Material Source

A supply chain firm either depends on inventory stock or look for alternative supply sources. Single, dual and multiple suppliers have their tradeoffs. However availability, accessibility and proximity of raw material sources provide the opportunity to switch to alternate supplier without time, quality and financial loss. Such locations are critical for firms that work on make to order basis and stock of raw material can be kept to a certain level because of the variations. Also medium sized firms have financial limitation to stock raw material in bulks. In case the regular supply of raw material is affected due to internal or external change event at the supplier, or during transportation or inventory stage, alternate sources and means are used to resist or mitigate the adverse effects.

The fabric suppliers play key to timely carryout manufacturing process. Each time the garments ordered by a customer has unique requirements of fabric type, color and amount. There is risk of that the fabric is not available at the regular supplier to because of require type of cloth for example firefighters, chemical laboratories, traffic controllers and electricians. The color variations also requires to arrange dyeing that would take longer depending on the vendor how long queue is there and also the power shortages. Fabric is also exposed to risk of damage during transportation and storage. In such situations fabric stock in the firm, regular supplier and the possibility of shifting to alternate suppliers without much of additional time and cost constitute adaptive capability that helps to continue functioning. Serious disruptions can be intervened by using substitute supplier of garment accessories in the locality.

2) Alternate Production Methods

Supply chain firms, like others, may be observing production disturbances due to capacity limitations, raw material shortage, human resources issues, and machine breakdowns. In such situations, production schedules are disturbed. Alternate production methods like intensive production, extra or overnight production shifts, invoking standby production units, subcontracting production, and others are adapted to meet the production targets.

3) Alternate Utility Sources

One of the important resource for operations is the availability, accessibility and reliability of utilities including water, petroleum, gas, electricity besides information technology. In case of breakdown of utilities, supply chain operations are suspended for example the production stoppages. To overcome such issues alternate sources are used like firms own or contractors sources for meeting the utilities requirements.

Firms also acquires own power generating plants in order to fill the gaps due to power outages from the main supplier. Power generating plants are expensive and also has high running costs and needs frequent maintenance and repair. Also the plants generate energy at full capacity so overtime shifts with partial workers is not cost effective. However in order to catch the production schedule, such arrangement is necessary.

4) Longer Production Time

Availability of alternative resources and methods enables supply chain firms to respond to disruptive events. However to reduce uncertainties and ensure reliability extra time is negotiated to get purchase orders with longer time. The longer lead times serve as buffer to extreme variations in the supply chain processes.

Besides the firm’s internal and external opportunities to use as alternate, firm also considers extra time that may be used as buffer against disruption. It was pointed out by garments manufacturers that under normal conditions an order takes 90 days while the promise to serve an order is 120 days considering the disruption during manufacturing and transportation.

The items for manufacturing adaptive capability are alternate material source, alternate operations capacity, alternate utilities sources and lead time flexibility.

3.5.2 Manufacturing Disruption Vulnerability Indicators

Manufacturing process requires raw material and other factors of production like workers, machines and utilities. Unexpected events resulting in disruptions of these factors constitutes the construct of manufacturing disruption vulnerability.

1) Procurement Delays

The occurrences of raw material delays owing to factors like unavailability in the market, supplier inability to serve, transportation delays from supplier, or stock out situations in the firm may cause manufacturing delays and result in discontinuities. Garment manufacturing requires fabric of specific quality, color and sizes. The timely availability of fabric is exposed to risks for example the supplier has stock out of a specific quality, color or required size due internal, upstream or environmental reasons. In such case the manufacturing process is suspended and delays the production. In a location with volatile conditions, the availability and accessibility fabric is always exposed to risk of disruption. Besides fabric, there are other raw material that are used in garments manufacturing for example buttons, zippers and tags. The unavailability of a single item causes stoppages in the process of manufacturing. Raw material availability is considered as an indicator of manufacturing disruption. The more the raw material shortages are observed the manufacturing will have more discontinuities and risks of delay. The volatile conditions like power outages, workers strike, political demonstrations and natural hazards all cause disruptions in the textile values chain from cotton grower to ginners and weaving mills to dying and printing mills that causes procurement of delays.

2) Workers Shortages

The unavailability of workers due to reasons of scarce labor market, job versus social preferences, medical, legal and financial issues may cause discontinuities in production operations. Garments industry is labor intensive and requires trained workers. The workers with not proper education and training are having the issues of quality and quantity. The properly trained worker produces 8-10 units per day while a semi-skilled worker produces 5-6 units per day. The availability of workers is also risk with the market having many garments firms in the locality. Workers also constantly moving from one firm to another due to reason for example fewer order during a season would need downsizing. The hunt for trained workers and higher payment and benefits offers competitors are the labor market dynamics causing volatile conditions that potential threaten the continuation of manufacturing. On the social side the labors lives in a collectively social structures where liabilities to families, relatives and community are preferred than attending job. Religious festivities and social gatherings are supposed to be spent among the own community. Such are the dynamics of labor market that has potential risk of worker shortages and manufacturing stoppages.

3) Machine Closures

The occurrence of machine breakdowns and stoppages also cause manufacturing stoppages, disturbing the production plan and order completion. Garments industry is also machine intensive with machines with special functions for example normal stitch, button fix, button holes, double stich, and over-lock. The machines are used across shifts that needs regular maintenance. Besides regular maintenance stoppages, machines also experience down time due to disorders. The machine down time potentially disrupt the continuation of manufacturing process.

4) Utilities Breakdown

The occurrence of utilities breakdowns like electricity, gas and water result in idle time that causes delays in order completion. The power interruptions and switches between regular electricity supply and firm's own power generators adds to machine down time that affects the overall production of the firm. The power stoppages cause disruptions and also the fluctuation cause machine defects that are closed for maintenance.

Therefore, manufacturing disruption vulnerability is related to material resources, human resources, machine resources and utilities resources. The procurement delays, workers shortages, machines closures, and utilities breakdown are used as indicators of manufacturing disruption construct.

3.5.3 Transportation Adaptive Capability Indicators

Transportation adaptive capability allows the use of alternate ways and methods in case of delays during the process. In the advent of disruption in transportation process, alternate shipping service, alternate shipping method and extra time to transport are the measures taken to ensure delivery of products in time.

1) Alternate Shipping Services

Products are directly containerized at factories or moved from factory to collection point through trucks for containerization. The availability and accessibility of shipment service is important. The location with many freight forwarder give the flexibility to use alternate freight forwarders in case of unavailability or closure of regular shipping service provider. This allows the use alternate freight forwarding firm who fulfills the shipping request and help to maintain the transportation plan.

The delays at service provider is often sought to be solved by calling alternate shipping service. This depends on the number of shipping service providers in the locality. With fewer shipping service it is always difficult to get alternate service with shortest time and competitive costs.

2) Alternate Shipping Methods

The goods may be transported through sea, air, and road or train freight. Similarly shipments through alternate routes is also a contingency approach to ensure timely transportation. Multi-model transportation approach is also applied to utilize combination of freight transportation modes and routes. In case of occurrence of disruptions, freight forwarder offers alternate mode or route to customer for timely delivery of shipment. Adaption of alternate transportation mode is subject to customer's agreement and used once the customer commits to bear any additional costs.

Road transportation is challenged by number of disruptions. The road haulage schedule is exposed to disturbances due to many reasons. The shipper had to decide and request alternate route or mode transport in order to meet the schedule and deliver goods at port in time to catch the shipping line. Otherwise the next possibility would be after days, weeks or months depending on the frequency of international shipping lines in a location. A location with alternate road, train, air, or ship routes and modes allow the shipper to adapt to alternate route or mode in order to meet the schedule targets.

3) Longer Shipping Time

As an approach to reduce uncertainties, extra time is added to the normal lead time as a buffer to delays caused by disruptions within and outside the system. The use of extra time requires cautious usage only under pressing conditions. Otherwise the firm will not be able to offer competitive advantage and qualify for supply chain partnership.

Shipment is threatened by delays at ports during administrative procedures, documentation, custom and security clearance, cargo handling. In such situation, the shipper can intervene but to a certain extent. In case of delays the shipping lines are missed and delivery schedules are difficult to be meet. As a buffer the manufacturer negotiates longer time for delivery of an order. Transportation process has buffer of extra time that absorbs delays causing during transportation. Manufacturers in locations with other competitive advantages are compromised for longer times in order to have reliable delivery schedule.

The transportation adaptive capability has indicators of the frequency of using alternate shipping service provider, alternate shipping method among road, train, air or ship, and the use of longer time for delivering goods.

Given to the nature of transportation process, the input, operations and expected services are different. The transportation adaptive capability is measured by alternate shipping services, alternate shipping methods, longer shipping time items.

3.5.4 Transportation Disruption Vulnerability Indicators

Transportation process spreads across different locations involving different supply chain entities such as shipping services providers, ports services and shipping lines. The process is exposed to disruption at different stages of transportation at the shipping services provider, road transportation, cargo handling and administrative procedural delays at ports, and shipping lines. The construct of transportation disruption vulnerability has indicators measuring the delays during transportation process at the shipping services, road haulage to/ from ports, handling and administrative processing of shipment at ports and the shipping lines. Transportation disruption vulnerability is related to freight forwarding services, transportation infrastructure, cargo processing facility, shipping lines.

1) Shipping Service Delays

The inability of freight forwarding firm to attend the shipping requests by customers due to unavailability of containers, limited trucking facilities, service closure on days other than scheduled holidays due to social occasions or strikes.

Closure for a single day may cause a delay for whole week in case of missing the scheduled shipping line

2) Road Haulage Delays

Delays may occur during road transportation between facilities and ports due to carrier breakdowns, accidents, traffic jams, road blocks and others. Outbound transportation from manufacturer facility to port of export is located in the manufacturer's country. Inbound transportation from port of import to customer facility is situated in customer's country in case of international supply chain. The quality of transportation infrastructure is determinant of disruption vulnerability during shipment.

3) Shipment Processing Delays

Delays may occur during the administrative processing of the cargo because of capacity issues, high security levels, bureaucratic culture, bribery and others. Delays at this stage may result in missing of scheduled cargo lines and cause late delivery at the ports of import and then to the customer facility.

4) Shipping Lines Delays

Delays during departures and arrival of shipping lines due to limited cargo handling capacity at ports, ports congestions, shipping lines delay and others situations may arise resulting in late delivery at ports of import and later on to the customer facility.

3.5.5 Manufacturing Resilience Indicators

Supply Chain resilience is predicted by its constituent's processes for example manufacturing. As mentioned above, resilience is the continuation of processes such that the desired objectives of a process are achieved. Manufacturing aims at producing product in demanded quantities and according to the quality specifications. According to the framework of resilience, manufacturing is affected by disruption vulnerabilities that potentially causes discontinuities and variability and whereas the firm's ability to respond to such disruptions effectively prevents manufacturing from potential disturbances and help to resist, recover or adapt the function of manufacturing to it normal level. Normal functioning would mean that demanded quantity is produced with specified quality and within minimum costs. The indicators of manufacturing resilience are meeting of quantity targets, with required quality objectives and planned cost targets. Manufacturing aims at meeting the quality and quantity objectives constitutes the construct of manufacturing resilience.

1) Manufacturing Quality

Manufacturing processes is carried to produce the desired products. The level of rejects during manufacturing of an order represents the process quality. Supply chain resilience aims at maintaining conformity to specification.

2) Manufacturing Quantity

Manufacturing quantity is unique to organizations depending on number and capacity of machines and human resources. The ability of firm to conform to order quantities is determined by production capacity that allows the firm to handle order quantities.

3.5.6 Transportation Resilience Indicators

The process of transportation aims at moving materials and good across supply chain. The process seeks reliability in terms of moving required amounts with minimum damages. It ensures that material and goods are delivered at destinations in demanded quantities and with quality specified. Transportation resilience is determined by transportation disruption vulnerability and transportation adaptive capability. The construct of transportation has indicator variables measuring that how often the transportation process is able to serve the complete quantity demanded and how often the quality is maintained with fewer losses. The aspects are explored through measuring losses during transportation and capacity issues to transport required amount.

1) Transportation Quality

Products shipment is vulnerable to losses during transportation because of issues related to road haulage, condition of route, containers and handling of shipment. The aim is to maintain shipment services with required quality targets.

2) Transportation Quantity

The ability of transportation service to ship complete order quantities to customers is important for timely delivery of products to customer. In locations with less developed infrastructure and insufficient shipment services, transportation is vulnerable to disruptions and may not be able to cater the needs of shippers.

3.5.7 Supply Chain Global Resilience Indicators

Supply Chain Global Resilience (SCGR) is a construct that measures how well a supply chain functions after a disruption occurs and adaptive measures are taken. This is dependent variable that is predicted by resilience of supply chain processes. The model in this study proposes that garments manufacturing resilience and garments transportation resilience determine the overall or global resilience of supply chain.

It is important to understand that supply chain resilience looks for the continuation of functioning. The concern of both the manufacturer and customer is the reliability of supply that stands against disruptions through interventions or corrective measures. The ultimate aim is to complete timely manufacturing and ensure on time delivery of products at the customer. It is suggested that supply chain resilience is formed by timely manufacturing and on time delivery. The customer requires manufacturers to manufacture and deliver products in time so that the sales offers could be made available on time otherwise variability will result in loss of customer for the wholesalers and retailers and in turn the manufacturer would lose supply contract in the long run. The indicator variables of supply chain resilience are the manufacturing process producing and delivering products in time to the customer that is the timely manufacturing and on time transportation.

1) Manufacturing Schedule

The ability of firm to meet order schedules depends on quality and capacity of manufacturing process. Variations in input resources, quality of production process and capacity of manufacturing leads to variations in manufacturing schedules.

2) Transportation Schedule

In order to ensure the supply of products to customers in time, meeting of delivery schedules and lead time reliability of the supply chain firm are critical. Transportation service quality and capacity determine the delivery of product on schedule.

3.5.8 Supply Chain Risk Costs Indicators

One of the dependent variables in the supply chain resilience framework is the construct of supply chain risk costs (SCRC). Supply chain has processes that are carried out within stipulated time and costs. Variability in supply chain operations leads to increase in planned costs as shown in Figure 7. Shortage of raw material requires to approach alternate supplier that adds to cost in terms of price negotiation and transportation. The worker shortages stress upon to arrange for substitutes at the high remunerations. The frequent machine maintenance and repair stoppages result in unused time of the workers and the power that is supposedly generated for all the machines. The power outages from supplier is substituted by firm internal power generators that are costly in terms of operation and maintenance. Use of longer manufacturing time is also used as a preventive measure to absorb the disruptions and ultimately produce the demanded products in time with using minimum alternatives. However, the additional time is a resource and has thus its cost. Manufacturing cost is one of the indicators of supply chain cost.

Disruptions in transportation stage is also result in excess costs. The unavailability of containers or capacity constraints of transportation provider poses potential threat to timely delivery and is intervened through opting for alternate transport provider. The temporary contracts are not price competitive as the shipper is interested in meeting the delivery time at the cost of comprising the costs. The road transportation has hazards for example road accidents, blockades, robberies, and vehicle breakdowns. The alternate transport is sought as problem resolution in quest for timely delivery and additional costs are added. Similarly, using alternate method for example truck, train, air or sea is switched for quantity, quality or schedule objectives resulting in additional costs. The additional time for transportation is a preventive measure that is used as buffer against disruptions. The use of alternate resources has cost impact. Transportation cost is the second measure of supply chain cost.

1) Manufacturing Cost

The ability of manufacturing firm to keep the prices at minimum while ensuring quality, amount and schedule of orders. Manufacturing rejects, limited production capacity and delayed production cause increase in overall order production and supply chain costs.

2) Transportation Cost

Transportation losses, partial shipments and delayed deliveries cause increase in transportation costs. Supply chain resilience ensures cost minimization by maintaining transportation resilience.

To sum up, supply chain resilience extended model has been developed into the constructs of manufacturing and transportation disruption vulnerability, manufacturing and transportation adaptive capability, manufacturing and transportation resilience, supply chain global resilience and supply chain risk costs with respective indicators. The indicators are related to supply chain processes of manufacturing and transportation. The constructs have the respective indicators as presented in Table 3.

Table 3 Research Variables[124]

Research Variables	Sub Variables	Indicators
Disruption Vulnerability (Exogenous Variable)	Manufacturing Disruption Vulnerability	Procurement Delays
		Workers Delays
		Machine Closures
		Utilities Breakdown
	Transportation Disruption Vulnerability	Shipping Service Delays
		Road Haulage Delays
		Shipment Processing Delays
		Shipping Lines Delays
Adaptive Capability (Exogenous Variable)	Manufacturing Adaptive Capability	Alternate Raw Material Sources
		Alternate Production Methods
		Alternate Utility Sources
		Longer Production Time
	Transportation Adaptive Capability	Alternate Shipping Services
		Alternate Shipping Methods
		Longer Shipping Time
Supply Chain Processes Resilience (Endogenous Variable)	Manufacturing Resilience	Manufacturing Quality
		Manufacturing Quantity
	Transportation Resilience	Transportation Quality
		Transportation Quantity
Supply Chain Global Resilience (Endogenous Variable)		Manufacturing Schedule
		Transportation Schedule
Supply Chain Risk Costs (Endogenous Variable)		Manufacturing Risk Costs
		Transportation Risk Costs

The variables of disruption vulnerability, adaptive capability and processes resilience have sub variables related to the processes of manufacturing and transpor-

[124] Blackhurst, Dunn, & Craighead, 2011 / Pettit, Fiksel, & Croxton, 2010 / Gallopín, 2006

tation. The processes, being unique in nature, adapts relevant indicators for measuring purposes. The variables of supply chain global resilience and supply chain risk cost are detailed level concepts and therefore has no sub variables.

It is important to note that disruption vulnerability and adaptive capability are exogenous variables. In the extended supply chain resilience model, manufacturing disruption vulnerability, transportation disruption vulnerability, manufacturing adaptive capability and transportation adaptive capability are independent variables. The causality flows from these variables and not vice versa therefore these are termed as exogenous variables. Whereas causality flows into the variables of manufacturing resilience, transportation resilience, supply chain global resilience and supply chain risk costs therefore these variables are termed as endogenous variables.

Thus, supply chain resilience model has been elaborated with all the constructs and indicators. The theoretical relationship between indicators and constructs is to be empirical investigated before examining the relationship between constructs. As the extended model of supply chain resilience is having outer and inner model, the following section discusses structural equation modelling as suitable modeling approach for analysis.

3.6 Structural Equation Modeling

Empirical studies attempt to measure variables of interest and assess the assumed relationship among these variables. The supply chain resilience model suggests relationship between indicators and constructs and among constructs shown in Figure 14. Survey instrument has been devised and used to conduct survey to collect data. The next step is to find suitable statistical method for estimation of the model for relationships among variables. The model of supply chain resilience presented in Figure 14 has unobserved variables with each represented by a set of measured variables. Structural equation model is a state of the art method to assess the relationship among unobserved variables and observed variables. It is a statistical method to model, measure and test variables for such relations[125]. It is based on statistical methods like analysis of variance, factor analysis, multiple regression analysis and path analysis. It has been applied in psychology, management, economics, sociology, political science, marketing and education since 1980s.

Structural equation modeling has the ability to model and estimate the unobserved variables on the basis of observed variables. It is also capable of capturing the causal relationship among unobserved variables where the variables adapt the roles of dependent and independent variables[126]. Casual relationships among variables are drawn from theory and structural equation modeling has the ability to test the hypothesized model of relations among observed and unobserved variables. It uses number of measurements to see how well the model is represented by the observed data. However, structural equation modeling only shows the statistical significance of the proposed hypothesis and therefore a statistically significant model does not necessarily mean that the theory of the model is true. It is primarily related to the fit of model to data and not to be used to confirm the theoretical basis of the model[127]. The hypothesized structure model rather needs to be based on sufficient knowledge and sound theoretical foundations.

Structural equation modeling can be used for theory development, theory testing and testing of causal relationship among variables. Theory development is the process of exploring relevant indicator variables of unobserved variables. The unobserved variables are also termed as constructs. The approach does not impose structure of relations among variables. Indicators variables are tested freely without being assigned to a construct. The significantly related indicator variables are grouped together and are named under a suitable common heading as a construct. It is necessary that a construct sufficiently represents the indicators

[125] Hoyle, 2012, p. 3

[126] DiLalla, 2000, p. 439

[127] Hoyle, 2012, p. 4

because factors are used in place of the individual indicator variables for further analysis. As a result theoretical models are developed that consist of factors and the respective indicator variables. This approach is known as exploratory analysis. Unlike theory building, theory testing proposes a theory at first that is modeled and tested for soundness statistically. Constructs are derived from theory and respective determinants and specifics are developed as indicator variables. Theoretically proposed models consists of constructs along with assigned indicators. The indicators of constructs are tested for soundness to identify whether a construct represents the indicator variables adequately as reflective model or the indicator sufficiently captures the concept as formative model. This approach is called as confirmatory analysis. Furthermore, the constructs assume roles of independent and dependent variables and develops in a causal model. Independent variable, in causal model, adapts the role of predictor variables that determine dependent variable. Dependent variable is the outcome variable. Variables, in such relations, are developed as structural equation models that are tested for cause and effect relations[128]. As the construct is an unobserved variable that is estimated through the shared covariance among the observed variables[129]. Therefore, structural equation modeling is also termed as latent variable modeling, covariance structural modeling and causal modeling[130].

Structural equation modeling is well suited statistical method to estimate the causal relationship proposed in this study. There are unobserved variables namely manufacturing adaptive capability, manufacturing disruption vulnerability, transportation adaptive capability, transportation disruption vulnerability, manufacturing resilience, transportation resilience, supply chain global resilience, and supply chain risk costs. These are the constructs that are supposedly representing group of certain measurement variables called indicators. The indicators are to be tested for validity and the causal relationship among the constructs is to be exam-

---

[128] DiLalla, 2000, p. 439

[129] Hoyle, 2012, p. 3

[130] Hoyle, 2012, p. 3

ined. The purpose of measuring the relationship is to help describing, differentiating, explaining, predicting, diagnosing and deciding on problems. A theory helps either implicitly or explicitly to identify the relevant variables to be studied about their operations or relations among themselves[131]. In order to study the relevant variables numbers are assigned to aspects of objects or events according to the practices. Advanced mathematical or statistical tools are applied to measure and examine aspects and relationship among objects[132]. Structural equation modeling has been considered as appropriate tool for the measurement and evaluation of supply chain resilience model in this study.

For analysis purpose it is important to differentiate that structural equation model comprising of inner model and outer model. Inner model is the part that has constructs and respective indicators. Outer model has the constructs that are related in a directional way having cause and effect relationship. The inner model is tested for validation in order to establish that the indicators and constructs are sufficiently related. The inner model is tested for theoretical relationships for significance.

Once structural equation model modeling is determined as an estimation method, further decisions are to be made regarding the nature of indicators as reflective or formative and selection of estimation approach as partial least square method (PLS) or covariance based (CB) structural equation modeling.

3.7 Establishing Nature of Indicators

Indicator are either reflective or formative in nature and there are different criteria to establish the nature of constructs as summarized by researchers like Jarvis et al.[133] and Coltman et al.[134]. The constructs of supply chain resilience model are

---

[131] Pedhazur & Schmelkin, 2013, p. 15

[132] Stevens, 1968, p. 854

[133] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203

[134] Coltman et al., 2008, p. 5

manufacturing disruption vulnerability, manufacturing adaptive capability, manufacturing resilience, transportation disruption vulnerability, transportation adaptive capability, transportation resilience, supply chain global resilience, and supply chain risk costs as shown in Figure 8. The following section the indicators are discussed against the given criteria to establish the nature as reflective or formative. There are theoretical and empirical considerations that are considered for establishing the nature of indicators[135].

3.7.1 Theoretical Considerations

The theoretical considerations include the composition of construct, direction of causality, and characteristics of indicators. The first criteria is to examine the composition of construct that explains the structure of construct. Reflective constructs exists independent of indicators, whereas formative construct is a combination of indicators[136]. The question posed are whether the indicators are naturally existing or formed. Reflective indicators are the manifestations of construct naturally existing in the nature. Formative indicators are the defining characteristics of construct that are devised by bringing different aspects under a single phenomenon[137]. For example, manufacturing and transportation cost variables have been combined into construct of supply chain risk costs. The construct of supply chain global resilience is a result of timely manufacturing schedule and transportation. Quality of manufacturing process and meeting quantity targets represent manufacturing resilience. Similarly transportation has indictors of transportation process quality and quantity. Raw material shortage, workers shortages, machine breakdowns, and utilities outages represent the construct of manufacturing disruption vulnerability. Manufacturing adaptive capability has indicators of using alternate supply of raw material, alternate production method, alternate utility source, and extra time for manufacturing. Transportation disruption vulnerability

---

[135] Coltman et al., 2008, p. 5

[136] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203

[137] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203

is formed of shipping service delays, road delays, shipping processing delays, and shipping lines delays. The construct of transportation has indicators of alternate shipping service, alternate shipping methods, and extra time for transportation.

The indicators are not manifestations of constructs and therefore not dependent on constructs. Rather, all of the constructs of the model are dependent upon the indicators. The indicators are the defining characteristics of these constructs suggesting formative nature.

The second criteria is to assess the direction of causality that explains whether the indicators are reflection of the construct or the indicators forms the concept. Reflective indicators causality is directed from construct to indicators and for formative indicators the flow of causality is from indicator to construct[138]. As the reflective indicators are manifestation of construct, changes in the construct would cause changes in the indicators. The causality flows from constructs to indicators. On the contrary, variation in formative indicators would result in changes in construct and therefore the causality flows from indicators to construct. As the composition of indicators in the preceding section is suggested as formative, the causality is assumed to flow from indicators to constructs as shown in Figure 14. For example, raw material delays, workers shortage, machine stoppages or utilities breakdowns would cause variation in the construct of disruption vulnerability.

The next criteria is characteristics of indicators that examines the indicators with respect to the theme. The indicators of reflective indicators shares a common theme because these are manifestations of a common construct whereas formative indicators do not share common theme as these are defining characteristics of the construct[139]. The indicators of alternate raw material sources, production

---

[138] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203 / Coltman et al., 2008, p. 5

[139] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203 / Coltman et al., 2008, p. 5

methods, utilities sources and extra time buffer for production are different inputs of process that together define the construct of adaptive capability. Reflective indicators are different aspects of a single theme and are therefore interchangeable. Formative indicators are different dimensions and are therefore not able to take the place of each other. For example raw material sources cannot take the place of production methods and so on. Reflective indicators, pinned around a common theme, are interchangeable and thus dropping of an indicator would not change the conceptual domain of the construct. However formative indicators are the different dimensions combined together to give rise to theoretical construct that are not interchangeable and thus dropping of an indicator would change the conceptual domain of the construct. For example the formative construct of disruption vulnerability would change in scope if the any of the indicators of raw material delay, workers shortages, machine closures or utilities breakdown is removed. The indicators in supply chain resilience model are neither of a common theme, nor interchangeable and therefore treated as formative indicators shown in Figure 14.

3.7.2 Empirical Considerations

From empirical perspective, the considerations taken into account are items correlations, items relationship with constructs and measurement error and collinearity. The first consideration is the correlations among indicators that explain the behavior of each indicator against the rest of the set of indicators of a construct. As mentioned, reflective indicators are manifestations of a construct and are expected such that change in one indicators would result in change in the other indicators of the construct. For formative indicators correlation among indicators is not necessary[140]. The supply chain resilience model with formative indicators is therefore expected to have any pattern of inter correlation unlike reflective indicators that are expected to have high positive inter correlations.

[140] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203 / Coltman et al., 2008, p. 5

The second consideration is the relationship between indicators and construct relationship. Reflective indicators are expected to have the same antecedents and consequences as these are characteristics of a construct that are interchangeable. Formative indicators are different dimensions and are expected to have different antecedents and consequences[141]. For example the antecedents of raw material delay could be failure of supplier, the shortage of workers would have other antecedents for example political demonstrations.

The third empirical consideration is the measurement error that explains the discrepancy between the data and the model. Error terms in items can be identified in reflective indicators but these are not estimated in formative indicators. The formative indicators in the supply chain resilience model are tested for predictability that attempt to establish if formative items behaved as predicted unlike reflective indicators that aim to extract out measurement error[142].

The guidelines for establishing the indicators as reflective or formative have been followed. All the constructs of supply chain resilience model including supply chain cost, supply chain global resilience, manufacturing resilience, manufacturing disruption vulnerability, manufacturing adaptive capability, transportation resilience, transportation disruption vulnerability, and transportation adaptive capability have been discussed in terms of the nature of construct, direction of causality, interchangeability and correlation. The answers to question posed by Petter et al. are tried to be answered to assess the nature of constructs[143]. The constructs of the model are combination of various indicators. The causality flows from constructs to the respective indicators. Dropping of any of these indicators would change the domain that is being measured. Change in one indicator is not expected to necessarily cause changes in the rest of indicators. These measures have different antecedent and consequence. As an example adaptive

---

[141] Jarvis, MacKenzie, & Podsakoff, 2003, p. 203 / Coltman et al., 2008, p. 5

[142] Coltman et al., 2008, p. 5

[143] Petter, Straub, & Rai, 2007, p. 642

capability is predicted by alternate sources and operation methods and disruption vulnerability is predicted delays in input and operation of the process, dropping out any of the indicators would change the measuring purpose of construct, changes in any of these indicators do not necessarily cause change in the other indicators and lastly the antecedents and consequences of the indicators are different as mentioned earlier.

The formative constructs are constructivist, operationalist or instrumentalist interpretation of by the scholar and therefore requires content validity[144]. Content validity ensures that the entire domain of a formative construct is captured[145]. The methods are establishing content validity on theoretical foundations in literature and expert panel. For the constructs in supply chain model two approaches were adapted. The formative indicators are based in the well-known system theory and resource based view of organization[146]. The indicators have been discussed by Pettit et al. and comprehensively tabulated[147]. The other approach is the involvement of experts in the business. The contents were developed in the special context in consultation with the practitioners. The content was thus also validated through experts.

Once the nature of the indicator variables of the model is established, the next step is to choose methodology of structural equation modeling to be used for estimation of the model. The estimation methods are partial least square and covariance based structural equation modeling. In the following section, suitability of estimation method is discussed for the proposed model of supply chain resilience.

---

[144] Borsboom et al., 2004, p. 1065

[145] Petter, Straub, & Rai, 2007, p. 633

[146] Blackhurst, Dunn, & Craighead, 2011, pp. 375-376

[147] Pettit, Fiksel, & Croxton, 2010, pp. 18-20

3.8 Summary

The preceding sections discusses the existing supply chain resilience literature suggesting that resilience is influenced by vulnerability and capability. This study is considering supply chain resilience context and therefore the factors are discussed within the context. The existing supply chain resilience framework is extended by including manufacturing and transportation disruption vulnerability, adaptive capability, and processes resilience, besides supply chain global resilience and supply chain risk costs. This study incorporates the factor of resilience of process carried out during supply chain stages of manufacturing and transportation. Additionally the framework includes consideration for the organizational situation and locational settings of supply chain firms that contribute to both reliability or variability of operations. Furthermore, supply chain processes are viewed from system perspective that has input, operations and output carried out by supply chain partnering firms. The output of a firm is input to another firm in the supply chain.

The relationship among constructs are hypothesized. For measurement purpose, indicators are assigned to the constructs of extended resilience model for international garments supply chain. The constructs and indicators are summarized in Table 3. The extended model is discussed as a structural equation model and the outer model is established as a formative model. The next chapter presents the design and methodology for empirically testing the framework defined in this chapter.

4 Research Design and Methodology

Research design and methodology attempts at 'linking empirical data to study's initial research questions and ultimately, to its conclusion'[148]. The research hypotheses presented in Table 1 are to be examined empirically. The data on research variables and indicators is to be collected for the purpose of testing and analysis. Section 4.1 is introduction to research paradigm. Section 4.2 presents research design including the ontological, epistemological and methodological considerations for this study. Section 4.3 explains research methodology including research strategy, research technique, purpose of research, selection of research sites, population, sample and time horizon. Section 4.4 discusses the structured questionnaire as the data collection technique. Section 4.5 of the chapter discuss the administration of questionnaire for collection of data. Section 4.6 discusses the statistical method for estimating the model. The last section 4.7 presents the summary of the chapter and mentions the following chapter that provide setting for empirical study.

4.1 Research Paradigm

It is important to define the philosophical understanding of the real world phenomena that is the subject of enquiry or research. Research paradigm assigns one or the other norm to approach reality and guide on ontology, epistemology and methodology. Ontology refers to the nature of reality, epistemology is the researcher's relation with reality and methodology is the use of approach to capture the reality[149].

Ontology defines the form and nature of reality. It answers such questions as what is there to be explored. How does the reality exist? Reality may be viewed from the perspective of positivism, post-positivism, critical theory or construc-

[148] Yin, 2014, p. 19

[149] Guba & Lincoln, 1994, p. 105

tionist. Positivism considers reality as time and context free that is generalized and comprehendible by immutable law of nature. Post-positivism views reality that cannot be captured completely because of flawed human and scientific methods and nature of phenomenon. According to critical theory reality is thought to be historically developed as refined truth. Reality form constructionist point of view is multiple and intangible as perceived from individual perspectives according to Guba and Lincoln.

Epistemology defines the relation between researcher and reality. The relations are guided by ontological assumptions of the nature of reality. Guba and Lincoln explains the situation as ‘if reality is assumed, then the posture of knower must be one of the objective detachment or value freedom so as to discover how things really are and how things really work’[150]. The positivism guides the relationship between researcher and subject as independent without any influence on reality. The post-positivism suggests the influence of preexisting knowledge through editors and reviewers. The critical theory assumes the intervening role of researcher that mediates the findings through the values system of the researcher. The constructionist considers the mutual importance of researcher and the subject and reality is interpreted after developing mutual consensus.

The nature of reality and relation of researcher with subject guide the methodological approach to capture reality. The methodology for positivism is scientific and quantitative method that assumes controls in order to avoid influence[151]. The methodology for post-positivism includes information on the situational setting to make up the deficiency of positivism. Critical theory capture reality through dialogue between the enquirer and subject to get informed. The constructionist uses the methodology to talk to the actor and interpret the information. The research design and methodology used in this study is presented in Table 4.

[150] Guba & Lincoln, 1994, p. 108

[151] Guba & Lincoln, 1994, p. 109

Table 4 Research Design and Methodology

Research Design	Paradigm	Description
Ontology	Post Positivism	Reality is context based
Epistemology	Post Positivism	Guided by preexisting knowledge
Methodology	Post Positivism	Inquiry was made in natural setting
Strategy	Quantitative	Deductive, theory testing, data collection
Technique	Survey	Questionnaire, Interview or data collection
Purpose	Explanatory	Explaining causality among variables
Time Horizon	Cross sectional	In a point of time, across three countries

In the background of above discussion the ontological and epistemological considerations for the study are presented that guides the methodology for capturing the reality as summarized in Table 4.

4.2 Research Design

Manufacturing and logistics firms fall under the category of human intuitions different from natural science and thus post positivism approach has been taken. The firms are studied for different aspects under internal and external influences from where the input resources are sourced to perform operations for specific objectives. The research have developed framework for the phenomena of supply chain resilience.

The researcher involves manufacturers through questionnaire in order to capture the reality by considering the settings and experience of the subject. The serving of questionnaire in person was to get the perspective of the supply chain focal firm on the processes of manufacturing of garments and transportation to customers.

The question of how to perform research is answered in order to clearly define the approach to investigate the research issue. This study is qualitative and primarily for theory testing to empirically investigate the hypothesis proposed in the research framework, unlike the theory building research approach that does not assume relationships. The next section details the research methodology.

4.3 Research Approach

Research methodology explains the approach to capture reality. The research methodology in this study is quantitative. Strategy to conduct quantitative study is theory testing or verification. The technique used is survey through questionnaires to collect data for empirical analysis.

The study is quantitative and uses survey technique to study international garments supply chain with partners in different countries. The advent of globalization accompanied with development in communication and transportation has changed the business paradigms from local organizational focuses to cross cultural and cross organizations. Coupled with supply chain concepts the international supply chain phenomena has been the focus of research during last decades. The business are taken across geographical boundaries and search for location of supply, production and distribution processes disperses over countries and continents. Many a reason have been assigned to this for example the increased labor and production costs in the industrialized countries have urged for shift of production facilities to developing countries including china, India, Turkey, Malaysia in Asia and Brazil and others in Latin America.

The purpose of research is explanatory. The study aims to explain the causal relationship among constructs of supply chain resilience. The study is not exploratory or descriptive that aims at theory building or description of situations. The study of international garments supply chain is cross sectional and conducted at a point of time. The variability is studied from the perspective of subjects across the population of interest unlike longitudinal studies that examine variability regarding an individual over a period of time. The study is limited in its scope and does not include the consideration of what happens to resilience over a period of time. The following part of the chapter is concerned with selection of research sites, population and sample.

4.3.1 Selection of Research Sites

The population is selected such that the purpose of the study is served. The framework of the study intends to examine the effect of manufacturing and transportation resilience on garments supply chain global resilience and risk costs as shown in Figure 7. The approach is to follow international supply chain stages over countries and also to compare a stage in two different countries to assess the impact of country conditions. Garments supply chain is considered and the processes of manufacturing and transportation to the customers are surveyed through questionnaire.

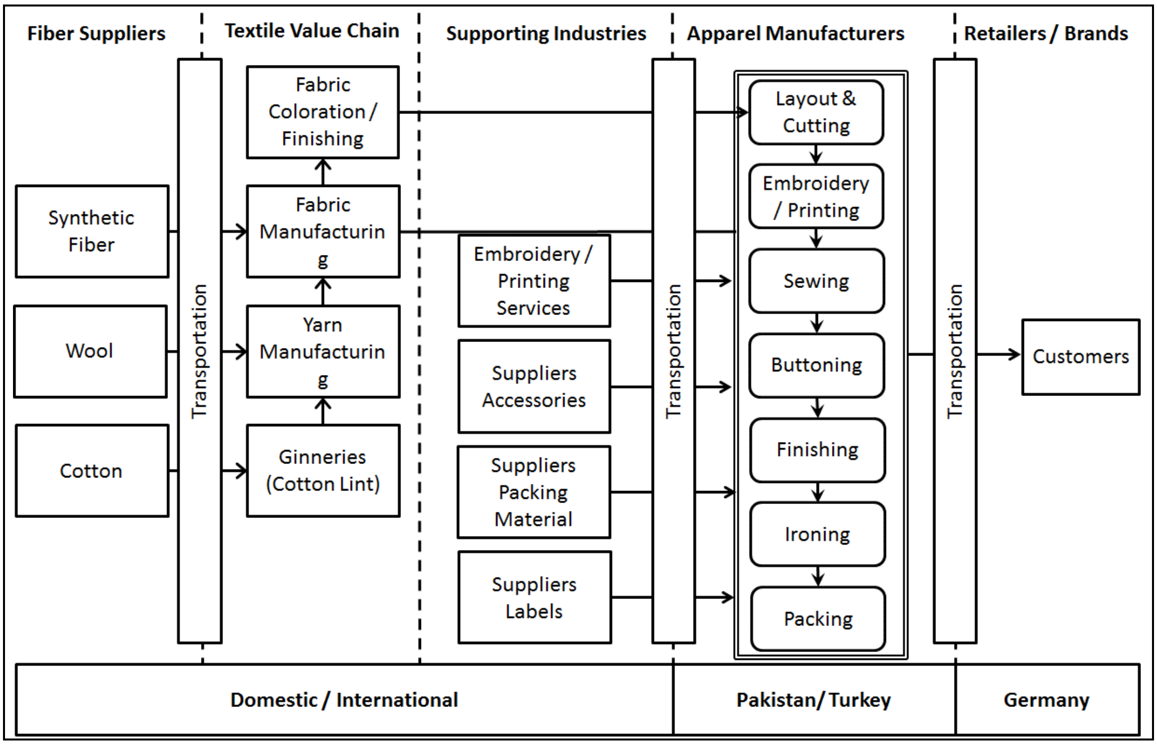

Figure 15 International Garment Supply Chain

The research sites that serves the purpose of the study are the manufacturers in Pakistan and Turkey. They are surveyed to examine the assumption that same stage of international garments supply chain in different countries is influenced by the conditions of the country for example manufacturing and transportation in Pakistan and Turkey. The other approach is to follow the subsequent stages of international garments supply chain manufacturing and transportation in the same country for example Pakistan and Turkey. The transportation stage in Germany is also included for comparison purpose. The aim is to assess the assumption that the country specific conditions affect the stage of international supply carried out there and the impact is propagated to the following stages operated in the same or other country.

4.3.2 Selection of Research Population

The international garments supply chain stages covered in this study are manufacturing and transportation. Garments manufacturer work as the focal firm of the international supply chain that produces garments to serve customer orders. The respondents are the garments manufacturers and exporters located in Pakistan and Turkey.

The population frame consists of the registered members of Pakistan Readymade Garments Manufacturers and Exporters Association (PRGMEA). The garments manufacturer firms populate mainly three districts located in north and south regions of Pakistan. The Turkish garments registered at Turkish clothing manufacturers association (TCMA) are located in Izmir and other districts.

The focal firm of international garments supply chain are the manufacturers and exporters responsible for making garments products and shipping to the customers. The processes across international garments supply chain are therefore surveyed through manufactures. Garments manufacturers in Pakistan and Turkey are the research population for the study of manufacturing and transportation stages. Garments customers are the population for study of transportation stage in Germany.

4.3.3 Selection of Research Sample

The firms operating in international garment supply chains were selected as population of this survey. The prime reason for the selection was that these chains were manufacturing in a developing country and serving the customers in an industrially developed country. This helps to examine the effect of country attributes on the operations carried out in that specific environment. The same supply chain was followed to see how a stage of the supply chain is affected by the respective country conditions. The secondary reason was the accessibility to information regarding garment supply chains with the help of personal contacts in the industry. The focal firms of the supply chain under study are manufacturing firms involved in supply chain process of procurement, production, and transportation. Firms related to shipping services take care of arranging shipping and custom clearance. The customer on the receiving end of supply chain is concerned with process of delivery of shipment from manufacturers. The upstream supply chain processes are carried with in the same country of manufacturing. As a focal firm of international garments supply chain, research sample is selected of manufacturers in Pakistan and Turkey to study manufacturing and transportation stages in these locations.

The formal information on manufacturers is available with the official association of Pakistan Readymade Garments Manufacturers and Exporters Association (PRGMEA). The garments manufacturing firms are located in two zones - north and south zones. The former comprises of Sialkot and Lahore while the later has enterprises located in Karachi. The total number of registered firms is 551 and target sample was set 120 firms to have sample size suitable for analysis.

The Turkish garments manufacturer were searched from the Turkish Clothing Manufacturing Association (TCMA). A Turkish colleague has helped for language to navigation on the website of the association to find the garments manufacturing firms and their email address for online surveys. The request for filling the questionnaire in Turkish language was also composed with the help of Turkish colleague. The target sample of Turkish firms was set 50 given to the cultural, time and other issues.

Survey of customers in Germany is conducted for studying transportation stage in Germany. The sample size was set as 50 given to the fact that there was not a single website on customers and their supply sources. It was to physically visit the garments wholesalers and stores for carrying survey.

As the data is to be collected for more than hundred cases, the data collection is done at a single point of time in 2013. The purpose is to investigate the cross sectional data for investigating causal relationships among different variables representing the concept of supply chain resilience.

4.4 Collection of Data

As the research approach is deductive therefore data has been collected to test hypothesis. The data will be analyzed for hypothesized causal relationship to explain pattern of relations among variables of the proposed supply chain resilience framework. A single questionnaire was developed to measure the resiliency of manufacturing and transportation in international garments supply chain, provided in Annexure. The different sections in the questionnaires are related to supply chain disruption vulnerability, adaptive capability and resilience of supply chain. The data of country attributes is collected through secondary sources.

The questionnaire items, presented in Annexure A, are asked on five points Likert scale. The numbers from 1 to 5 represent very low, low, moderate, high and very high. The items for disruption vulnerability and adaptive capability are positively keyed questions suggesting that low would mean low value. The question items related to resilience are negatively keyed suggesting that low number would mean high values for example if the number for product reject during manufacturing process is 1, it would mean that the quality issues are minimum and the indicators is of high value. Therefore, the negatively keyed items of MR1 and MR2 for manufacturing resilience, TR1 and TR2 for transportation resilience, and SCGR1 and SCGR2 for supply chain global resilience are reversed during analysis. The items of SCRC1 and SCRC2 for supply chain risk costs represent a negative concept and are therefore not reversed as it would change the meaning of the construct.

4.5 Administering the Questionnaire

Once the questionnaires was developed, number of strategies were sorted out to serve selected samples of garment manufacturers in Pakistan and Turkey. The lists of garments manufactures was retrieved from the official websites of Pakistan Ready Garments Manufacturers and Exporters Association Pakistan (PRGMEA) and Turkish Clothing Manufacturers' Association (TCMA).

In the case of PRGMEA, the lists contains information on the owner and company name, postal address, and phone numbers while the email address is hyperlinked to the company name that is displayed in a separate window. Thus, it takes a good deal of time to get the email address. It was an also issue to come across such companies that did not have any information about website or email address. The information on website address is rarely seen, limited to only few companies. The companies were then searched through internet to get to the email addresses, each individually making the task extremely difficult. TCMA has more organized list but does not offer translation of the subcategories and internal texts on company information, making it difficult for website visitor with no Turkish language skills.

While composing the message, with input from the business colleague, care was taken of number of issues. The subject of the survey mail should be appealing in terms of purpose and clarity. The first look of the message should make the receiver believe that it comes from a real person. The message should emphasis the fact that it is important in general for the garments industry, for the country and as a researcher for me in short term and long term. It should make the link available without code and authentication of account to avoid extra efforts by the respondent. Care was taken to avoid technicalities of survey codes and authentication in order to facilitate the respondents. Anonymity was ensured in order to pacify the concerns of respondents so as to convince them to record their responses.

First, the questionnaire was served through web to all the manufacturing firms listed on PRGMEA and garments related firms listed on TCMA. In most cases, the addresses for PRGMEA members had returned with delivery failed notification. The email addresses of manufacturing firms on the website of TCMA were not readily accessible. In all the cases, the response rate was less than 1%. The reason were many like low aptitude towards use of information technology, fear of spams, and cautiousness about business secrets.

Second option was to conduct survey through phone, or proxy through business colleagues in the field or hiring of survey group. These options were not feasible given to cost, time, and other constraints. As a last option, the manufacturing firms were personally visited along with local acquaintances and data was thus managed for about 90 garment manufacturers firms in Pakistan. In case of Turkish garment manufacturers, the online approach also did not work. The data on Turkish manufacturers was managed through a contact who is dealing in garments wholesale in Germany and owns a manufacturing firm in Turkey. With his help data on 40 Turkish garments manufacturers was collected. Thus a combined sample of less than 150 was managed despite the location of manufacturers in various locations.

Transportation process in Germany was surveyed through garments customers in Germany. The web survey and mailing of questionnaire to the respondents in Germany also did not get the response. The data was collected through personal contacts related to the business. The sample size was 29 as the customers to garments suppliers from Pakistan and Turkey was difficult to be traced. As the garments manufacturing is not taking place in Germany, only transportation stage is surveyed in Germany. This data is used merely to compare the transportation process across countries with different conditions.

In the preceding chapter, extended model of supply chain resilience has been discussed in the context of structural equation modelling. The nature of indicators have also been establish. It is the stage to decide the methodology of structural equation modeling that is suitable for formative indicators. The following section presents the discussion regarding selection of SEM methodology for estimation of the model.

4.6 Selection of SEM Methodology

Partial least square (PLS) is considered as a suitable method for research in business studies. PLS is a regression based approach and has fewer identification issues besides it works well both with smaller and larger samples. It also estimates both reflective and formative indicators[152]. On the other hand, covariance based (CB) structural modeling approach does not explain variance and also does not focus on prediction. CB estimates the parameters of a model such that the discrepancy between the sample covariance matrix and the implied covariance matrix is minimal. The choice of either PLS-SEM or CB-SEM depends on a number of considerations like purpose of research, nature of indicators, nature of inner model, data characteristics, sample size, and purpose of model evaluation[153]. These considerations are used alternatively to select the estimation method.

4.6.1 Purpose of Research

The first criteria is to consider the purpose of research as either theory building or theory testing. For theory testing or confirmation CB method is preferred. However in case where theory confirmation is not the primary concern and assessing prediction of a causal model is the major objective, PLS is the preferred method. The reason is that CB does not focus on prediction as mentioned earlier[154]. The supply chain resilience model is primarily concerned with the nature of predictors that determine the resilience of processes and global resilience of supply chains. Theory testing or confirmation is a secondary purpose that has been worked out in the study. PLS is considered as a preferred choice for the study in the light of first criteria for choosing between the two methodologies, for the purpose of testing causal model for predictability.

---

[152] Hair, Ringle, & Sarstedt, 2011, p. 143

[153] Hair, Ringle, & Sarstedt, 2011, p. 144

[154] Hair, Ringle, & Sarstedt, 2011, p. 144

4.6.2 Nature of Indicators

The second recommendation is that in case of formative indicators use PLS methodology. With CB methodology, formative indicators can also be estimated but it asks for relatively complex and stringent specification rules[155]. As discussed in the preceding section, all the indicators are formative in nature, therefore PLS is considered appropriate for estimation.

4.6.3 Nature of Inner model

It is also suggested that PLS is suitable estimation method in case the inner model is having many constructs and many indicators[156]. Supply chain resilience model has twenty three indicators and eight construct that is pretty complex. In this context, PLS is considered appropriate for estimation of the model.

4.6.4 Data Characteristics

Covariance based structural equation modeling assumes normality of data, minimum sample size rule, and other characteristics of data. Normality assumes that the data is evenly distributed and shows a normal curve shape, without skewness and kurtosis. Normality shows that data is evenly distributed with normal curve. Skewness is deviation from normality with lack of symmetry where the most of the data is clustered around a point. Kurtosis is also deviation from normality and the data is grouped at an end of the curve. Data with normality, skewness, or kurtosis issues causes problem in analysis. The sample size rule needs that the number of observations are required to be equal to ten times of the number of variables in the model. Supply chain resilience model with around thirty variables will need at least 300 observations whereas the sample size of data collected in the survey is short of 150 that is far below. PLS assumption for distribution of data and sample size are different than CB method. The sample size required by PLS

[155] Hair, Ringle, & Sarstedt, 2011, p. 144

[156] Hair, Ringle, & Sarstedt, 2011, p. 144

is ten times of the largest number of formative indicators or ten times of the largest number of structural paths directed at a construct in model[157]. The largest number of formative indicators in supply chain resilience model is five for manufacturing disruption vulnerability, manufacturing adaptive capability or transportation disruption vulnerability constructs. The strict data requirements for covariance based method and the fact that the sample size is small, PLS method for model estimation is used.

4.6.5 Purpose of Model Evaluation

The purpose of evaluation is to assess the relationship among constructs for prediction and not the global goodness-of-fit or test of invariance of outer model[158]. Supply chain resilience model is interested to assess the relationship between indicators and constructs and among constructs for predictability. In this case, PLS method is considered appropriate for estimation of the model.

Looking in to the goal of research, nature of indicators, characteristics of data, sample size, and purpose of model evaluation, PLS has been identified as preferred method for the analysis of supply chain resilience. The following section presents the evaluation of outer model by assuming the indicators as formative and using PLS method for estimation of the model.

4.7 Summary

The research paradigm in this study is logical empiricism that adapts quantitative method to analyze the research question. In deductive approach, theory is tested through hypothesis with the help of empirical data collected from the population of interest. The design of research is explanatory to explain causal relationship among constructs. The research strategy is survey carried over countries and

---

[157] Hair, Ringle, & Sarstedt, 2011, p. 144

[158] Hair, Ringle, & Sarstedt, 2011, p. 144

supply chain firms. The study is cross sectional for which data was collected through structured questionnaire, filled in person, at a specific point in time.

The framework is to be tested for conformity across countries for finding the role of locational factors in supply chain resilience. PLS SEM methodology has been selected for testing of the extended model of supply chain resilience. The next chapter presents the setting for international garments supply chain spread over Germany, Pakistan and Turkey.

5 Profiles of Garments Supply Chain Countries

The chapter provides the profile of countries involved in garment supply chain that constitutes the setting for the conceptual framework developed in chapter 3. The study focuses on process of garments supply chain that receives input from the environment, transforms the raw material into desired product through organizational resources and distributes products to customer facilities. The conditions, where the supply chain facility operates, are supposed to determine the resilience of facility. Therefore, the approach to develop the profile of the supply chain countries is narrowed to such attributes that directly influence the operations of supply chain facility. This led to the necessity to focus on factors related to supply chain processes of procurement, production and transportation. The general categories are natural resources, human resources, physical resources, transportation infrastructure, utilities infrastructure, political-economic capital and social-cultural resources of these countries. From garment manufacturing perspective, the comparative profile of country attributes is discussed for Pakistan and Turkey while from transportation perspective the country attributes of Pakistan and Germany are compared. Section 5.1 presents an introduction to international garments supply chain. The natural endowment attributes are presented in section 5.2. The following section 5.3 gives details of physical resources including utilities service infrastructure, water resources and communication services. Mobility infrastructure is detailed in section 5.4 including road infrastructure, rail infrastructure, shipping infrastructure and air infrastructure. Section 5.5 presents the industrial infrastructure related to garments industry including ginning, spinning, weaving and knitting sectors, dyeing, printing, and embroidery services and accessories market. Human capital is discussed in section 5.6, followed by political-economic conditions and social-cultural environment in section 5.7 and 5.8 respectively. Section 5.9 proposes theoretical assumptions in the contextual environment of international garments supply chain. Section 5.10 of the chapter summarizes the discussion and provides settings for the analysis chapter.

5.1 Introduction

In the age of race for competitive advantage and urgency for reduction of variation in business processes different research approaches are being recognized in supply chain body of knowledge. The search for exploiting lower processing costs locations is of major interest for customers due to the rising processing costs in developed countries. The big brands and retailers are zero tolerant to variations. The order targets are considered as unachievable in locations with high risk profile. Despite competitive product quality, lower labor rates and low processing costs, countries with high risk profiles are the least favorable and perceived as unreliable in terms of meeting the order targets. Vulnerability approach considers not only the exposure to risks but also takes into account how sensitive the supply chain is to these risks in terms of probability and magnitude. Vulnerability takes a preventive approach and attempt to include mitigation measures as adaptive capability of supply chain. Resilience encompasses the concepts of risks and vulnerability and goes beyond the preventive approach to reactive approach in case supply chain threshold is crossed and supply chain operations are disrupted. Alternate possibilities to resume and continue supply chain operations are invoked to ensure resilience that is the ultimate interest of a customer. The decision of facility or supplier location on the basis of risk profile is limited in the sense that it does not go beyond to the ultimate resilience considered by the resilience framework.

Developing countries are the major exporters of garments. There is also trend of increase in exports for these countries. Turkey and Pakistan are among the developing countries showing increase in garments export. Pakistan has shown a growth in garments export and has registered export worth of 4.5 billion US Dollars in 2013. Turkey has shown the growth trend over years and has increased garments export to 15.4 billion US Dollars in the year 2013. China is the leading garments exporter and their exports has increased to 177.4 billion US dollars in 2013. The trends for some of the leading developing countries is compared and presented in Figure 16.

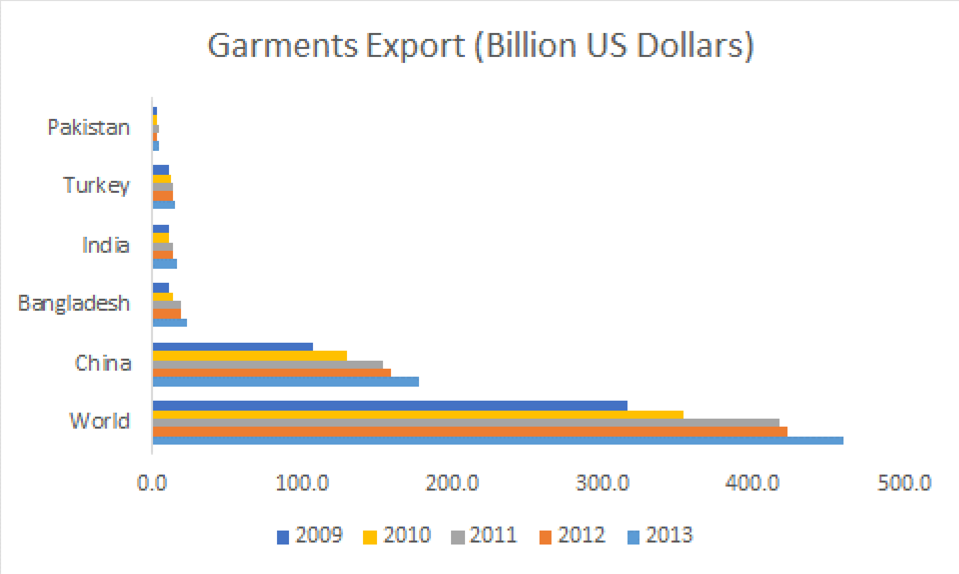

Figure 16 Comparison of Garments Exports[159]

Interestingly, the recent trends towards competitive and reliable garments supply has significantly shifted to locations that are having comparatively high risk and vulnerability profiles. Among leading garments exporter the developed countries are EU 27 and United States. There share is 116 billion US dollars and 5 billion US dollars respectively that is low as compared to the share by developing countries presented in Figure 16.

For comparison purpose, the countries that have shown increase in garment exports are looked for adaptation index that 'summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience.'[160] Vulnerability is used to 'measure a country's exposure, sensitivity and ability to adapt to the negative impact of climate change.'[161] Readiness 'targets those portions of the economy, governance and society that affect the speed and efficiency of absorption and implementation of Adaptation pro-

[159] World Trade Organization, 2014, p. Databases

[160] GAIN, 2013, p. Adaptation Index

[161] GAIN, 2013, p. Vulnerability

jects.'[162] It is good for a countries to have high adaptation index, low vulnerability and high readiness score.

Global Adaptation Index has been referred so as to get the relative idea of how good is the score for the countries of interest[163]. For example the top adaptation index scores are for Norway, New Zealand, and Sweden, and with values of 82.70, 82.20 and 81.60 respectively that means that these countries are able to adapt to disturbances quickly. For developing countries, the adaptation score is low for example 61.80 for Turkey and 46.80 for Pakistan.

The vulnerability score is good when low. The lowest vulnerability score are for Australia, Canada and United Kingdom with values of 0.19, 0.20 and 0.21 respectively that are extremely low as compared to the scores for countries as shown in Table 5. Readiness is the coping capacity and is good when the score is high. The highest readiness values are 0.87, 0.86 and 0.85 for Denmark, Sweden and Finland respectively are better than all the countries in the Table 5. This means that developing countries are having high vulnerability profile as compared to developed countries.

Table 5 Gain Index, Vulnerability and Readiness Scores[164]

Country	Gain Index	Vulnerability	Readiness
Pakistan	46.80	0.41	0.35
Turkey	61.80	0.31	0.54
India	48.70	0.41	0.39
Bangladesh	42.30	0.50	0.35
China	61.00	0.28	0.50

162 GAIN, 2013, p. Readiness

163 GAIN, 2013, p. Country Ranking

164 GAIN, 2013, p. Country Ranking

The trends in garments export mentioned in Figure 16 and vulnerability scores as shown in Table 5 are showing the trend against the perception that countries with high vulnerability are least favorable for facility and supplier locations. There is a consideration that surpasses the concepts of risk and vulnerability to resilience. Low cost factors of production, tax amenities, duties relaxation and lenient rules and regulations seems to be fully utilized in the current competitive market of garments sector. The research question of the study aims investigate the impact of country condition on supply chain resilience and to look for the answer to the above trend in garments export. It is important to provide comparative profile of countries involved in international garments supply chain.

The garments supply chains in the study are with partners located in Germany, Pakistan and Turkey with unique conditions. In the context of international garments supply chain, it is important to provide a comparative overview of the countries involved in the supply chain. The characteristics of these countries are presented in the following section.

5.2 Natural resources

There are different approaches to classify resources as capital or endowment factors of location. Costanza et al. define “natural capital as the renewable and non-renewable goods and services provided by ecosystem[165]. However, the focus of Costanza is from the perspective of the natural resources as an input to meet basic human needs like clean air, water and others. Prasad and Sounderpandian terms natural resources as primary factors including natural resources of raw material in the form of minerals, crops and plants used as an input for supply chain processes[166].The approach of Dou and Sarkis to resources is from managerial perspective deciding on location of facility[167]. The natural resources mentioned

[165] Costanza, et al., 2007, p. 271

[166] Prasad & Sounderpandian, 2003, p. 242

[167] Dou & Sarkis, 2010, p. 571

are production of material resources, natural markets, environmental amenity, environmental regulations, natural gas, water, topographic features and natural events.

The international garment supply chain feeds on natural resources of fiber including cotton and synthetic fiber as shown in Figure 15. The raw material sources for garments manufacturing are fibers from plants, animals, and manmade fibers from oil and natural gas[168]. It is in this perspective that natural resources profiles of Pakistan and Turkey are discussed as a setting for garments value chain. The world cotton production for year 2011-12 was 25471 metric ton led by China, India, USA, Pakistan and Brazil with 7403, 6314, 3391, 1881, and 1960 metric ton respectively. Turkey had cotton production of 459 metric ton and seventh in the world in cotton production[169]. Country with abundant raw material offers alternate supply in case of disturbances with the regular supplier. Comparative cotton production for Pakistan and Turkey is presented in Figure 17.

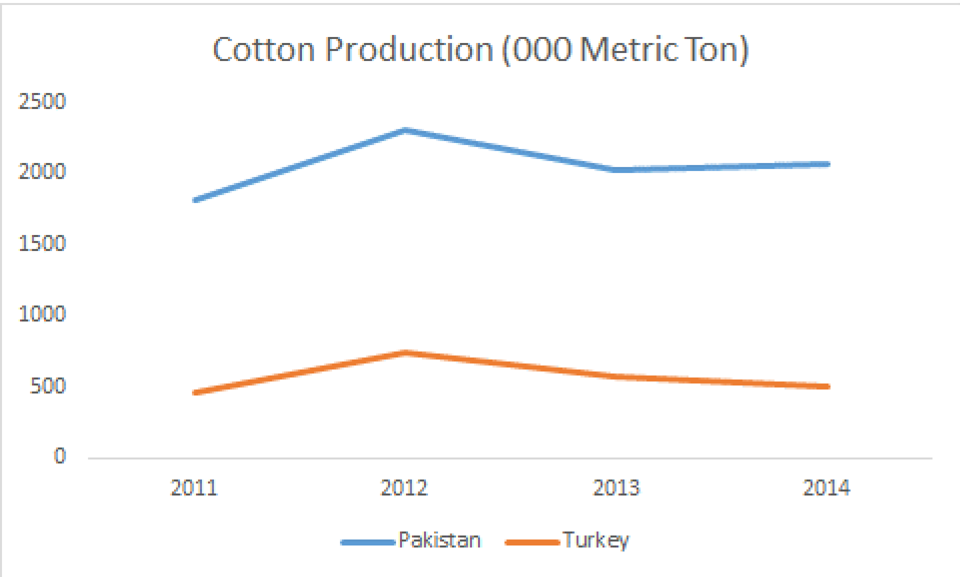

Figure 17 Comparative Chart of Cotton Production[170]

---

[168] Gereffi & Memedovic, 2003, p. 5)

[169] USDA, 2014, p. Data and Analysis

[170] USDA, 2014, p. Cotton: World Markets and Trade

The natural capital is exposed to environmental risks of drought, floods, pests and severe weather. The quality of cotton depends on many factors like seed fertilizers, pesticides, weedicides, water, labor and land quality[171].The crop is vulnerable to plant diseases that results in lower production of cotton both in terms of quality and quantity. Unavailability of cotton in the market causes increase in prices. The lack of adaption to new farming and biotechnological control of pests' technologies renders the crop susceptible to environmental exposures[172]. The picking of cotton by unskilled labors and shortage of mixed variety of cultivation are the sources of contamination of cotton.

The cotton losses due to diseases in Pakistan are 5-15% usually and raises to 30-40% in case of insufficient prevention measures. For Turkey, the usual losses are 5-10% that raises to 30% as the prevention measures are lacking. The other major causes of cotton losses are the torrential rains, floods and drought. The floods together with diseases has caused a drop of 12% in cotton production in year 2012-13. Contamination is also a substantial cause of cotton losses and the report of Pakistan Central Cotton Committee Survey 2001 under International Textile Machinery Manufacturers' Federation found that the cotton from India, Pakistan, Turkey and Tajikistan as the worst contaminated. The production of cotton in these countries enables the supply market to cater for the needs of value chain. However, due to risks the situation of cotton supply is volatile.

5.3 Physical Resource

Physical resources are called the built capital that includes service infrastructure, mobility infrastructure and industrial infrastructure[173]. Physical infrastructure is also referred to as secondary endowment factors. The utilities like water, gas and oil are natural resources tamed and tapped by societies to draw power for ma-

---

[171] Salam, 2008, p. 42

[172] Salam, 2008, p. 46

[173] Costanza, et al., 2007, p. 271 / Dou & Sarkis, 2010, p. 575

chines developed for variety of functions. Water dams are built on natural sources for irrigation and energy generation purposes. Mobility infrastructure is also developed on natural resource of space to construct roads, railroads, sea-ports, airports and dry-ports[174]. The raising of industrial infrastructure owes to research and development work of societies. Communications has been recognized as essential part of societies that enable global interaction for all purposes.

5.3.1 Utilities Services Infrastructure

Utilities services infrastructure includes supply of utilities of water resources, energy sources – oil, gas, combustibles and electricity and communication services telephone and internet.

5.3.2 Water Resources

Rainfall is major source of water that feeds rivers and underground reservoirs. The average precipitation in Pakistan is 494mm and Turkey is 593mm over the period from 2008-2012[175]. In Pakistan, monsoon rains during summer makes the major portion of rainfall. Main rivers in Pakistan are Indus and Jhelum where reservoirs are built on for hydropower generation and irrigation through canal systems[176]. The annual fresh water withdrawal for agriculture- irrigation and livestock production in Pakistan is 94% and in Turkey is 74%, for domestic use in Pakistan is 5% and in Turkey is 15%, and for industrial use in Pakistan is 1% and in Turkey is 5% of the total withdrawal for the period between 2008 and 2012. This amounts to the total withdrawal of freshwater in Pakistan up to 183.5 and in Turkey up to 40.1 billion cubic meters[177]. These figures show that the two coun-

[174] Prasad & Sounderpandian, 2003, p. 242

[175] The World Bank, 2013, p. Average Precipitation

[176] Pakistan Bureau of Statistics, 2013, p. Agriculture Statistics

[177] The World Bank, 2013, p. Infrastructure

tries have sufficient water resources for irrigation and industrial usage besides domestic consumption.

5.3.3 Energy Resources

The primary sources of energy production are petroleum, natural gas, combustible material and electricity. The total energy sources are measured as equivalent of oil and are presented for Pakistan and Turkey as below in Figure 18[178].

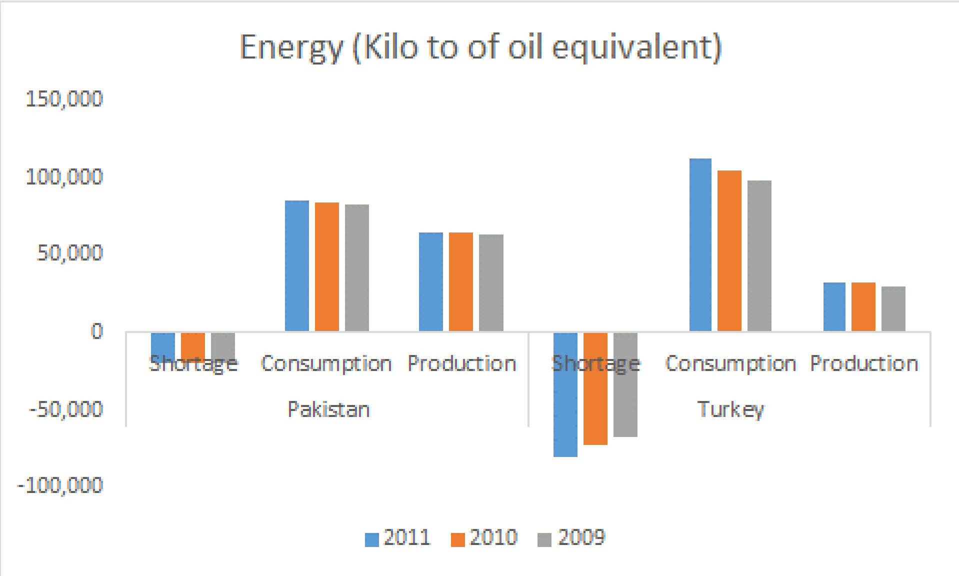

Figure 18 Comparative Energy Production

As the production of energy is less than the use of energy for Pakistan and Turkey, the gap is fulfilled either with import or outages. For example, the real time power break down in Pakistan is up to 18 hours a day that disturbs the commercial and domestic activities[179]. The situation of power supply in Turkey is comparatively better and possibly the gap is filled.

---

[178] The World Bank, 2013, p. Energy and Mining

[179] Pakistan Economic Survey, 2012-2013, p. 1

5.3.4 Communications Resources

The availability and accessibility of communication technologies enables societies to interact globally for all purposes. The level of communications infrastructure development is measured by the number of people able to avail the technologies. In Pakistan, 10 of every 100 people and in Turkey is 45 of every 100 people uses the communication services[180]. The situation is comparatively better for Turkey as compared to Pakistan.

5.4 Mobility Infrastructure

The built infrastructure for transportation includes road, railroad, seaport, airport and dry-port facilities. The availability and quality of mobility infrastructure affect the movement of goods in term of quality, quantity, time and cost[181]. Availability of variety of transportation means provide flexibility for adapting alternative mode in case of occurrence of disturbance in one form of transportation. The measurement parameters for mobility infrastructure are summarized by Prasad and Sounderpandian as cost, accessibility, shipping patterns, on time performance, service, warehouse locations, routing constraints, transportation modes, carrier qualifications and intermodal systems[182]. In case of international supply chain, regulations and bureaucratic procedures affect the transportation processes[183]. The comparative transportation profiles of Germany, Pakistan and Turkey are presented in the following sub sections.

5.4.1 Road Transport Infrastructure

Roads network connects supply chain facilities located inside a geography spread over land. Reliability of supply is dependent upon the quality of roads network in

[180] The World Bank, 2013, p. Infrastructure

[181] Dou & Sarkis, 2010, p. 571

[182] Prasad & Sounderpandian, 2003, p. 245

[183] Meixell & Gargeya, 2005, p. 553

a region. Comparative road infrastructure for Germany, Pakistan, and Turkey is presented in Figure 19.

The total road network in Germany is 644, for Pakistan is 262 and for Turkey is 367 thousand kilometer reported for year 2010[184]. The density of traffic is 71, 30 and 11 vehicles per kilometer for Germany, Pakistan, and Turkey respectively. This shows the flow and frequency of traffic catering the transportation needs. The ability of roads is considered in terms of number of passenger and amount of goods being transported over distances. The passengers transported are 949, 301, and 227 billion per kilometer and goods are 434, 153, and 190 thousand metric ton for Germany, Pakistan and Turkey respectively.

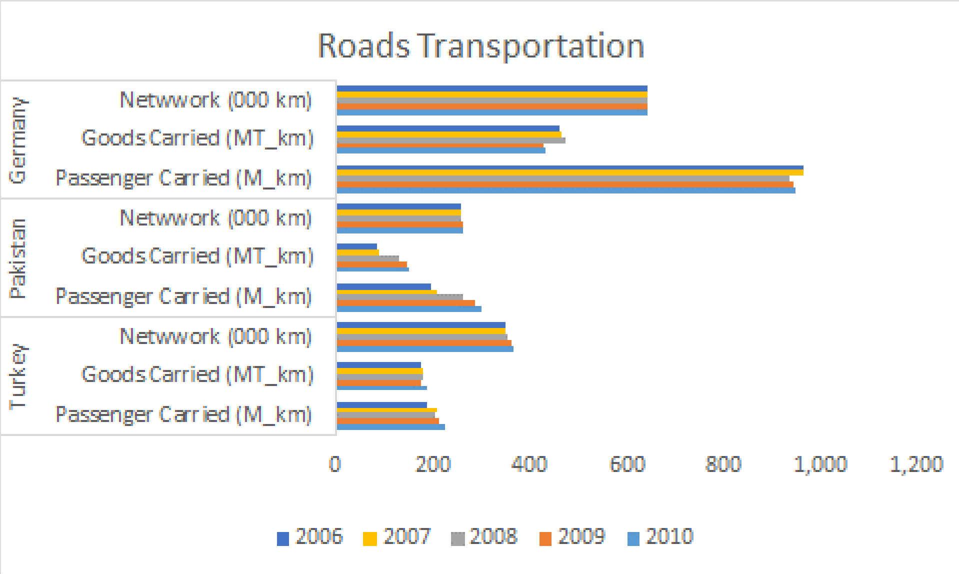

Figure 19 Comparative Road Transport Infrastructure[185]

Germany is having the extensive network of roads and are having high traffic density as compared to Pakistan and Turkey. The carriage of passengers and goods indicates that road infrastructure is developed in terms of capability.

[184] The World Bank, 2013, p. Infrastructure

[185] The World Bank, 2013, p. Data: Indicators

5.4.2 Rail Transport Infrastructure

Rail is the means for bulk transportation of human and goods. Comparative rail infrastructure for Germany, Pakistan, and Turkey is presented in Figure 20.

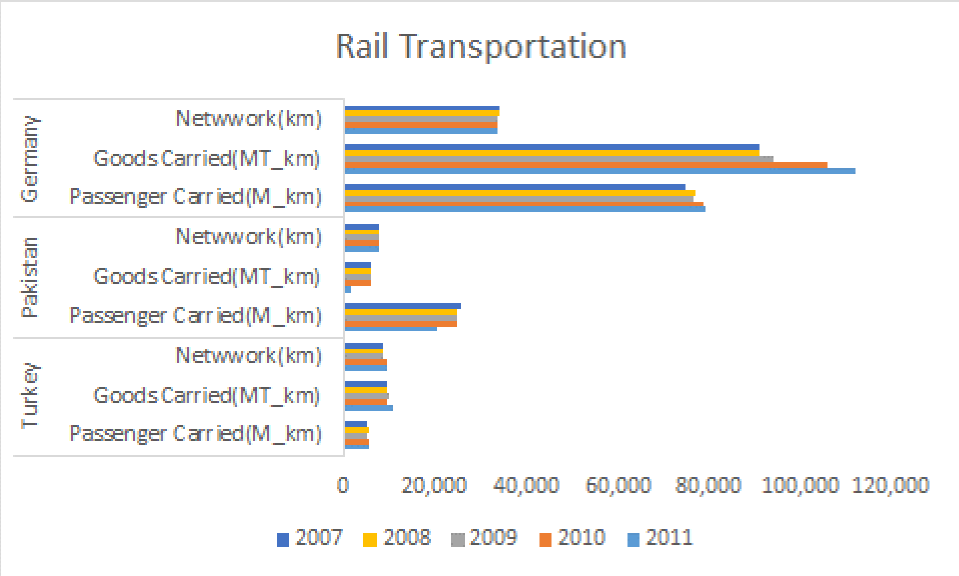

Figure 20 Comparative Rail Transport Infrastructure[186]

The passenger carried by train is 79228, 20619, and 5491 million person per kilometer in Germany, Pakistan, and Turkey. The goods transported are 111980, 1757, and 11030 metric ton per kilometer in Germany, Pakistan, and Turkey. The rail network in Germany is very extensive and connects most parts of the country.

5.4.3 Sea Transport Infrastructure

Sea has been the used as a major means of transportation through passenger and container ships. It is used for international transportation connecting the countries situated by water bodies like ocean, sea or rivers. The shipping infrastructure enables a location to connect with other countries across the globe depending on the availability and flexibility of capacities and schedules, port infrastructure and the ease of custom proceeding of shipping transportation infrastructure.

---

[186] The World Bank, 2013, p. Data: Indicators

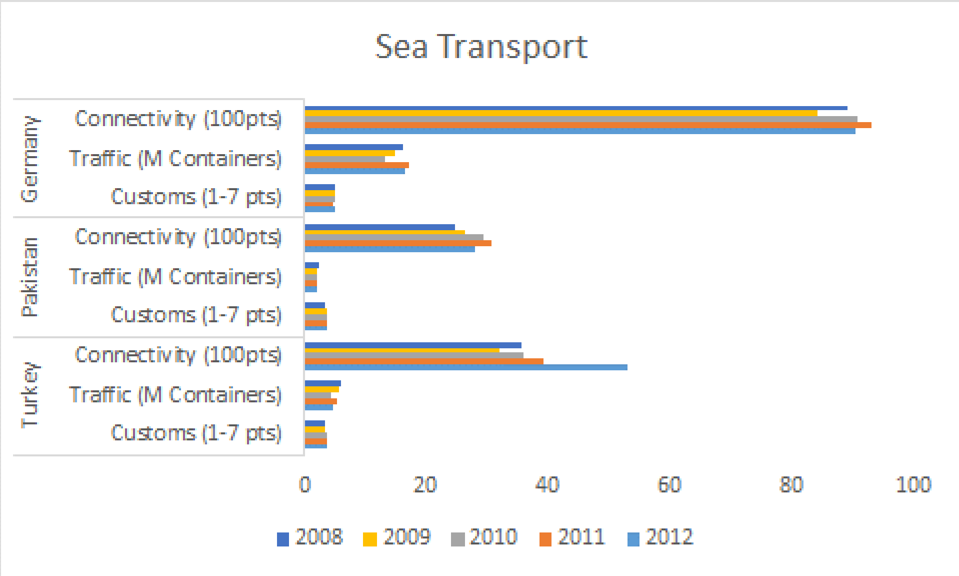

Figure 21 Comparative Sea Transport Infrastructure[187]

The container port traffic for Germany, Pakistan, and Turkey is 16.64, 1.93, and 4.67 million containers for year 2012. The burden of custom proceeding is 4.9, 3.7, and 3.6 for Germany, Pakistan, and Turkey respectively. Germany is having high global connectivity with huge port traffic however the custom proceeding are more intensive for Germany.

5.4.4 Air Transport Infrastructure

Air freight is the fastest mode as compared to road, rail or ship freight. However the capacity of air cargo is far less than ship, train and roads. Availability and of accessibility of airports and airlines enables global connectivity. The airlines flight frequency suggests the condition of air transport infrastructure.

[187] The World Bank, 2013, p. Data: Indicators

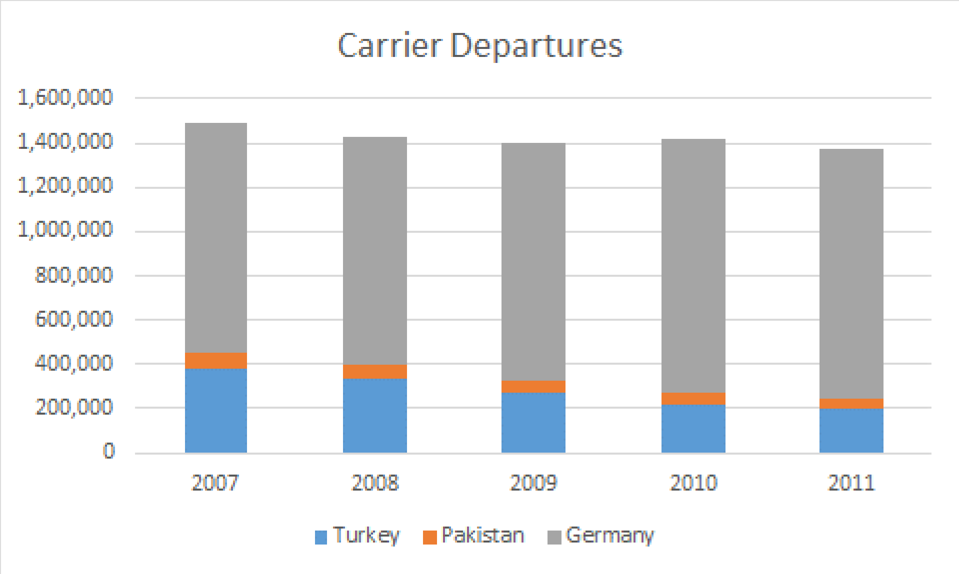

Figure 22 Comparative Air Transport Infrastructure[188]

Passengers carried by air transport is 106, 7, and 47 million in Germany Pakistan, and Turkey during the year 2011. The goods transported by air transport is 7.712, 338, and 1654 metric ton in Germany Pakistan, and Turkey. Given to the carrier's frequency, passengers and good transported, the air transport infrastructure is very developed for Germany as compared to Pakistan and Turkey.

5.5 Industrial Infrastructure

The supporting industrial structure enables supply chain operations and is considered as critical factor of location of facilities and suppliers[189]. The upstream garments supply chain industries are cotton and textile that supplies cotton lint, yarn, raw fabric and ultimately finished fabric to garment manufacturers[190]. The availability of raw material for garment manufacturers depends on the value chain from cotton growers to finished fabric producers.

---

[188] The World Bank, 2013, p. Data: Indicators

[189] Prasad & Sounderpandian, 2003, p. 243

[190] Altaf, 2008, p. 52

5.5.1 Ginning Sector

The first processing stage of garment value chain is to separate cotton lint from seed. The quality of cotton is ensured through grading of cotton and reduced contamination during the picking and storage stage at the cotton grower and transportation to ginneries. As mentioned earlier, Pakistan Central Cotton Committee Survey 2001 has found cotton from India, Pakistan, Turkey and Tajikistan as the most contaminated at ginning mills in different mills around the globe. Therefore state of the art technology is required to process raw cotton[191]. Pakistan and Turkey are among the world leading producers and consumers of lint as shown in Figure 23.

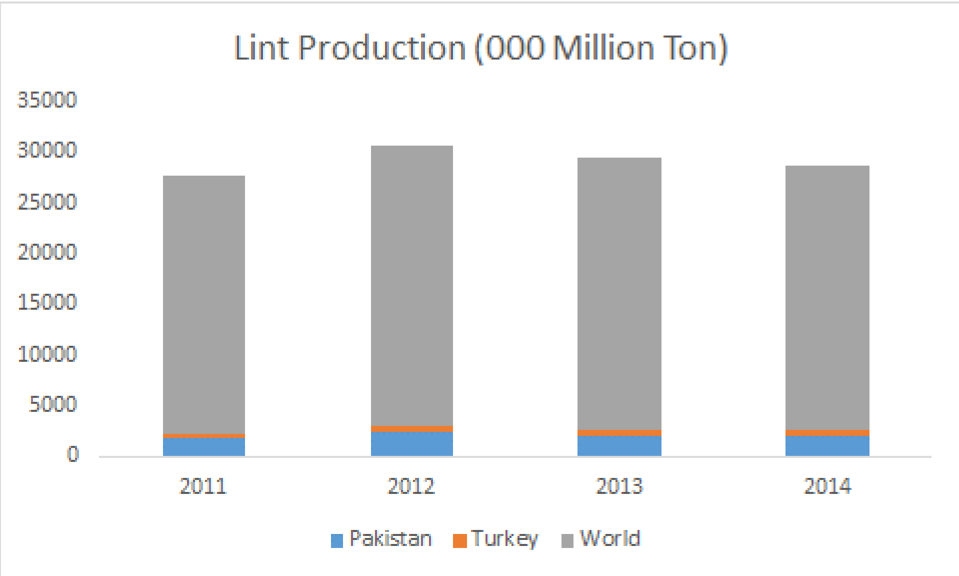

Figure 23 Comparative Lint Production [192]

The international cotton processing standard is 60 bales per hour. For Pakistan and Turkey, along other developing countries the cotton processing rate is 10-12 bales per hour far below the international standards[193]. There are around 1200

[191] Salam, 2008, pp. 48-49

[192] FAO UN, 2014, p. Country by Commodity

[193] Altaf, 2008, p. 60

ginning mills in Pakistan[194]. Turkey has around 500 ginning units, almost all privately owned[195].

5.5.2 Spinning Sector

Spinning is the process where the fiber is converted into yarn. The cotton lint produced at the ginneries comes to spinners for manufacturing yarn that is input for the raw fabric manufacturers at the next stage of the value chain. Pakistan has around 516 spinning units with 11.3 million ring and 0.21 rotors.

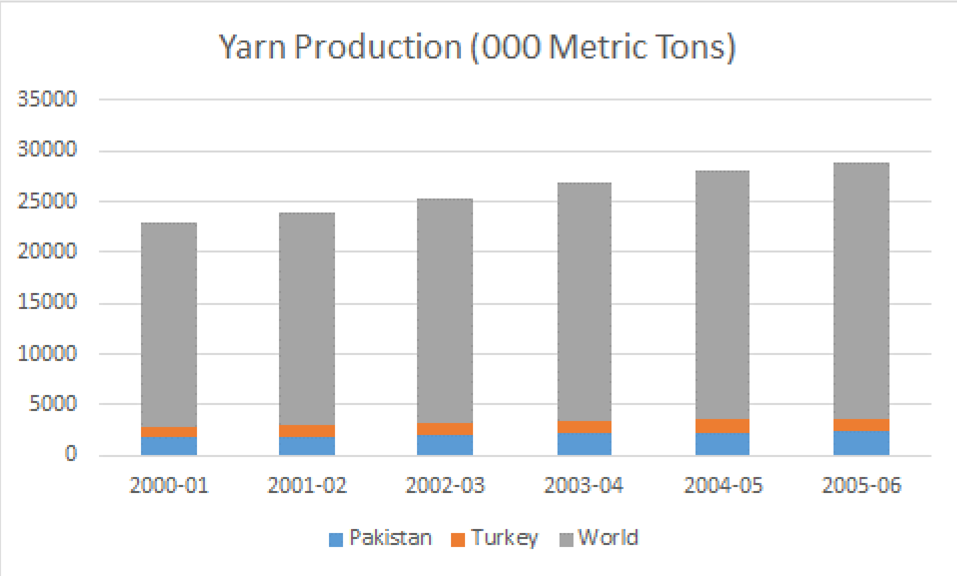

Figure 24 Comparative Yarn Production[196]

Pakistan and Turkey contribute considerably to world yarn production and export of yarn is given in Figure 24.

5.5.3 Weaving Sector

The weaving process transforms yarn into cloth through machines. There are composite weaving mills with spinning and dyeing facility in Pakistan and Tur-

---

[194] PCGA, 2013

[195] USDA, 2014, p. 8

[196] APTMA, 2013, p. Global Yarn

key. Comparative cloth production for Pakistan and Turkey is presented in Figure 25.

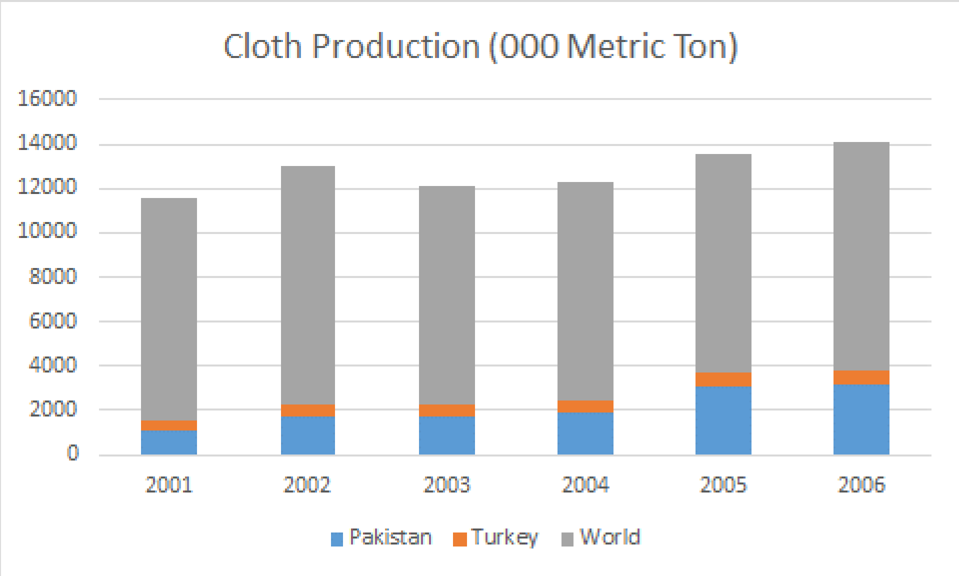

Figure 25 Comparative Cloth Production[197]

Both Pakistan and Turkey are major contributors to world cloth production (Figure 25). The fabric needs of garments industry is catered by the domestic production of cloth.

5.5.4 Dyeing, Printing & Embroidery Sector

Yarn, fabric, apparel and made-ups has dyeing, printing and embroidery requirement specified by customer. Yarn, weaved and knitted fabric are bleached and colored as required by customers for direct consumption or apparel and made-ups. The fabric, apparel and made-ups with printing requirements uses the printing facilities. The embroidery work is served by embroidery facilities as required by manufacturer of garments. As mentioned earlier there are composite weaving units with spinning and dyeing facilities. There are around 18 dyeing and 5 independent printing mills in Pakistan[198]. Turkey has large size garment

---

[197] APTMA, 2013, p. Cloth Production

[198] APTMA, 2013, p. Pakistan Textile Statistics

manufacturing with composite facilities for spinning and dyeing catering the needs of garments production.

5.5.5 Garments Sector

Textile and garments are traditionally major export industries in the world. The developing countries are rich in natural resources and are thus nurseries for the industries in the textile and garments value chain. The garments export of Pakistan accounts for important share in overall export and economy of the country. European Union and United states are the major garments importing countries[199]. The US has increased its import to 1646 Million US dollars from Pakistan in 2009[200]. Similarly, European Union has increased the imports to 5137 Million Euros from Turkey and 779 Million Euros from Pakistan in 2009.

The garments sector is one of the thriving sector in the developing economies. Pakistan Readymade Garments and Export Association (PRGMEA) and Pakistan Hosiery Manufacturers Association (PHMA) have more than 1500 registered member concentrated in three cities of Karachi, Lahore and Sialkot. The presence of such a good number of garments manufacturers and exporter makes intensive competition within the country and with other developing countries. The garments sector depends on the textile value chain that is well developed in the country. The cloth production from the locally grown cotton through knitting and weaving fabric sector are well developed and are able to cater not only the needs of the domestic consumers but also the international customers. Dyeing, printing, embroidery services support and cater the needs of garments manufacturers.

Turkish clothing manufacturers association has around 400 numbers. Compared to Pakistan, Turkish manufacturer are large sized organizations with some of them having capacity of around 0.6 Million pieces and more in month. The production is located in cities of Izmir, Ankara and others. According to the ministry

---

[199] Masakure, Henson, & Cranfield, 2009, p. 412

[200] Gereffi & Frederick, 2010, p. 5

of economy, the woven and kitted production was estimated at 36 Million tons. Turkish textiles and garments account for about 6.5 percent of the GDP together. The garments sector has shown steady increase and exports even in the post-World Trade Organization era of Agreement on Textile and Clothing that ended in 2004. The export products, knitted, crocheted and woven categories include overcoats, caps, cloak, suits, jackets, trousers, shirts, shorts, sportswear, work wear and clothing accessories. Turkish major clothing export is to Germany, UK, Spain, France, Netherlands with value more than 1 billion US dollars in 2011 according to the Turkish ministry of economy. The performance of the clothing industry is dependent on the textile value chain. Turkish with number eight in cotton production and number four in cotton consumption in the world. Turkey is the leading exporter of garments to European Union after China according to the Euro stats in 2009.

5.5.6 Accessories Market

Fabric, being the primary raw material in garments manufacturing, is the product of a long value chain originating from the cotton growers, livestock keepers and synthetic manufacturer. As a result of research and development activities the fiber is transformed into yarn and fabric. The fabric is designed, cut and made into required product. However number of accessories are attached during the manufacturing. The availability and accessibility of accessories is important factor for manufacturing and delivering the garments orders in time.

The basic accessories are thread, zippers, interlining, button, label, Velcro, elastic, chord, ribbons, toggles, rivet and collar bone. There are also decorative accessories like tapes, piping, ribbon, chords. The finishing accessories are hang tag, price tag, plastic bag, tissue paper, carton, squash tape, paper belt, tag pin, plastic clip, sticker, butter fly, collar insert, back board and neck inserts.

Accessories are partly produced in Pakistan while most of the accessories are imported from China. However, the trading companies in garments are able to cater the demands of the garments sectors. The quality is strictly observed and certifications for quality are required. The Turkish textile and garments industry is multipronged with machines manufacturing and other accessories, used in garments sector. The industry has been meeting the requirement of the garments sector in the country.

5.6 Human Resources

Garments sector is labor intensive and require skilled labor. Sustainable human capital is required to keep the labor cost low. The shortage of skilled workers poses challenge for manufacturers. The unskilled labor is less productive and also in poor condition prone to unrest and strikes. Human development index is one of the approaches to assess the development of human resource of a country. Human Development Index was developed to 'emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone' and that 'the Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living.'[201]

Pakistan is the country with population of more than 180 million and Turkey has population of over 75 million. The human development index for Pakistan is 146 and for Turkey is 90[202]. Most of the human resource is unskilled or semi-skilled given to availability and quality of education system in the country. In Pakistan, the operator's skills, market management, shop floor management and management organizations are graded as poor[203]. Similarly the education and training of the operators are also rated as very poor in the study. Turkey has been ranked as number two in European Human Capital Index for central and Eastern Europe. The index illustrates that the cost of education and training is received by an individual are at the lowest among the central and eastern European courtiers. The

[201] UNDP, 2014, p. HDI

[202] UNDP, 2014, p. International Human Development Indicator)

[203] Cororaton, et al., 2008, p. 86

utilization of human capital is ranked at number eight for Turkey. For the output per hour work, Turkey is number four and is the first for the projection of number of people to be employed by the year 2035[204]. The human resource potential has not yet been sufficiently developed and employed. The labor market in these countries is having fewer skilled labors and the business rely on semi-skilled and inexperienced labor. Labor intensive industries like garments needs skilled labor and country with developed human resources offer such a market. Given to the HDI for Pakistan and Turkey, semi-skilled workers dominate the labor market. The garments manufacturer relies on a mix of skilled and semiskilled labor.

5.7 Political Economic Capital

The laws, regulations, policies and procedures, litigation an implementation are the political capital that bread a culture of transparency and meritocracy and rule of law in carrying business activities in a country[205]. Germany being the old industrial country has one of the strongest economy in the world. The rule of law is very strong and property rights are fully protected. The government transparency is high and business and enterprises are fairly treated. The government has reduced the public spending to 45 per cent of domestic economy and public debt has been stabilized at 85 percent of GDP. The regulatory efficiency ensures transparency and straightforwardness. Labor rights are ensured and culture of subsidy is minimized. The European Union market has low tariff and non-tariff barriers. Investment is possible in all most all sectors and is open for domestic and foreign investors. The financial sector is offering full range service with least government intervention according to the index of economic freedom 2014.

Pakistan being the 126th freest economy according to the index of economic freedom 2014. Social and political instability are major causes of Pakistan economic ills. The government is practicing the use of discretionary powers that

---

[204] Ederer, Schuler, & Willms, 2007, pp. 3-17

[205] The Heritage Foundation, 2013, p. Country Rankings

leaves little room for merit and transparency. The business laws are either poorly defined or poorly implemented to ensure property right to domestic or foreign entrepreneurs. Due to poor performance of legal system, the control of corruption is not effective. The government spending is 20 percent and the public debt is 62 percent of domestic economy. The procedures to start business take three weeks' time. The labor is facing under employment. Government subsidizes electricity and control fuel prices. The tariff rate is 10.1 percent. Some imported items have additional non-tariff barriers. Financial sector is intervened. Banking services are used only by limited portion of population and businesses according to the index of economic freedom 2014.

Turkey has shown great improvement regarding freedom of economy. Despite the improvement, judiciary is still not well equipped to serve business cases and corruption is still an issue in public sector and on private level. Public spending is 35 of domestic economy and public debt is 36 percent of GDP. The reforms in business procedures, labor practices and reducing subsidies are slow. The tariff rate is 2.7 percent. Investment opportunities are open to both domestic and foreign investors. Banking sector show stability according to the index of economic freedom 2014.

The economic conditions of Germany, Turkey and Pakistan are ranked at 18th, 64th and 126th respectively, according to the index of economic freedom 2014. The political conditions determine the economic conditions for carrying out business processes.

5.8 Social Cultural Capital

Societies interact on the basis of norms and networks developed as traditions over a long period of time[206]. These norms and networks has an impact on working habits and organization behavior. The motivation, priorities and obligations result into a level of cooperation towards achievements of organizational objec-

206 Woolcock & Narayan, 2000, p. 226

tives[207]. Human resources in garments industry are from social groups that are strongly bonded and responsibility to the family and relations comes first. Leaves from job is a regular phenomenon that mangers face and are required to manage routinely through human skills and alternate resources. Self-respect and honor are deemed above financial gains and often leads to resignation in case of straight forward demand for task completion. Compromises on objective, all time politeness and extra care are required in the social set up in order to avoid high turnover and shortage of workers. Religious activities, social occasions and cultural festivities are attended on priority basis. The shortage of workers affect the production target to be achieved in time. For Pakistan the social indicators are unique from turkey and for both Pakistan and Turkey are different for Germany[208].

The social cultural capital is represented by power distance, individualism, masculinity, uncertainty avoidance, pragmatism and indulgence. The human resources are governed by social norms has unique approaches to business patterns, organizational behavior and work habits given to the different cultural backgrounds. Germany has low power distance followed by Pakistan and then Turkey among the three selected countries involve in international garment supply chain. Pakistan has a collective society and responsibility to family and relatives is above any other consideration. Masculinity is the driving force for competition achievement and success. Pakistan and Turkey showing low scores as compared to Germany indicates that the former societies have consideration for other factors than being best in field. Similarly Pakistan and Turkish societies have high preferences for avoiding uncertainty while business culture needs risk taking, adventurism and entrepreneurial characteristics. The quality of pragmatism enables societies to modify tradition and adapt to new situation. Pakistan and Turkey are comparatively normative societies and tend to give explanation to all phenomenon. The flexibility of society to adapt to new situations is essential for

---

[207] Narayan & Pritchett, 1999, p. 3

[208] The Hofstede Center, 2013, p. National Cultural Dimensions

change management. The discipline and control of desires and impulses are taught to human resources of a society. While Germany and Turkey shows that societies are focusing on restrained behavior the data for Pakistan is zero that means highly restrained society. The product of such society lack optimism, creativity and innovation. Going out of the box is a big challenge that is perceived in clash with social norms.

The Germany social and cultural capital is said to be well suited to business as compared to Turkey and Pakistan. Business takes human resource from society and have therefore an impact on the productivity of a business. In the context of profiles of countries involved in garments international supply chains, following assumptions are proposed.

The relationship between country conditions help to understand the influence of disruption vulnerability and adaptive capability on resilience of supply chain. Supply chain processes receive input from the external environment and also operates in such unique conditions. The location provides both threats and opportunities. In the light of above of above discussion, the following assumptions are stated. These assumption will help to understand and asses the comparative influence of location on resilience of supply chain processes. Descriptive statistics will be used for comparative analysis.

5.9 Theoretical Assumptions

The preceding sections provides contextual details for the study. In the light of deliberations regarding resilience process, research question, conceptual framework and contextual background the study assumes the following situations:

1) Supply chain stage carried out in a country with volatile conditions is expected to demonstrate frequent disruption vulnerability.
2) Supply chain stage carried out in a country with volatile conditions is expected to invoke adaptive capability more frequently.
3) Supply chain stage carried out in a country with volatile conditions are expected to have low resilience.

4) Supply chain stage carried out in a country with volatile conditions is expected to have low supply chain global resilience.
5) Supply chain stage carried out in a country with volatile conditions is expected to have high supply chain risk costs.

5.10 Summary

International garments supply chains, in the study, are located in Germany, Pakistan and Turkey. The comparative attributes of these countries have been presented in order to understand the context in which different processes of supply chain are carried out. The attributes are regarding natural resources, physical resources, mobility infrastructure, ancillary industry infrastructure, human capital, political economic capital and social cultural capital. The physical resources includes service infrastructure, water resources, energy resources and communication infrastructure. The mobility infrastructure includes road, rail, water and air transportation services. The related industries to garments supply chain are ginning, spinning, weaving, dyeing, printing, embroidery, garments manufacturing, accessories manufacturers and suppliers. The contextual background will help to understand whether location conditions are explanation to supply chain resilience. The following chapter analyzes data for the hypothetical framework in order to find answer to the question, posed earlier, whether international garments supply chain processes show differences in resilience for firms located in different countries.

6 Analysis of Supply Chain Resilience Model

In order to investigate the research aim posed in section 1.2, the extended model of supply chain is developed in section 3.3. For the purpose of analysis, methodology is devised to collect data in chapter 4. The contextual setting for international garments supply chains is provided in chapter 5. This chapter, chapter6, investigates to find how well the hypothetical model is represented by the empirical data. For this purpose, section 6.1 provides the motivation for empirically testing the extended model of supply chain resilience. Section 6.2 presents the evaluation of outer model for the quality of indicators assigned to the constructs by examining empirically how well the indicators represent the respective constructs. Section 6.3 details the evaluation of inner model by examining how well the data represent the causal model. Section 6.4 assess the hypothesis proposed for direct relationship, mediation relationship, and moderation effect. Section 6.5 presents the descriptive part and analyzes the assumptions posed earlier in section 5.9 in the contextual setting. The hypothesis testing investigates the relationships as stated in Table 1 for direct effect and moderation and mediation effects summarized in Table 2. This chapter is concluded with section 6.7 that summarizes the analysis of structural equation model of supply chain resilience.

6.1 Introduction

The existing framework of supply chain resilience proposed by researchers shown in Figure 6, makes the foundation of the model for this study. The model is extended into the components of disruption vulnerability, adaptive capability, resilience of supply chain processes, supply chain global resilience, and supply chain risk costs, as developed in Figure 14. Supply chain vulnerability to disruption can be defined as 'an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain'[209]. Supply chain adaptive capability can be defined as the ability to respond to disturb-

[209] Christopher & Peck, 2004, p. 3

ances[210]. This study defines supply chain resilience as the ability of supply chain entity to respond to disruption in order to continue normal function[211].

In section 3.3, supply chain model has been described with all constructs and respective set of indicators. The model in this study encompasses the production and transportations stages of international garments supply chain. The manufacturers of garments are located in developing countries and export garments products to customers in old industrial countries. This specific study surveys garments manufacturers in Pakistan and Turkey and the customers are located in Germany. Garments manufacturing and transportation processes are exposed to risks of disruption caused by external and internal factors. Supply chain firm's capability to take suitable measures against disruptions reduces occurrence of disruption and thus mediates adverse effect on resilience of processes and overall supply chain. Global resilience of supply chain is dependent on the resilience of the constituent processes i.e. manufacturing and transportation. As shown in Figure 14, the constructs are unobservable variables. This study aims at assigning suitable indicators to these constructs for measurement purpose, so that further analysis could be carried out.

International garments supply chain processes of procurement, production, and transportation are carried out by supply chain partners spread over distant locations. The processes are exposed to various risks besides firms internal and supply chain issues shown and discussed in detail in chapter 5. The purpose of supply chain process is to provide goods in demanded quantities and with specifications. However, the quantities and qualities produced or catered through a process determine the resilience of supply chain in terms of delivery reliability. The quality, quantities influence the schedule targets that further influence the costs of supply chain processes. The existing supply chain resilience framework given in Figure 6 is extended and presented in Figure 14. The extended model presents

---

[210] Pettit, Fiksel, & Croxton, 2010, p. 6

[211] Barroso, Machado, & Machado, 2011, p. 162/ Ponomarov & Holcomb, 2009, p. 131/ Falasca, Zobel, & Cook, 2008, p. 596/ Fiksel, 2006, p. 16/ Christopher & Peck, 2004, p. 2

the concept of supply chain resilience cause and effect chain suggesting that quality, quantity, schedule and costs of each process of supply chain are influenced by the situation of supply chain entities and local conditions. The Figure 7 exhibits how all supply chain process contribute to overall resilience in terms of quality, quantity, schedule, and ultimately costs. It is assumed that global resilience of supply chain influences supply chain risk cost. Supply chain risk costs variable is measured through indicators of manufacturing and transportation costs in the proposed model. Variability in production and delivery schedule will have cost implications. The excess cost diminishes profitability of supply chain entities and finally the effect trickles down to the wholesalers, retailers and customers. In highly competitive garments market, especially in Asia, lower price is one of the main competitive advantages besides quality of raw material, low labor cost, and operational cost. The supply chain processes are exposed to disruptions and supply chain entities take measures as a response in order to continue functioning. Supply chain resilience model has developed its constructs and indicators from the concept presented in Figure 7. Disruptions, adaptive measures and functioning objectives of supply chain processes are grouped as set of indicators under constructs, presented as structural equation model in Figure 14.

For the purpose of empirical investigation, structural equation model is considered appropriate because the extended model of supply chain resilience has both outer and inner models. Outer model consists of set of indicators and their relationships with respective construct whereas inner model consists of constructs and their relationships. Structural equation model is capable of estimation of the indicators, constructs, relationship between indicator and construct, and relationship among constructs. The following sections evaluation of outer model, evaluation of inner model, testing the hypothesis given in Table 1 and Table 2, and finally the descriptive analysis.

6.2 Evaluation of Outer Model

Outer model is the component of structural equation modeling that consists of indicator variables and respective construct. Part of structural equation model, representing relationship between indicators and constructs is referred to as outer model in partial least square structural equation modeling (PLS-SEM) context while the same is referred to as measurement model in covariance based structural equation modeling (CB-SEM)[212]. This study uses the term of outer model because the methodology used is PLS SEM.

It is considered pertinent that the outer model shall be distinctly specified before performing causal analysis. Poor outer model will potentially lead to misrepresentation and misinterpretation of the inner model representing the causal relationships. The causal model describes the relationships among unobserved variables that are measured through observed variables working as indicators of the unobserved variables. Therefore it is necessary that the constructs are significantly represented by the indicators. This requires assessment of reliability and validity of the constructs before performing further analysis[213].

The relationship between observed variables and unobserved variables of structural equation model is such that unobserved variable is a result of several observed variables operating as indicators. The analysis of outer model seeks to examine the reliability of indicator individually and in relation with others for a construct. The purpose is to find how well the indicator variables measure the construct. As the nature of indicators has been established earlier in the study as formative indicators, the relevant evaluation procedure will be followed. The appropriateness of formative indicators is assessed through examining the weights of indicators (representing relative importance), loadings of indicators (representing absolute contributions), the significance of weights and loadings, multi collinearity, and suppressor effect that are applied alternatively[214].

---

[212] Hair et al., 2012, p. 415

[213] Jarvis, MacKenzie, & Podsakoff, 2003, p. 199

[214] Hair et al., 2012, p. 426

Outer model with formative indicators is examined for how each indicator contributes to the forming of constructs. The relative importance of an indicator is represented by its weight and the absolute importance is represented by its loading. In order to evaluate the significance of weights and loadings of indicators procedure of bootstrapping is carried out. The sample suggested for bootstrapping procedure is 5000 and the number of cases shall be equal to the number of observations collected that is the sample size. The resultant test statistics is analyzed for significance that shows how well the model is fit to the data. The test values are 1.65, 1.96, and 2.58 significant at 10 percent, 5 percent, and 1 percent confidence level respectively. The indicators with significant weights are the ones that are appropriately representing the constructs and must be kept for further analysis. In case both weight and loading of an indicator are non-significant, the theoretical relevance of the indicator is to be checked[215]. The indicators are also checked for collinearity in order to identify redundant indicators that are highly correlated. In case of indicators with negative weights, suppressor effect is examined to see whether an indicator shows more variance with another indicators than with formative measured construct causing change in sign. If indicators with different signs are not suppressors or not collinear, they should be included in the analysis[216].

6.2.1 Weights of Indicators

The weights against the paths from indicators to constructs, shown in Figure 26 without parenthesis, represents the relative importance of indicators[217]. The general rule is that the weight is twenty percent or above, otherwise the relationship is of no practical significance. The indicators of alternate raw material sources, alternate production methods, alternate utility sources and longer production time form the construct of manufacturing adaptive capability. Alternate raw material

---

[215] Hair, Ringle, & Sarstedt, 2011, p. 145

[216] Cenfetelli & Bassellier, 2009, p. 692

[217] Cenfetelli & Bassellier, 2009, p. 692

sources and alternate utility sources have weights with more than 30 percent contribution to form the respective construct. The weight of alternate production method is close to 20 percent that is week but acceptable. Although the weight of longer production time is high but with negative sign and that requires analysis for collinearity and suppressor effect in order to decide whether to keep or remove the indicator. If there is no evidence of collinearity or suppressor effect, the recommendation is to include it for further analysis. Otherwise, in case of evidence of both collinearity and suppressor effect the indicator is to be dropped[218].

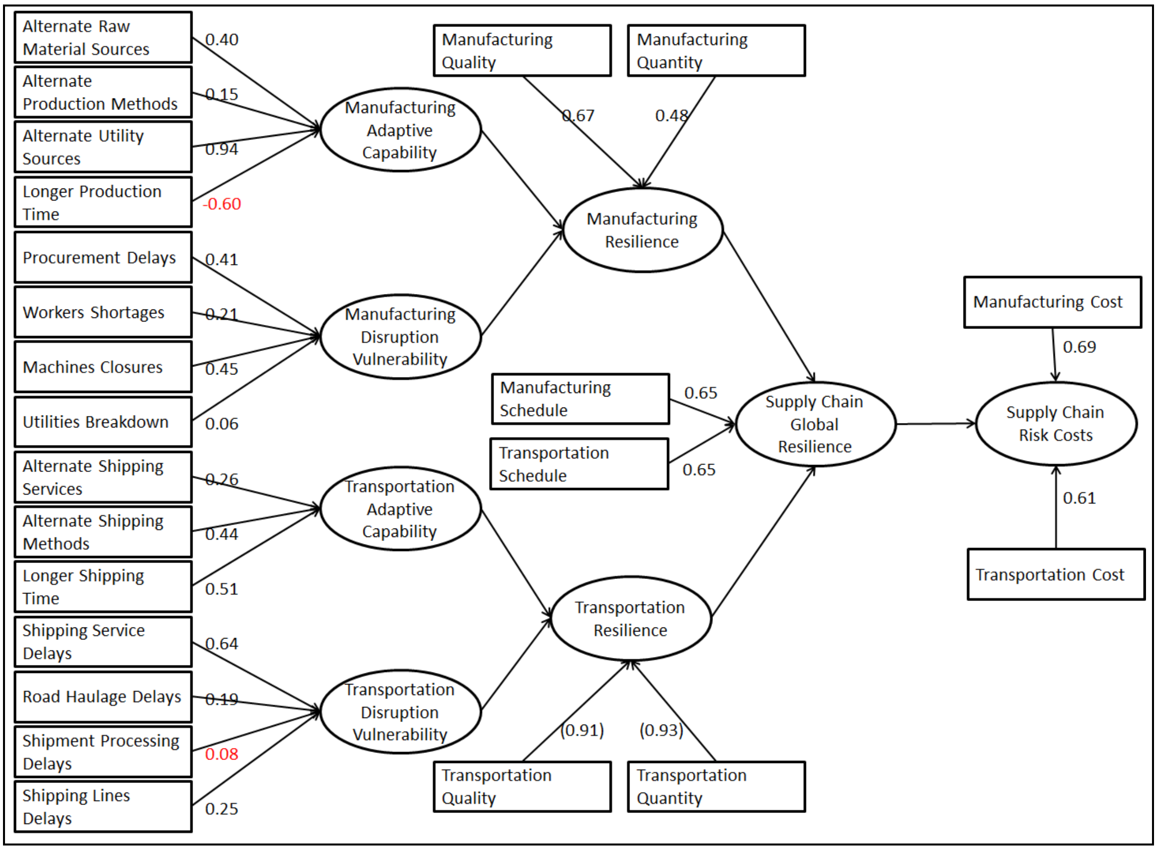

Figure 26 Weights of Indicators

The indicators of procurement delays, workers shortages, machine closures, and utilities breakdowns form the construct of manufacturing disruption vulnerability are having positive relationship with weights more than 20 percent except utilities breakdowns. The weight of utilities breakdowns indicator shows that it contributes to the construct less than 10 percent. The first three indicators qualifies

---

218 Cenfetelli & Bassellier, 2009, p. 692

that these variables contribute to the central theme of manufacturing disruption vulnerability that is supported by data for keeping theses in the model. The indicator of utilities breakdowns with low weight is to be analyzed further before considering it as a candidate for drop out of the model.

The construct of transportation adaptive capability has indicators all with weights above 25 percent. Among alternate shipping services, alternate shipping methods, and longer shipping time, there is no indicator that is potential candidate for dropping out according to the weight criteria for evaluation of quality of indicator. The indicators will be further analyzed through significance of weights and loadings and multi collinearity.

The weights of indicators representing transportation disruption vulnerability variable are 20 percent or more for shipping service delays and shipping line delays. The weight of road haulage can be rounded to 20 percent showing that the indicator is representing the construct though weekly. However, the indicator shipping processing delays is having low weight that will be considered for further analysis through loading, significance of effects and multi collinearity[219].

The indicators of manufacturing quality and manufacturing quantity for construct of manufacturing resilience are having weight more than 40 percent. Also, the transportation resilience have indicators of transportation quality and transportation quantity with weight more than 40 percent contributing to the respective formative constructs. Each of the constructs has two indicators and their relationship is supported by empirical evidence to be the part of outer models for further analysis. The indicators of manufacturing schedule and transportation form the construct of supply chain global resilience have weight more than 60 percent showing strong relationship. The construct of supply chain risk costs is well represented by respective indicators of manufacturing cost and transportation cost with weights more than 60 percent. The indicators of both the construct qualify for keeping in the respective outer models for further analysis.

[219] Hair, Ringle, & Sarstedt, 2011, p. 145/ Cenfetelli & Bassellier, 2009, p. 692

6.2.2 Significance of Weights of Indicators

Significance test of the weights is used to assess the quality of indicators. Smart PLS version 2.0 is used for estimation of test statistics as reported in Figure 26. As mentioned earlier, test statistics are calculated by using bootstrapping function of Smart PLS. The requirement for the test is to have bootstrapping sample of 5000 minimum and the number of cases is required to be equal to the number of observation in the original sample. The test statistics value of 1.65, 1.95 and 2.58 are significant at 10 percent, 5 percent and 1 percent confidence level respectively[220].

The weights for indicators of manufacturing adaptive capability, including alternate raw material sources and alternate production methods, are non-significant. The weights for indicators of alternate utility sources and longer production time are significant at 5 percent and 10 percent respectively. For manufacturing disruption vulnerability, weights for all the indicators are also non-significant.

The weight for indicators of transportation adaptive capability including alternate shipping methods and longer shipping time are significant while the weight for alternate shipping service is not significant. The weights for indicators of transportation disruption vulnerability is significant for shipping service delays while non-significant for road haulage delays, shipment processing delays, and shipping line delays.

[220] Hair, Ringle, & Sarstedt, 2011, p. 145

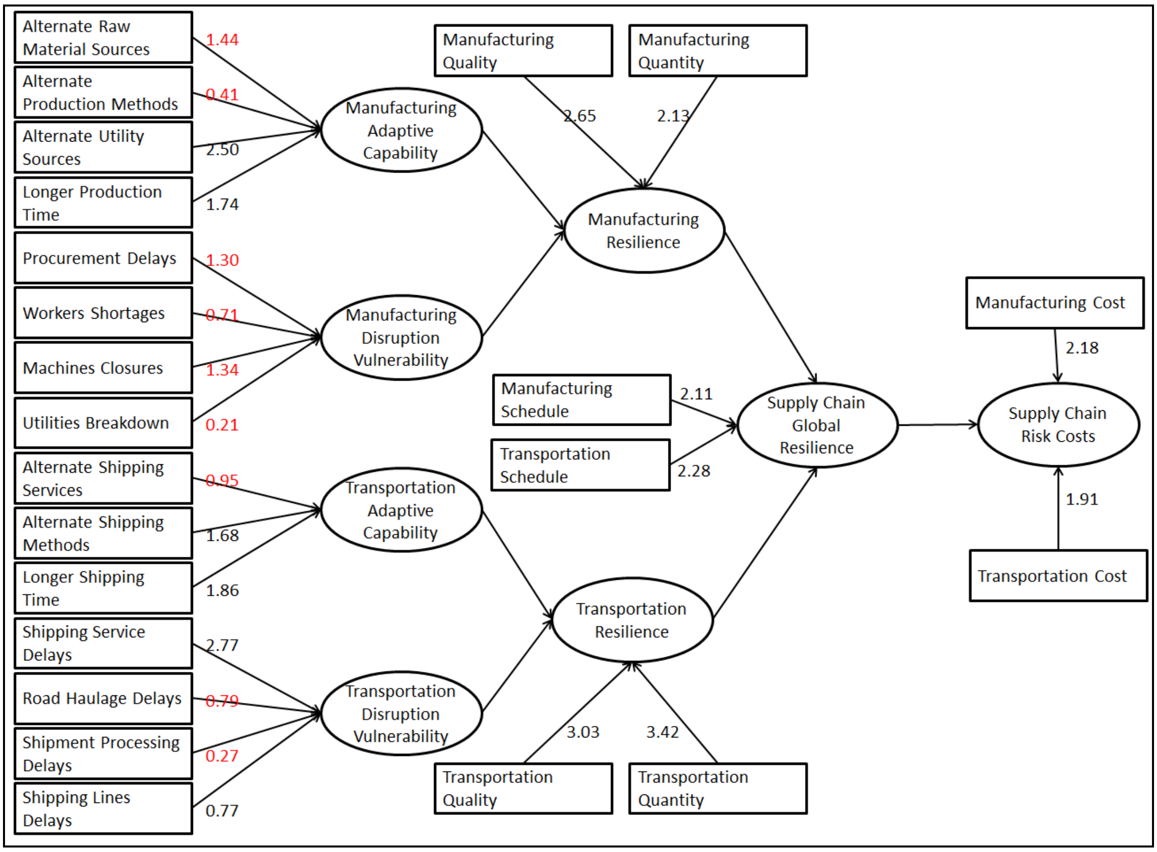

Figure 27 Significance of Weights of Indicators

The weights of indicators for manufacturing resilience including manufacturing quality and manufacturing quantity are significant at confidence level of 1 percent and 5 percent respectively. The weights of indicators for supply chain global resilience including manufacturing schedule and transportation schedule are significant at 5 percent confidence level. The weights of indicators for supply chain risk costs, including manufacturing cost and transportation cost are significant at the indicators are significant at 10 percent and 1 percent respectively. Further considerations for these indicators are their loadings and significance of the loadings.

6.2.3 Loading of Indicators

Loadings represents the absolute importance of indicators contributing to the construct. The loadings equal to or greater than 0.70 are reliable, however loadings at 0.40 are week but acceptable[221]. The loadings for all the indicators in the

[221] Hair et al., 2012, p. 429

extended supply chain resilience model, except longer production time, are above 0.70 as shown in Figure 28.

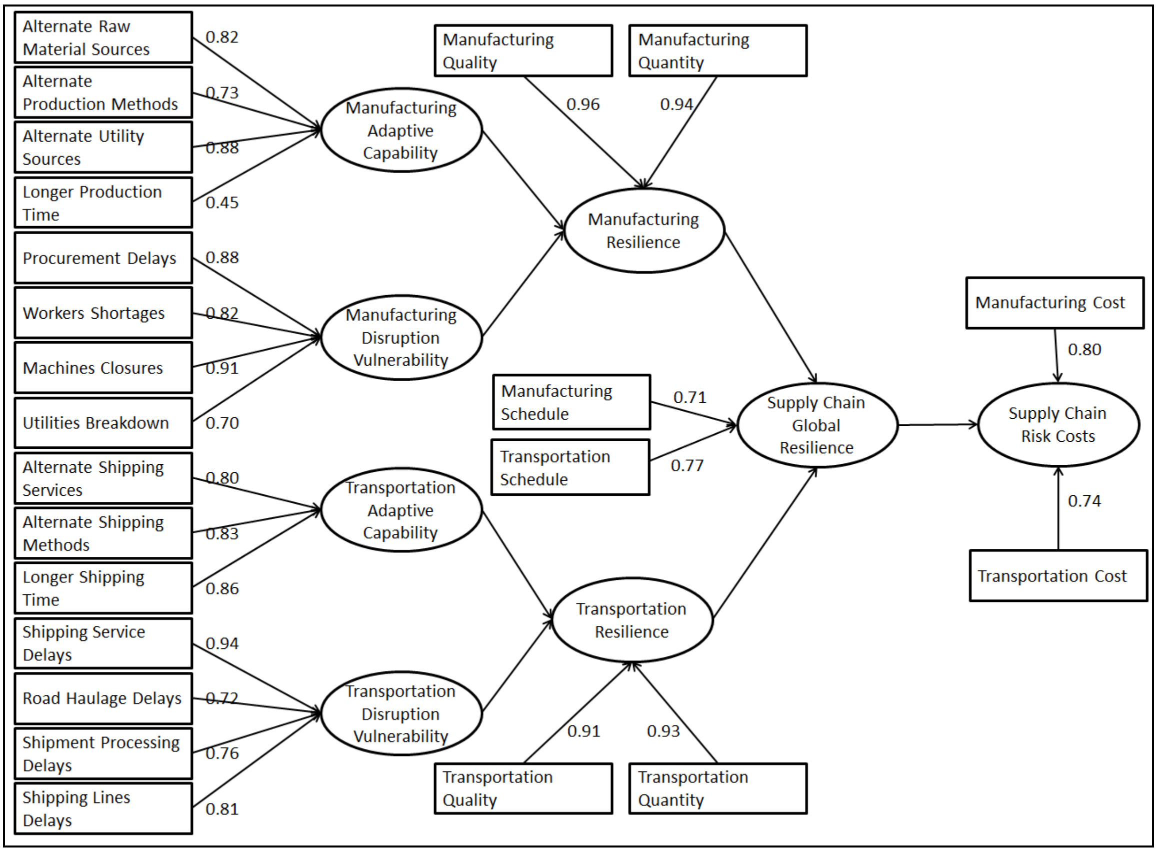

Figure 28 Loading of Indicators

The loadings for alternate raw material sources, alternate production methods, and alternate utility sources are above 0.70 that are shows moderate relationship. The loading for longer production time is above 0.40 although is week but acceptable. This suggests that all these indicators are to be kept in the model for further analysis.

The loading for indicators of manufacturing disruption vulnerability are above 0.70 and showing strong relationship with the construct. Similarly, loading for indicators of transportation adaptive capability and transportation disruption vulnerability are above 0.70 and has strong relationship with the construct.

The indicators of manufacturing resilience, transportation resilience, supply chain global resilience, and supply chain risk cost are having loadings above 0.70 with strong relationship with the respective constructs. Overall, the loadings are of practical value and are assessed for statistical significance in the following section.

6.2.4 Significance of Loadings of Indicators

Test statistics are calculated by using bootstrapping function of Smart PLS for estimating the significance of loadings of indicators, as mentioned earlier.

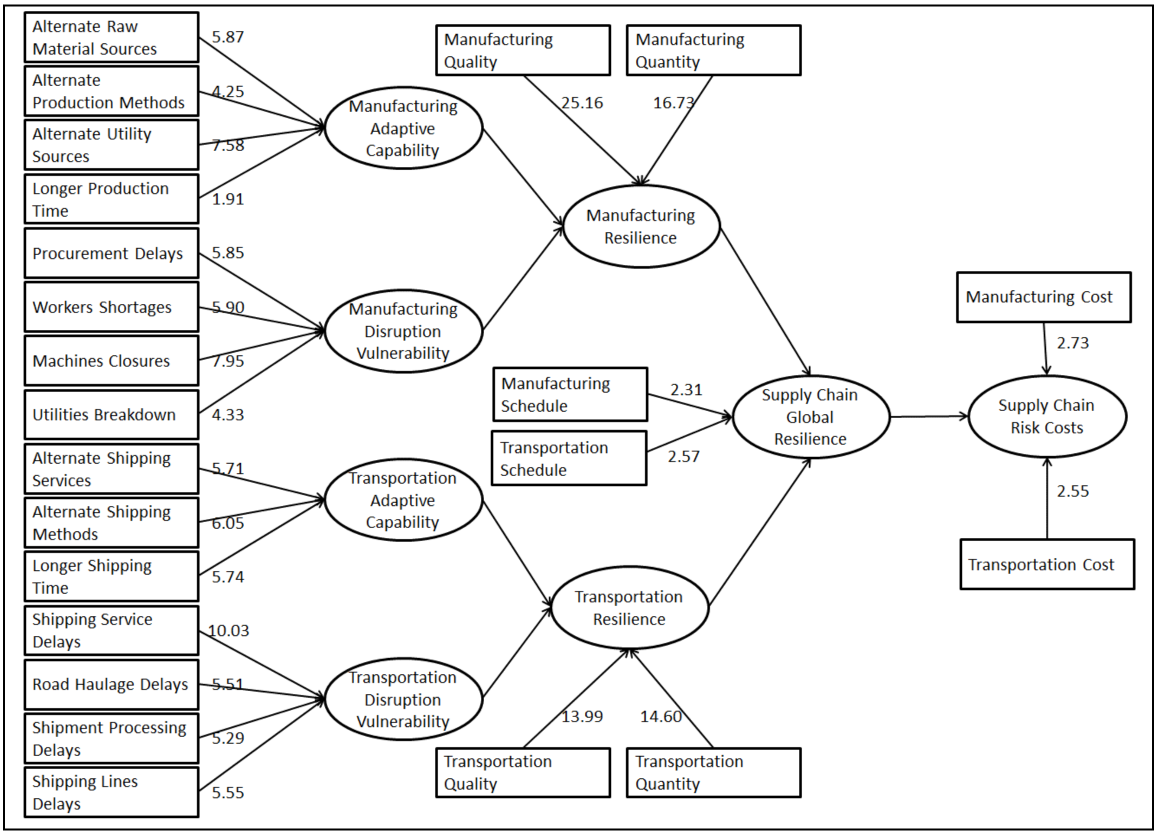

Figure 29 Significance of Loadings of Indicators

The loadings for indicators of alternate raw material sources, alternate production methods, and alternate utility sources for manufacturing adaptive capability are significant with 1 percent confidence level. The indicator of longer production time is significant with 5 percent confidence level. For manufacturing disruption vulnerability, the loadings are highly significant at 1 percent confidence level for all the indicators including procurement delays, workers shortages, machine closures, and utilities breakdown.

The loadings are significant for indicators of alternate shipping services, alternate shipping methods, and longer shipping times are significant at 1 percent confidence level. These indicators shows strong relationship with the construct of transportation adaptive capability. The loadings for indicators of transportation disruption vulnerability, including shipping service delays, road haulage delays, shipment processing delays, and shipping lines delays, are significant at 1 percent level.

The loadings for indicators, including manufacturing quality and manufacturing quantity for manufacturing resilience, are strong and are significant at 1 percent confidence level. The indicators for transportation resilience are transportation quality and transportation quantity and the loadings for these indicators are significant at 1 percent confidence level, showing strong relationship with the construct.

The loadings of indicators of manufacturing schedule and transportation schedule are significant at 1 percent confidence level for the construct of supply chain global resilience. The loadings of indicators of manufacturing cost and transportation cost are also significant at 1 percent level for supply chain risk cost.

Although there are some indicators with non-significant weights but their loadings are statistically significant. These indicators alternatively fulfils the criteria of having significant loadings and are therefore kept in the model for further analysis.

6.2.5 Collinearity of Indicators

Collinearity shows correlations among indicator variables. High correlation between two or more indicators will render the indicators as redundant. Redundant indicators are potential dropouts. In such case the model would show the indicators as non-significant. In order to check the redundancy, multi collinearity of formative indicators is examined. One of the approaches for collinearity test is examining the variance of inflation factor. Smart PLS version 2.0 does not include the feature of estimating the variance of inflation factor. IBM SPSS Statistics 20 is used for the purpose of calculating the variance of inflation factor for the indicators. The process is to use linear regression analysis. Each of the indicators is analyzed as dependent variable against the remaining set of indictors. The value of variance inflation factor is required to be less than 5, otherwise it will show collinearity and shall be considered for drop out[222]. The resulting variance inflation factor values are presented in Figure 30.

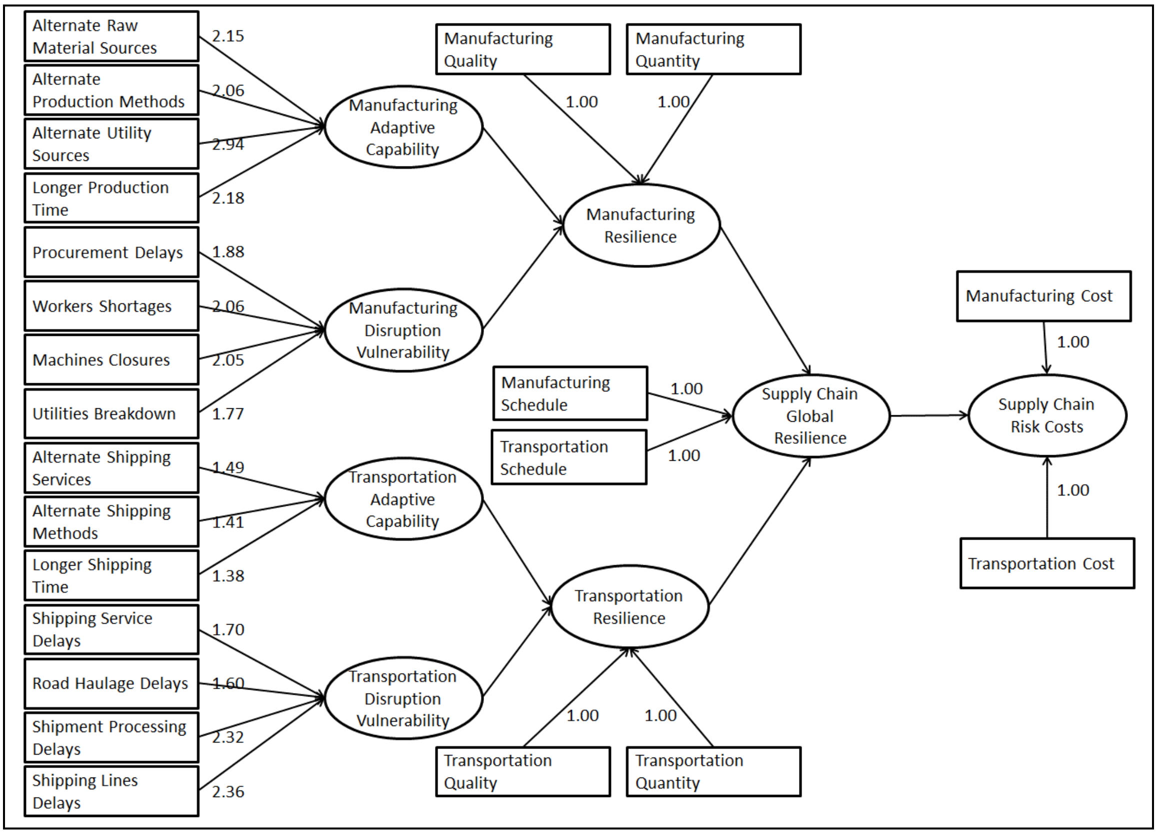

Figure 30 Variance Inflation Factor for Indicators

The values of variance inflation factor (VIF) are presented in Figure 30 for all the formative indicators of the supply chain resilience model. There is no VIF more than 3, so the values are well under the threshold of less than 5[223]. There is no evidence of collinearity that means there are no redundant indicators. The results provide support for retaining all the formative indicators.

[222] Hair, Ringle, & Sarstedt, 2011, p. 145

[223] Hair, Ringle, & Sarstedt, 2011, p. 145

6.2.6 Suppressor Effect of Indicators

Formative indicators may show negative weights because of the pattern of correlation with respect to the others in the set of indicators of a construct. It occurs when an indicator shows more variance with another indicator than the construct. It is therefore suggested to examine whether the negative correlation is with another indicator or with the construct. The indicator of longer production time has weight with negative sign that is examined for suppressor effect with the rest of indicators including alternative raw material source, alternate production method, and alternate utility sources alternatively. The indicator longer production time with alternate production method has weight with positive sign. In the presence of alternative raw material source and alternate utility sources, longer production time changes sign from positive to negative. This suggest that longer production time is showing suppressor effect. The recommendation is that if negative indicators are either not suppressor or not collinear, they should be included[224]. Though longer production time is showing evidence of suppressor effect, this indicator is not collinear as discussed earlier, therefore the indicator is retained in the model for further analysis.

After establishing reliability of the formative indicators in the outer models, the inner model is analyzed for the proposed relationships in the following section.

6.3 Evaluation of Inner Model

As the evaluation of outer model provides the evidence of reliability and validity, the evaluation of inner model estimates is to be carried out. It requires the evaluation of quality of the inner model by assessing significance of the path coefficients (weights of constructs), examining coefficient of determination of dependent constructs (R squared value), predictive relevance (Q squared value) and heterogeneity.

---

[224] Cenfetelli & Bassellier, 2009, p. 692

6.3.1 Path Coefficients

Path coefficients are the weights noted along the arrow between constructs as shown in Figure 31. The paths originate at independent construct and ends at dependent constructs. The paths coefficients represents the regression weights that explains the relationship between the constructs. The general rule is that the weight is twenty percent or above, otherwise the relationship is of no practical significance.

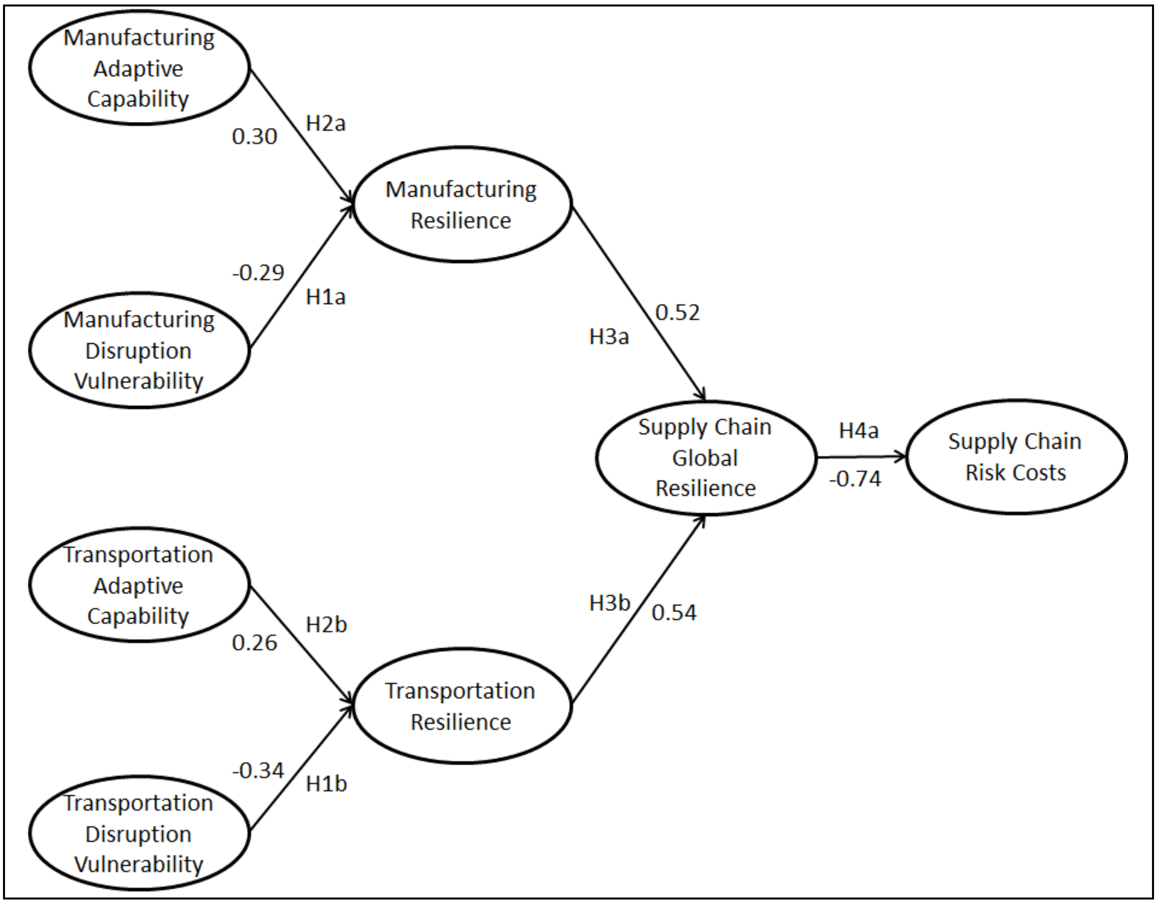

Figure 31 Path Coefficients of Inner Model

The path coefficients for all the proposed relationship between constructs demonstrates weights above twenty per cent and are therefore of practical value.

6.3.2 Significance of path coefficients

Test statistics is calculated for the significance of path coefficients and examined against the significance criteria presented earlier[225]. The t values for constructs of the extended model of supply chain resilience are reported against the paths in Figure 32.

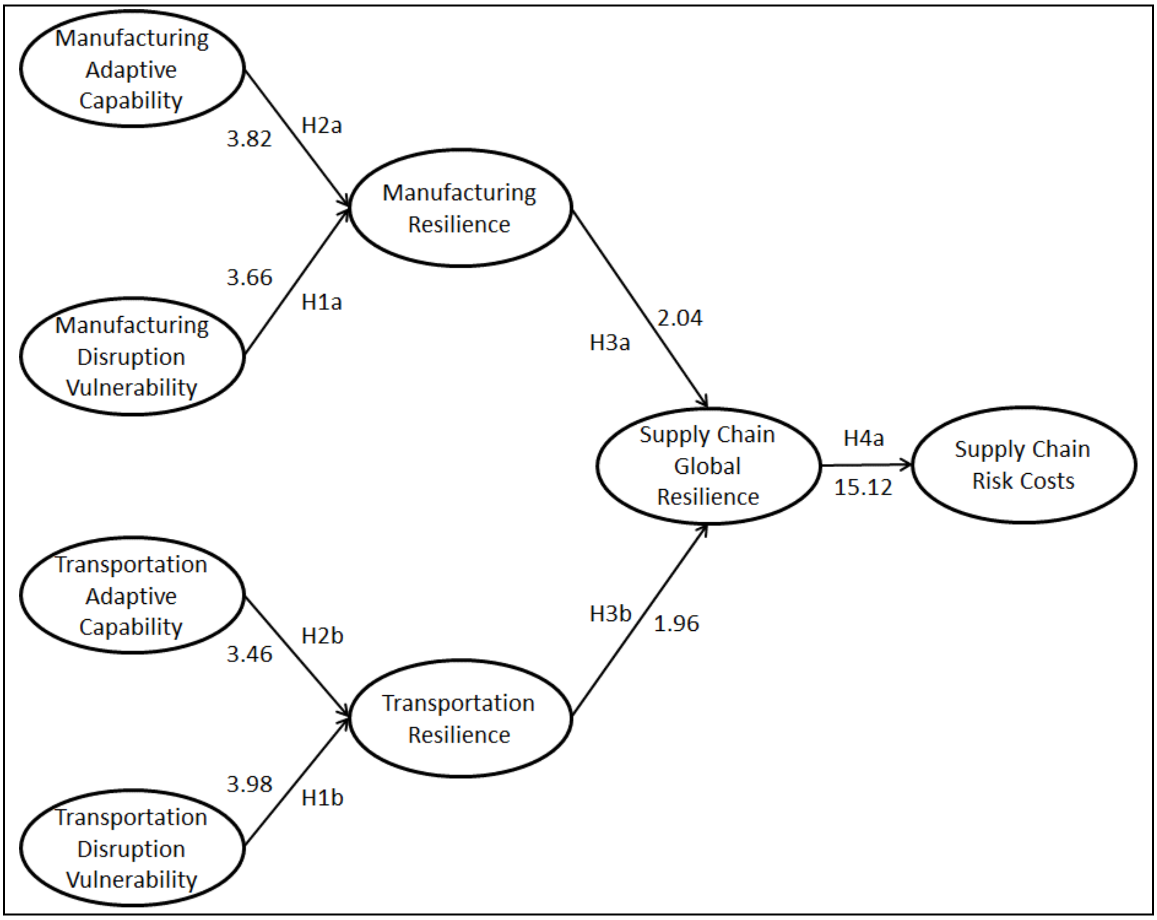

Figure 32 Significance of Path Coefficients for Constructs

All the paths between constructs presented shows significance with 5 percent confidence level. This suggests that the relationships among constructs are statistically significant. The relationships are to be examined for further considerations required for evaluation of inner model.

---

225 Hair, Ringle, & Sarstedt, 2011, p. 145

6.3.3 Coefficients of determination

The coefficients of determination is represented by the R Squared value shown at the dependent constructs (Figure 33). R squared is the square of correlation between the response values and predictor response values. It shows how well the regression line approaches the real data points. The R squared value of 0.75 is substantially showing good fit of model to the data. The R squared values of 0.50 and 0.25 are considered as moderate and weak means the real data points are scattered away from the regression[226].

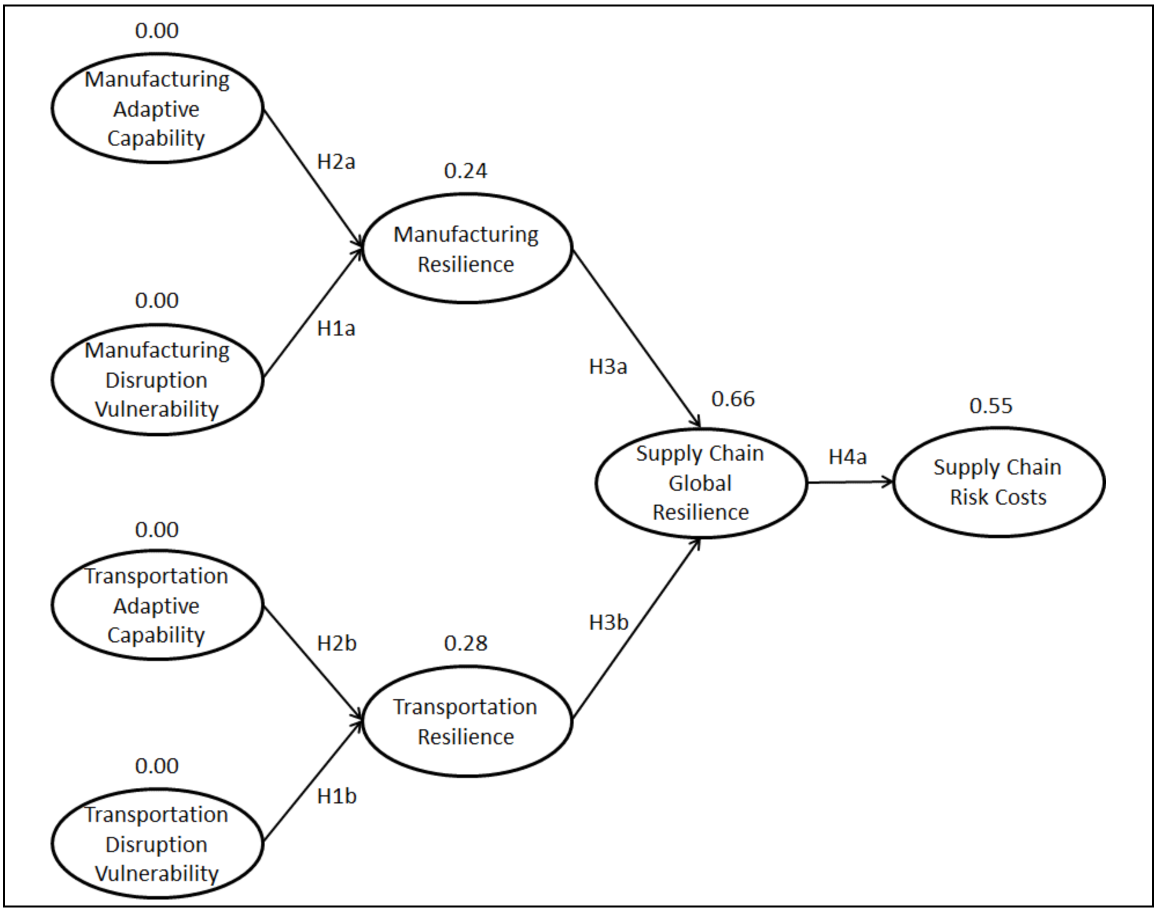

Figure 33 Coefficient of Determination for Constructs

The R squared values are calculated only for dependent variable that shows the variation in dependent variable with respect to independent variables. Therefore, R squared for independent variable is not calculated and reported in Figure 33 as

[226] Hair, Ringle, & Sarstedt, 2011, p. 145

zero for manufacturing adaptive capability, manufacturing disruption vulnerability, transportation adaptive capability, and transportation disruption vulnerability. The R squared values of manufacturing resilience and transportation resilience are 0.24 and 0.28 showing weak relationship regarding determination. The R Squared values of supply chain global resilience and supply chain risk costs are 0.66 and 0.55 shows moderate relationship between the independent and dependent constructs.

6.3.4 Predictive relevance

Predictive relevance is the determination of how well the independent constructs predicts the dependent variable. For this purpose the values of Q squared are calculated and reported in Figure 34.

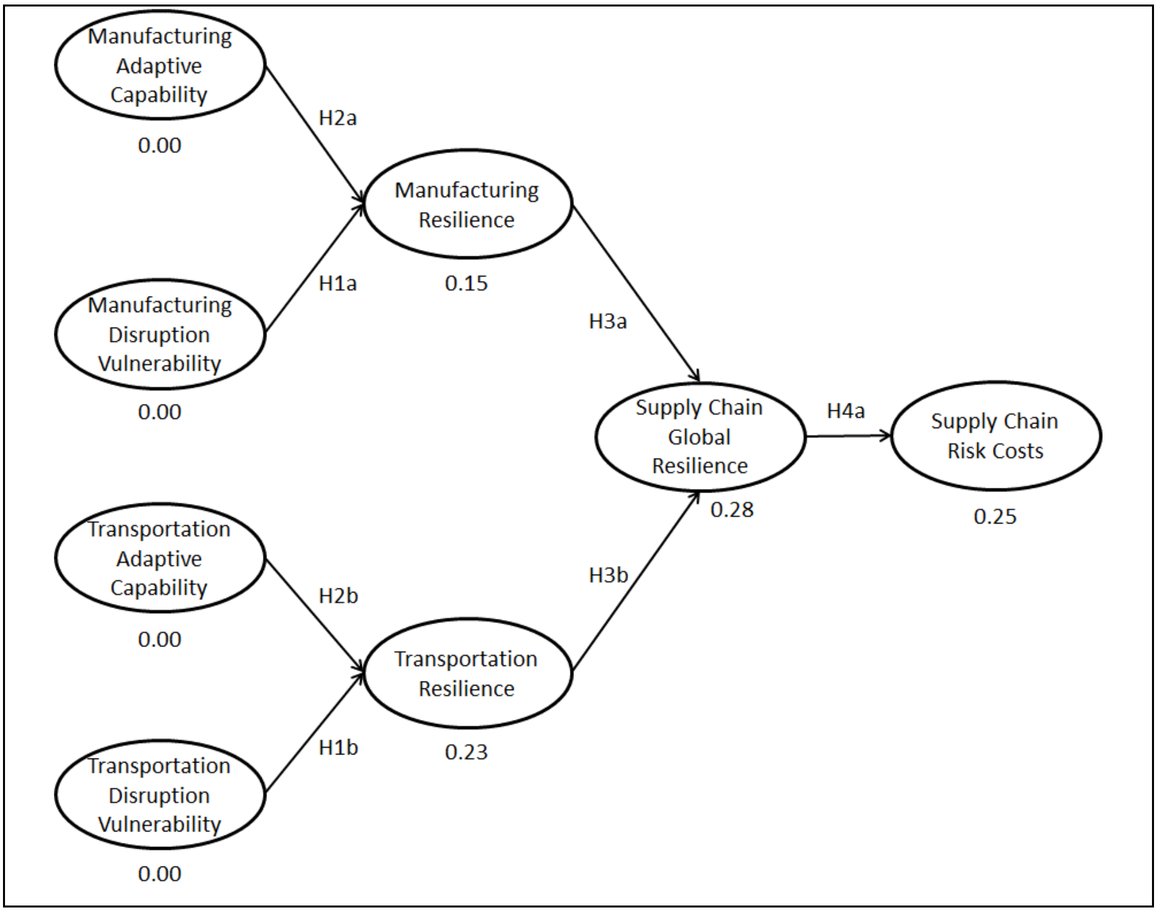

Figure 34 Predictive Relevance of Constructs

Blindfolding is used to assess the constructs for cross validity redundancy. The measure for assessment of cross validity redundancy is the value of Q squared.

The requirement for the test is that the number of valid observation is not a multiple number of the omission distance d. Blindfolding omits a block of data for particular indicator during parameter estimation through which the omitted part is estimated. The value of d is recommended between 5 and 10. Q squared greater than zero shows that the independent construct have predictive relevance for the dependent constructs[227].The Q squared values for all the dependent variables is above zero, suggestion predictive relevance of independent variables in the model.

6.3.5 Heterogeneity

Heterogeneity looks for consistency of results of a study. However in case the theory supports presence of group differences then multi-group or moderator analysis is suggested. Otherwise in the absence of theoretical support, test for existence of heterogeneity is conducted for unobserved heterogeneity[228]. In case of international garments supply chain, there are data groups for the partnering countries. The multi-group moderation analysis is carried out and presented in section 6.4.3.

Direct relationship, mediation effect, and moderation effect among constructs are hypothesized in Table 1 and Table 2. These relationships are analyzed in the light of results presented in the preceding section.

6.4 Hypotheses Analysis

The following section assess the relationship between constructs of the model. The one-to-one relationship between constructs is presented as direct relationship. The subtle relationship among constructs is presented as mediated and moderated relationship. In the latter case, more than two constructs are involved in explaining the relationship between independent and dependent constructs.

---

[227] Hair, Ringle, & Sarstedt, 2011, p. 145

[228] Hair, Ringle, & Sarstedt, 2011, p. 145

6.4.1 Direct Relationship

In direct causal relationship, a variable directly causes effect on another variable[229]. The independent determines the dependent variable. Independent variables is therefore called predictor variable and the dependent variable is called as outcome variable as shown in Figure 35.

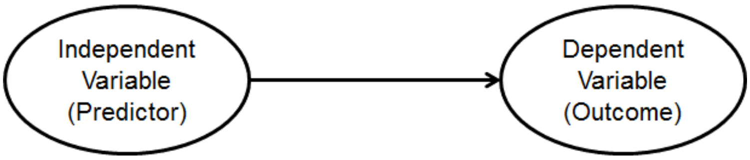

Figure 35 Direct Causal Effect

The paths between constructs suggest direct relationships among the variables (Figure 31). Direct relationship among constructs is evaluated against the parameters of coefficient of determination through value of R squared, significance of path coefficients through bootstrapping, and predictive relevance through value of Q squared as discussed in the preceding section. The relationship between disruption vulnerability and resilience and adaptive capability and resilience for both processes of manufacturing and transportation are examined. The relationship between manufacturing and transportation resilience with supply chain global resilience and in turn supply chain global resilience relationship with supply chain risk cost is assessed.

6.4.1.1 Disruption Vulnerability and Resilience

International garments supply chain consists of procurement, production and transportation processes as shown in Figure 7. The processes are exposed to internal or external factors that makes a process, carried by supply chain entity, susceptible to disruptions. The unexpected events cause variability in the objectives of processes. The frequency of variability in the objective of supply chain processes determines resilience of the respective process. Supply chain process hit frequently by disruptions would result in frequent variability or

[229] Iriondo, Albert, & Escudero, 2003, p. 368

low resilience. The general proposition is that supply chain disruption vulnerability negatively affects resilience of supply chain process resilience. Supply chain processes in this study under consideration are manufacturing and transportation. The hypothesis H1a and H1b are proposed to suggest relationship between supply chain processes disruption vulnerability and resilience as stated in Table 1.

H1a. Manufacturing disruption vulnerability negatively affects manufacturing resilience.

The path coefficient between manufacturing disruption vulnerability and manufacturing resilience is -0.29 (Figure 31). The significance test shows that the path coefficient is having test statistics value 3.66 (Figure 32) at 1 percent confidence level, criteria stated earlier. The R squared value for construct of manufacturing resilience is 0.24 (Figure 33). The value shows fit of model to the data though week suggesting that the data is scattered anyway close to the regression line. The coefficient of determination explains the relationship sufficiently. The next measure is significance of path coefficient. The measure of predictive relevance is examined through blindfolding test and has value of 0.15 (Figure 34), for dependent variable of manufacturing resilience showing that it is predicted by independent variable of manufacturing disruption vulnerability. The measures indicates that manufacturing disruption variability negatively affects manufacturing resilience.

H1b. Transportation disruption vulnerability positively affects Transportation resilience.

The path coefficient is -0.34 (Figure 31) with significance value of 3.98 (Figure 32). The value of R squared for transportation resilience is 0.28 (Figure 33), representing weak coefficient of determination. The measure of predictive relevance is 0.23 (Figure 34) for dependent variable of transportation resilience. The coefficient of determination, significance of path coefficient, and predictive relevance indicates that transportation disruption vulnerability is negatively related to transportation resilience.

The disruption vulnerability frequently hitting supply chain processes would cause frequent variability in meeting quality and quantity objectives resulting in frequent variability in resilience.

6.4.1.2 Adaptive Capability and Resilience

Supply chain adaptive capability is composed of attributes that enables the supply chain entity to respond to disruption by prevention, mitigation, or adaption. Adaptive capability is the possibility to use alternate means or methods available internally or externally to supply chain entity. Supply chain processes requires resources as input for operation that are vulnerable to disturbances. Supply chain entity intervenes through adaptive capability to adjust to such disturbances and ensure reliability of process functioning. The general proposition is that adaptive capability positively affect the resilience of supply chain processes. The hypothesis H2a and H2b are proposed to suggest positive relationship among supply chain entity’s adaptive capability and resilience of supply chain process.

H2a. Manufacturing adaptive capability positively affects manufacturing resilience.

Manufacturing adaptive capability directly affects manufacturing resilience. The coefficient of determination for manufacturing disruption vulnerability and manufacturing adaptive capability is the same because these two constructs are proposed to predict the construct of resilience. The path coefficient for manufacturing adaptive capability and manufacturing resilience is 0.30 (Figure 31) and the test statistics value is 3.82 (Figure 32) that is significant at 1 percent. As mentioned before, the R squared value for manufacturing resilience is 0.24 (Figure 33) fall under weak coefficient of determination. Similarly, the predictive relevance of manufacturing resilience is the same as 0.15 (Figure 34) that is above zero and is significant according to the criteria stated earlier. The parameters for hypothesis H2b are showing significance that means that manufacturing adaptive capability predicts manufacturing resilience.

H2b. Transportation adaptive capability positively affects transportation resilience.

Transportation adaptive capability directly affects transportation resilience. The coefficient of determination for transportation resilience is the same as transportation disruption vulnerability and adaptive capability are independent variables for transportation resilience. The path coefficient between transportation adaptive capability and transportation resilience is 0.26 (Figure 31) and has significance of 3.46 (Figure 32). The value of significance demonstrates significance ant 1 percent confidence level. The dependent variable of transportation resilience has R squared value of 0.28 (Figure 33) that is considered as week against the substantial value of 0.75 or moderate value of 0.50. Values above 0.25 are significant but ranked as weak as discussed earlier. The predictive relevance of transportation resilience is 0.23 (Figure 34) that is well above the threshold of zero. To conclude, these indicators demonstrate that transportation adaptive capability positively affects transportation resilience.

6.4.1.3 Processes Resilience and Global Resilience

Supply chain processes contribute to the overall objective of providing products or services to the customer. Supply chain processes of procurement, manufacturing, and transportation are suggested to contribute to overall supply chain resilience. In this study, manufacturing resilience and transportation resilience are supposed to determine the global resilience. The hypothesis H3a and H3b positively affect global resilience.

H3a. Manufacturing resilience positively affects global resilience of supply chain.

The model suggests direct relationship between manufacturing resilience and supply chain global resilience. To evaluate the relationship the parameter of coefficient of determination, significance of paths coefficients, and predictive relevance are examined through the values of R squared, test statistics value and Q squared value. The path coefficient is 0.52 (Figure 31) and significant value is 2.04 (Figure 32) with 5 percent confidence level. This means that the direct relationship is highly significant. The coefficient of determination for dependent variable of global resilience is 0.66 (Figure 33) that is moderately significant. The predictive relevance for dependent variable of supply chain global resilience estimated through blindfolding is 0.28 (Figure 34) that well above the threshold of zero representing significant predictive relevance. The parameters for relationship between manufacturing resilience and supply chain global resilience are significant.

H3b. Transportation resilience positively affects global resilience of supply chain.

The transportation resilience along with manufacturing resilience are independent variables determining global resilience. The path coefficient between transportation resilience and supply chain global resilience is 0.54 (Figure 31). The test statistics value obtained through bootstrapping estimation indicating the significance of the path coefficient is 1.96 (Figure 32) with 5 percent significance level. As already mentioned, the R squared value for coefficient of determination remains the same for dependent variable of supply chain global resilience as 0.66 (Figure 33) with moderate degree. The parameter of predictive relevance for dependent variable of supply chain global resilience, obtained through blindfolding estimation, is 0.28 (Figure 34) that is well above the threshold of zero. The direct relationship between transportation resilience and supply chain global resilience is positively and significantly demonstrated by the parameters considered for the evaluation purpose.

6.4.1.4 Global Resilience and Cost Resilience

Supply chain resilience model suggests direct relationship between the construct of global resilience and supply chain cost. Resilient supply chain is expected to have low risks costs. The relationship is stated in hypothesis H4.

H4. Supply chain global resilience negatively affects supply chain risk costs.

The path coefficient between supply chain global resilience and supply risks cost is -0.74 (Figure 31). The significance of path coefficient is 15.12 (Figure 32) at 1 percent confidence level. The suggested direct relationship demonstrates coefficient of determination at 0.55 (Figure 33) that suggests moderate relationship. The predictive relevance for dependent variable of supply chain risk costs is 0.25 (Figure 34) that is well above the threshold of zero. The direct relationship between supply chain global resilience and supply chain risk cost is negatively and significantly demonstrated by the parameters used for evaluation.

The direct relationship between constructs of the model have been examined and discussed for soundness and have been found of practical significance. The following section discusses the relationship between independent and dependent constructs with reference to a third variable. The relationships have been generalized as hypothesis in section 3.4 as variation of the model. As the study is concerned with the influence of disruption vulnerability and adaptive capability on resilience of supply chain process, mediation and moderation is analyzed only for this part of the model.

6.4.2 Mediation Causal Effect

Mediation model requires variables in the roles of predictor, mediator, and outcome variables. Supply chain resilience model suggests inherently that resilience is determined by disruption vulnerability and adaptive capability. Adaptive capability comes into play in the advent of disruption. Disruption vulnerability assumes the role of predictor variable, adaptive capability functions as mediator and resilience takes the role of outcome variable. The mediation assumes that the effect of disruptive vulnerability is supposed to cause changes in resilience after the contribution of adaptive capability.

For manufacturing process, the hypothesis is stated as:

H5a. Manufacturing adaptive capability negatively mediates the negative relationship between manufacturing disruption vulnerability and manufacturing resilience.

In order to test the role of manufacturing adaptive capability as mediating variable, the required empirical conditions are examined. For manufacturing, the direct relationship between disruption vulnerability and resilience is tested first for significance in the absence and then in the presence of mediator to assess mediation as shown in Figure 36.

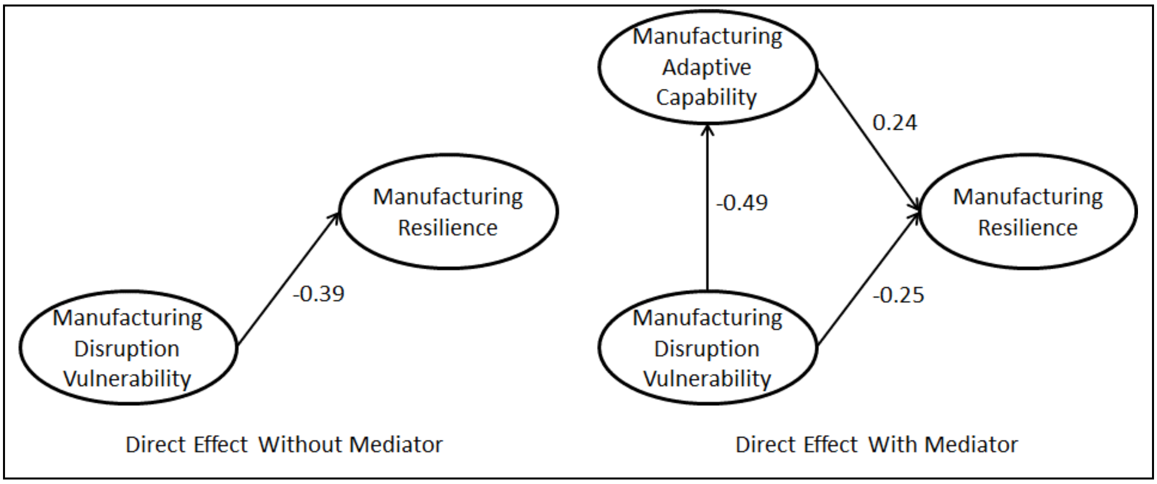

Figure 36 Mediation Effect for Manufacturing

This relationship is required to be significant. Bootstrapping is used for estimation of t value and the values of 2.58, 1.96, and 1.65 are significant at 1 percent, 5 percent, and 10 percent confidence level respectively[230]. The next step is to test the significance of direct relationship between disruption vulnerability and resilience variable, this time in the presence of mediator. The decision is made accord-

---

[230] Hair, Ringle, & Sarstedt, 2011, p. 145

ing to the criteria as stated above for empirical conditions. The relationship between independent variable and dependent variable is estimated first without and then with mediator. The relationship between independent variable and mediator and mediator and dependent variable are also assessed for identifying the type of mediation that is affected by mediating variable. The path coefficients, test statistics and significance are reported for the relationship among the constructs.

The direct effect between independent variable of manufacturing disruption vulnerability and dependent variable of manufacturing resilience is noted and tested for significance. The path coefficient between manufacturing disruption vulnerability and manufacturing resilience is -0.39 (Figure 36) in the absence of mediator. With introduction of mediation variable of manufacturing adaptive capability, the direct effect between manufacturing disruption vulnerability and manufacturing resilience drops to -0.25 (Figure 36).

The test statistics, estimated through bootstrapping, is 4.72 (Figure 37) that is significant with confidence level of 1 percent[231]. The direct effect is still significant with introduction of mediator for which the test value is 2.23 (Figure 37) that is significant with confidence level of 5 percent. The relationship between manufacturing disruption vulnerability and manufacturing resilience is statistically significant both in the presence and absence of manufacturing adaptive capability. This means that manufacturing adaptive capability is having mediation effect and the effect of manufacturing disruption vulnerability passes through manufacturing adaptive capability.

[231] Hair, Ringle, & Sarstedt, 2011, p. 145

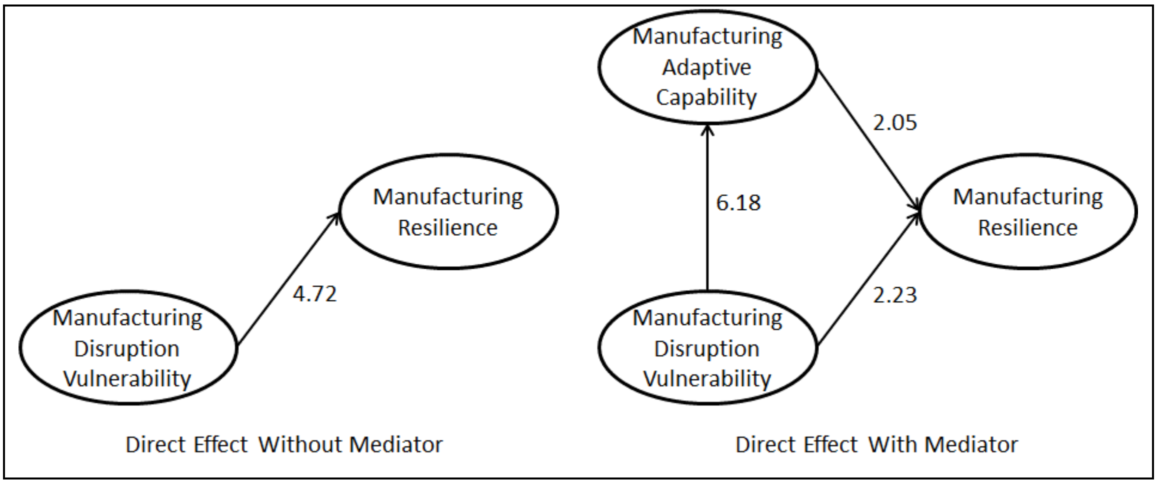

Figure 37 Significance of Mediation Effect for Manufacturing

The mediation is further analyzed for partial or no mediation. For this purpose the path coefficients between independent variable and mediator and mediator and dependent variable are to be assessed for significance. The relationship between independent variable and mediator i.e. manufacturing disruption vulnerability and manufacturing adaptive capability is -0.49 (Figure 36). The path coefficient is significant with test statistics of 6.18 (Figure 37) with 1 percent confidence level. As a last step, the paths from mediator to dependent variable are examined for significance. The path coefficient between manufacturing adaptive capability and manufacturing resilience is 0.24 (Figure 36). The test statistics, estimated through bootstrapping, is 2.05 (Figure 37) that is significant with confidence level of 5 percent.

All the relationships between manufacturing disruption vulnerability, manufacturing adaptive capability and manufacturing resilience are significant suggesting that H5a has empirical evidence to show partial. The sign for relationship between the manufacturing disruption vulnerability and manufacturing resilience remains the same as negative. This suggests that the mediation is also not inconsistent. The relationship between manufacturing disruption vulnerability and manufacturing resilience remains significant after the introduction of mediator so this does not suggest full mediation. With all the relationships significant, partial mediation is suggested. The implications are that manufacturing adaptive capability is used judiciously to respond to disruptions and contribute to manufacturing resilience. For mediation in transportation process, the hypothesis is stated as:

H5b. Transportation adaptive capability negatively mediates the negative relationship between transportation disruption vulnerability and transportation resilience.

For transportation, the direct relationship between disruption vulnerability and resilience is tested first for significance in the absence and then in the presence of mediator to assess mediation as shown in Figure 38.

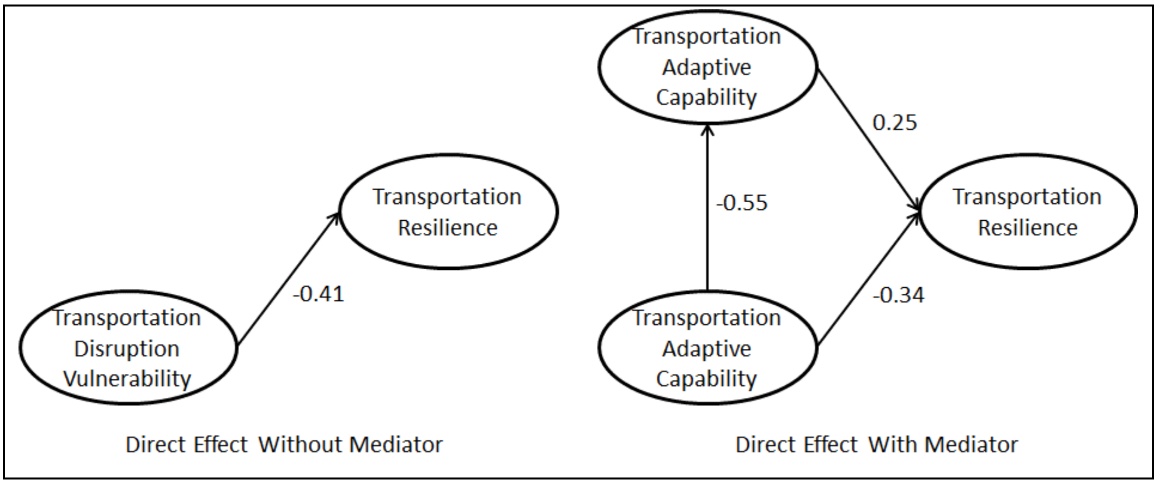

Figure 38 Mediation Effect for Transportation

The direct effect between transportation disruption vulnerability and transportation resilience is -0.41 (Figure 38). The test statistics, estimated through bootstrapping, is 6.36 (Figure 39) is significant with confidence level of 1 percent[232]. With introduction of mediation variable of transportation adaptive capability the path coefficients between transportation disruption vulnerability and transportation resilience drops for transportation process to -0.34 (Figure 38). However the relationships is still significant with critical t values as 3.56 (Figure 39) that is significant with 1 percent confidence level. Partial or no mediation for transportation process is analyzed. For this purpose, the relationship between independent variable and mediator i.e. transportation disruption vulnerability and transportation adaptive capability is estimated as -0.55 (Figure 38). The direct effect is significant with test statistics 9.03 (Figure 39) with 1 percent confidence level. As a final step, the path from mediator to dependent variable i.e. manufacturing adap-

232 Hair, Ringle, & Sarstedt, 2011, p. 145

tive capability to manufacturing resilience are analyzed. The path coefficient between mediator and dependent variable is 0.25 (Figure 38) for transportation process. The test statistics, estimated through bootstrapping, is 2.89 (Figure 39) that is significant with confidence level of 1 percent.

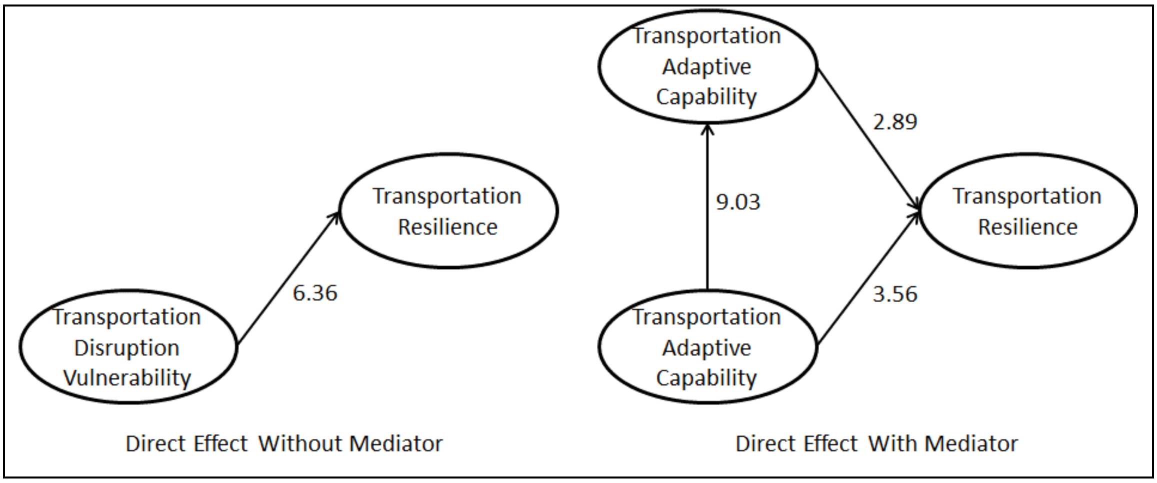

Figure 39 Significance of Mediation Effect for Transportation

All the relationships between transportation disruption vulnerability, transportation adaptive capability and transportation resilience are significant suggesting that H5b has empirical evidence to show partial mediation. The sign for relationship between the transportation disruption vulnerability and transportation resilience remains the same as negative. This suggests that the mediation is also not inconsistent. The relationship between transportation disruption vulnerability and transportation resilience remains significant after the introduction of mediator so this does not suggest full mediation. With all the relationships significant, partial mediation is suggested. The implications are that transportation adaptive capability is used judiciously to respond to disruptions and contribute to transportation resilience.

6.4.3 Moderation Causal Effect

In this model, adaptive capability is assumed as moderator, disruption vulnerability is the moderated variable, and resilience is the outcome variable. The interaction terms in the model are resulted as product of the moderating and moderated variables[233]. Following the interaction term for manufacturing moderation.

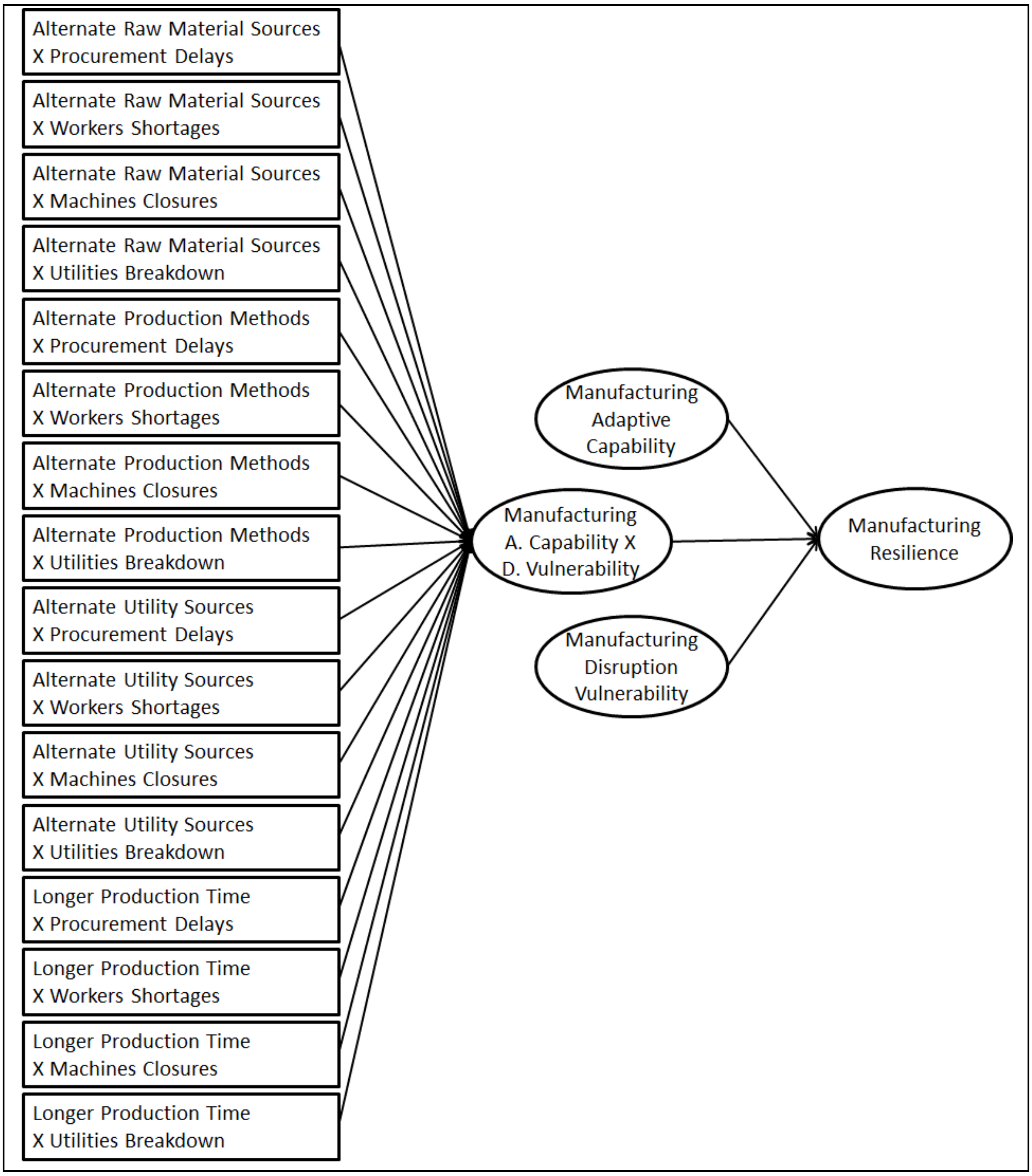

Figure 40 Interaction Term for Manufacturing

The interaction term in the model of supply chain resilience is the product of adaptive capability (moderating variable) and disruption vulnerability (moderated variable). The interaction term for manufacturing process is the product of all

---

233 Hair, Ringle, & Sarstedt, 2011, p. 145

indicator of manufacturing adaptive capability and manufacturing disruption vulnerability in supply chain resilience model. Manufacturing adaptive capability has four indicators and manufacturing disruption vulnerability has also four indicators. The manufacturing interaction term would calculate sixteen product variable as presented in Figure 40.

The interaction term for transportation process is the product of all indicator of transportation adaptive capability and transportation disruption vulnerability. Transportation adaptive capability has three indicators and transportation disruption vulnerability has four indicators. The transportation interaction term would calculate twelve product variables as presented in Figure 41.

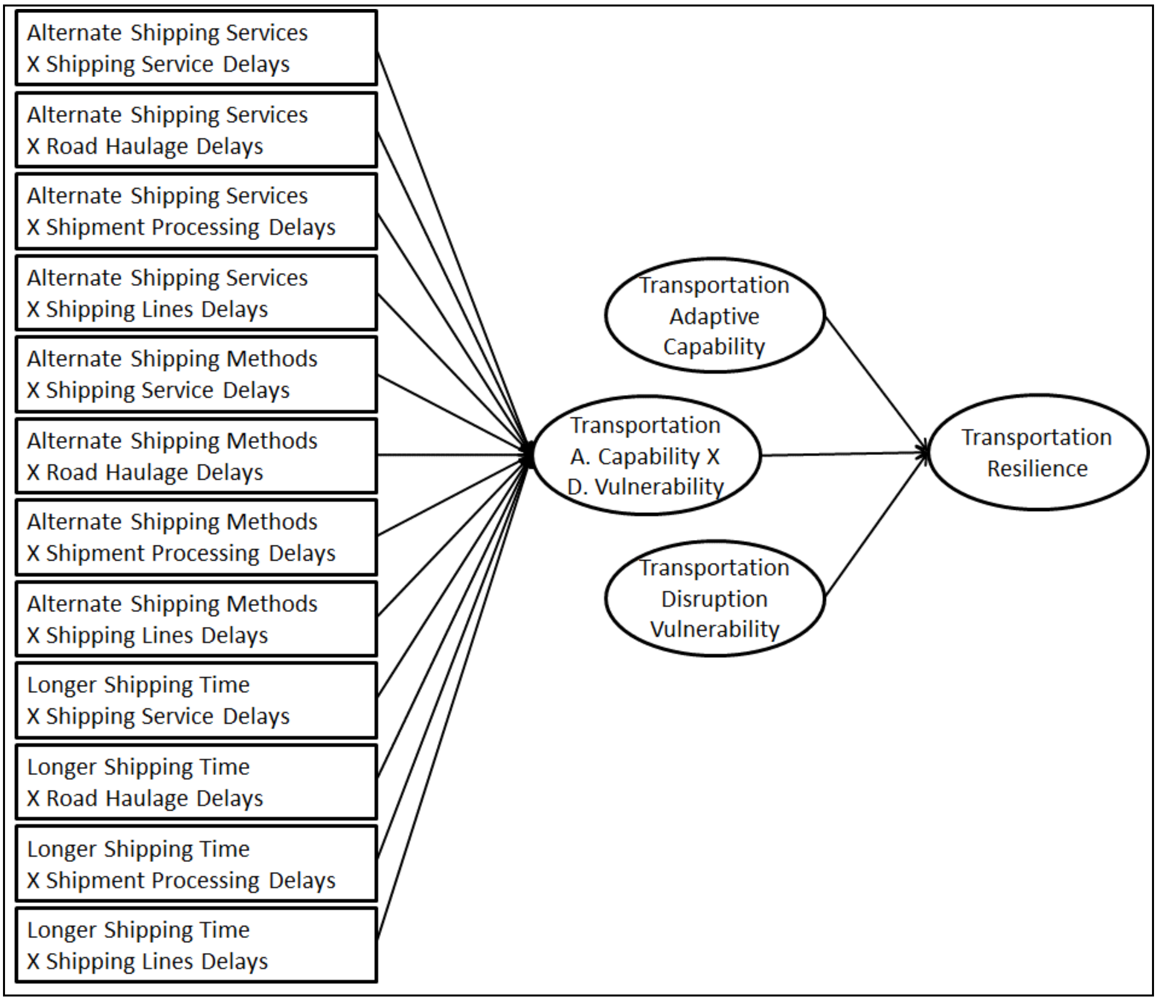

Figure 41 Interaction Term for Transportation

The effects of adaptive capability, disruption vulnerability and interaction terms are estimated and examined for significance. The indicators for constructs and interaction terms are huge in number and therefore not shown in Figure 42.

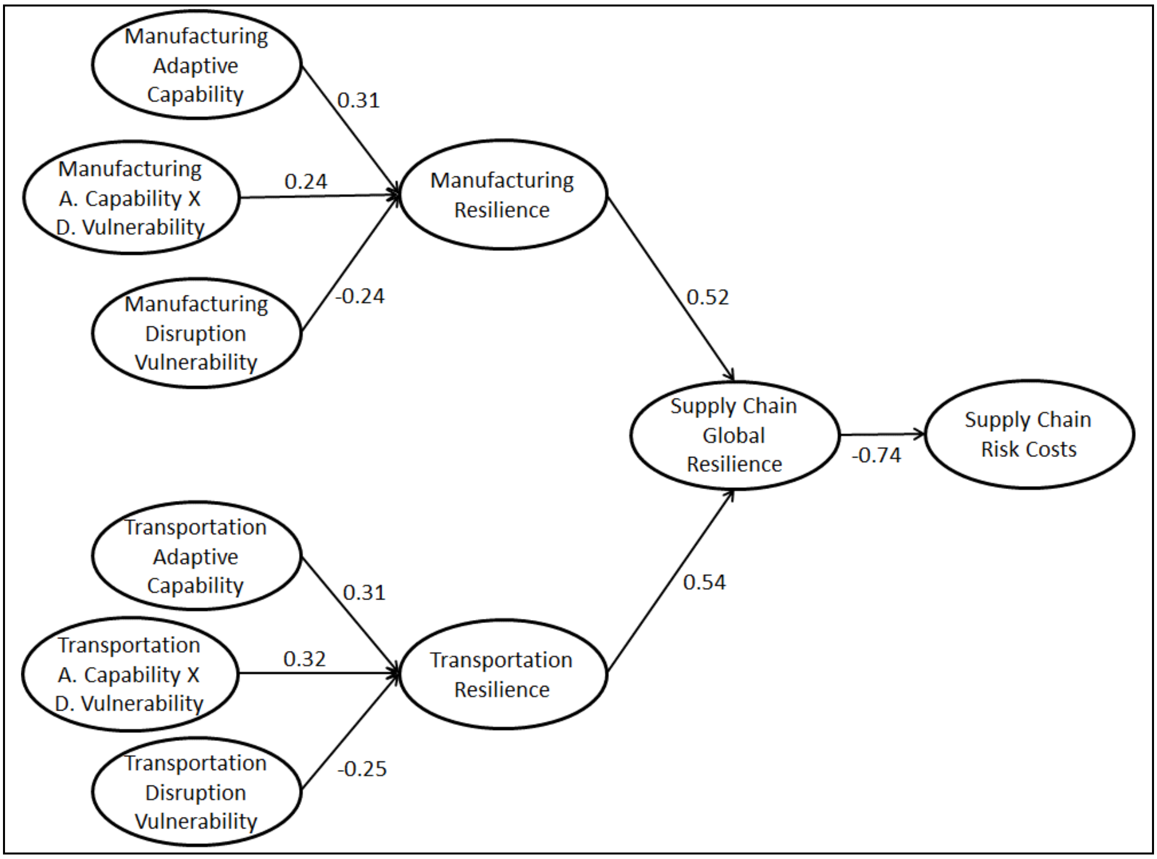

Figure 42 Interaction Moderation Effect

The mediation effect for manufacturing process is proposed as:

H6a. Manufacturing adaptive capability dampens the negative relationship between manufacturing disruption vulnerability and manufacturing resilience.

The effect between moderating variable of manufacturing adaptive capability and manufacturing resilience is 0.31 (Figure 42) with test statistics 3.95 (Figure 43) that is significance at 5 percent confidence level. The interaction terms for manufacturing process in the model has effect of 0.24 (Figure 42) on dependent variable of manufacturing resilience. The effect is tested for significance with bootstrapping procedure that calculate test statistics for the effect is 3.08 (Figure 43) that is significance at 5 percent confidence level. The relationship between moderated variable of manufacturing disruption vulnerability and manufacturing resilience is -0.29 with test statistics 3.13 with 5 percent confidence level.

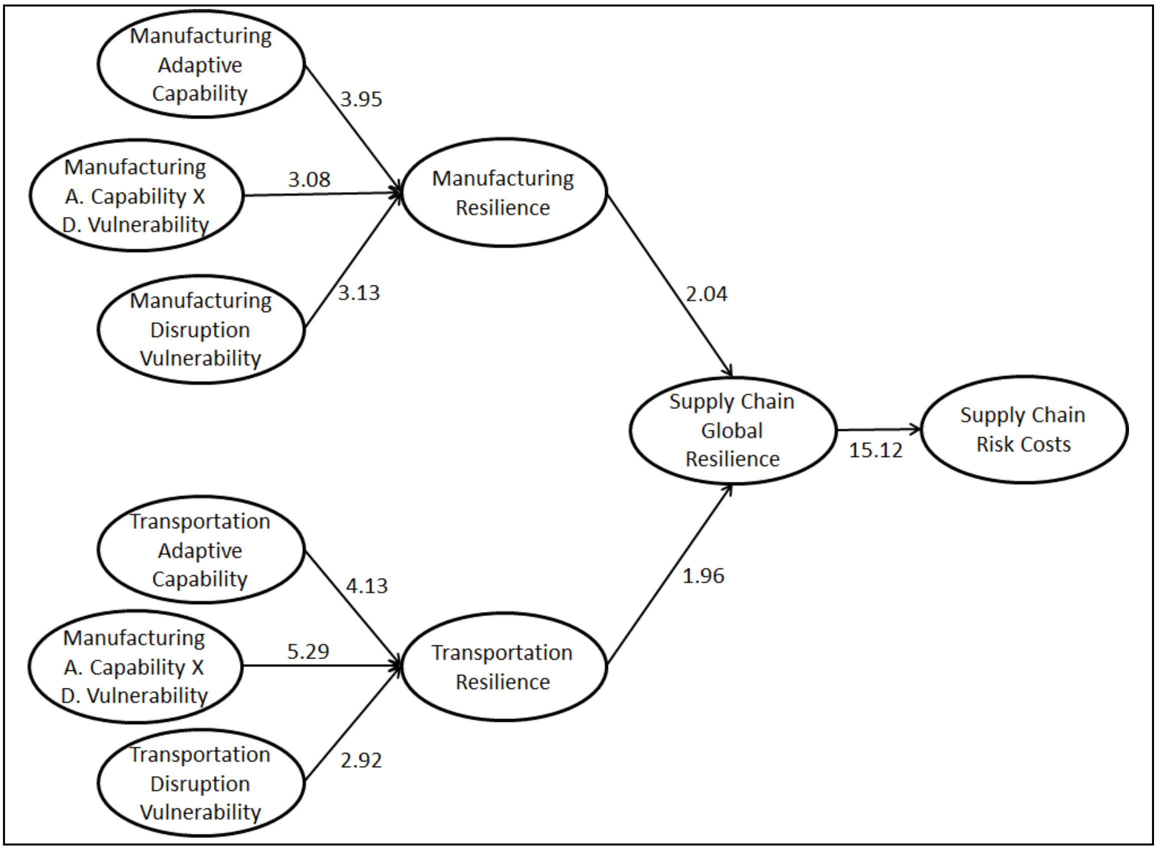

Figure 43 Significance of Interaction Moderation Effect

The mediation effect for manufacturing process is proposed as:

H6b. Transportation adaptive capability dampens the negative relationship between transportation disruption vulnerability and transportation resilience.

The effect between moderating variable of transportation adaptive capability and transportation resilience is 0.31 (Figure 42) with test statistics 4.13 (Figure 43) that is significance at 1 percent confidence level. The interaction terms for transportation process in the model has effect of 0.32 (Figure 42) on dependent variable of manufacturing resilience. The test statistics for the effect is 5.29 (Figure 43) that is significance at 1 percent confidence level. The relationship between moderated variable of manufacturing disruption vulnerability and manufacturing resilience is -0.25 (Figure 42) with test statistics 2.92 (Figure 43) with 5 percent confidence level.

So there is empirical evidence of the presence of moderating variable, cause change in the relationship of independent and dependent variable. In order to find whether the presence of adaptive capability negatively affect the relationship between disruption vulnerability and resilience, the interaction effect is represented graphically. For this purpose two way interactions are plotted, one for effect of disruption vulnerability on resilience without adaptive capability as moderator and the second effect in the presence of moderator.

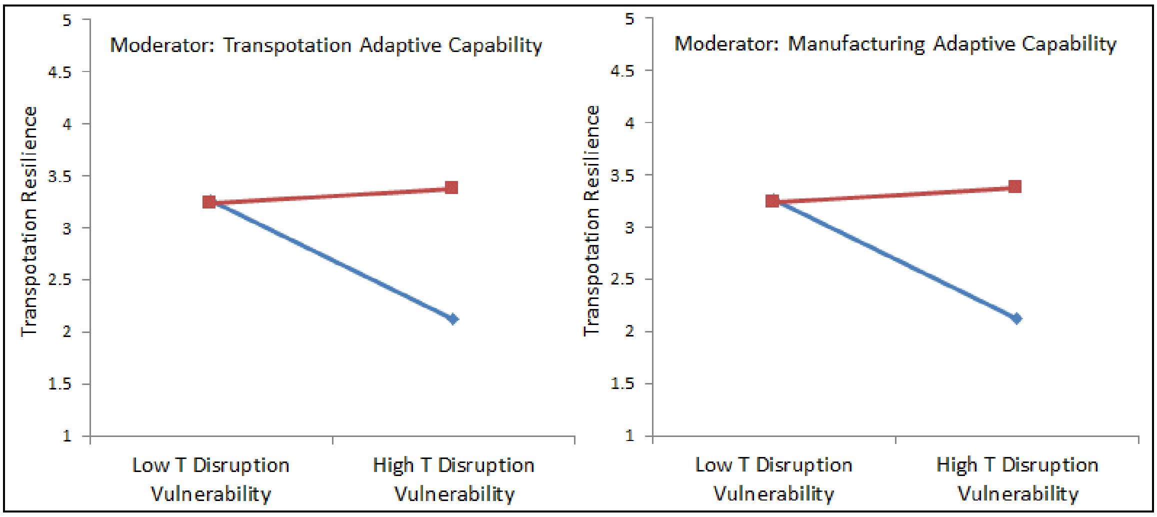

Figure 44 Interaction Moderation Plots

In Figure 44, the graph line with diamond heads represent the relationship between disruption vulnerability and resilience of supply chain processes of manufacturing and transportation, in the absence of adaptive capability. The line with square heads represents the relationship between disruption vulnerability and resilience of supply chain processes in the presence of adaptive capability. The graph indicates that resilience is high as the vulnerability disruption remain low but the resilience drops as disruption vulnerability increases in the absence of adaptive capability. However, in the presence of high adaptive capability, the resilience stays high against disruption vulnerability. This indicates that adaptive capability dampens the negative effect of disruption vulnerability on resilience of supply chain process.

As suggested during the evaluation criteria of heterogeneity, the model is test for data groups for different countries. The multi-group moderation for Germany, Pakistan and Turkey is tested. The moderation is examined for manufacturing process that is carried out in Pakistan and Turkey. Whereas, the moderation is examined for transportation process that is carried out across Pakistan, Turkey and Germany. As it has been established that adaptive capability moderates the negative effect of disruption vulnerability on resilience, the purpose of multi-group moderation is to assess whether the changing effect is invariably true across different population. However it is assumed that the intensity of effects would be different because of the difference between the locational conditions and situation of supply chain entity. The results are presented in Figure 45.

Mediated Relationship	Data Group	Sample Size	Effect	Standard Error	Test Statistics	Significance
MDV->MR	Pakistan	91	-0.42	0.09	1.22	0.23
	Turkey	40	-0.13	0.30		
TDV->TR	Pakistan	91	-0.36	0.11	1.79	0.07
	Turkey	40	-0.69	0.12		
	Pakistan	91	-0.36	0.11	0.45	0.66
	Germany	28	-0.45	0.18		
	Turkey	40	-0.69	0.12	1.14	0.26
	Germany	28	-0.45	0.19		

Figure 45 Significance Multi-group Moderation

For the purpose of multi-group moderation the difference in the significance of path coefficients for groups are tested. Test statistics for the data groups are calculated by using the path coefficients, standard errors, and sample sizes of the groups. The test statistics are used to calculate the significance level[234]. In Smart PLS, bootstrapping is used to estimate the effects and standard errors. The results are given in Figure 1.

The effects of disruption vulnerability on resilience for data groups changes for groups however the difference are not statistically significant with 0.23 (Figure 45) for manufacturing processes. The results suggests that relationship between adaptive capability and resilience is not significantly different in case of manufacturing for data groups of Pakistan, and Turkey. Similarly, the group difference for moderation in transportation process in Pakistan and Turkey, Pakistan and Germany, and Turkey and Germany are not significant.

[234] Chin, 2000, p. PLS FAQ

The non-significant differences among data groups for moderation shows that the model is true across population located at different geographical locations with unique conditions. The reason for non-significance is the fact that adaptive capability moderates and reduces the occurrence of disruption vulnerability and hence its effect on resilience. In case of inability of a supply chain entity to utilize adaptive capability when required, the data group for supply chain processes in volatile conditions would have different value. This suggests that adaptive capability enables supply chain entities to respond to disruption vulnerability, reduce the occurrence of disruption vulnerability, and supply chain process to function in a required manner. Volatile conditions of a location is not the only determinant of supply chain processes resilience. The complex relationship of adaptive capability has empirically tested and found through mediation and moderation.

Supply chain resilience has been studied in the context of international garments supply chain with partners located in Germany, Pakistan, and Turkey. Supply chain resilience is influenced by country specific conditions beside the condition of supply chain entity. It is in this context that assumptions were summarized in section 5.9. In order to analyze the assumptions, descriptive statistics (referred to as descriptives) are discussed in the following section.

6.5 Descriptive Analysis

The conditions of Pakistan, Germany, and Turkey are discussed in chapter 5 with the perspective of international garments supply chain. Vulnerability profile of Pakistan is relatively higher as compare to Germany and Turkey. The research question assumes that supply chain process carried out in country with volatile conditions will experience frequent disruption. The frequency of resorting to adaptive capability is expected to be high for the garments supply chain firms involved in supply chain processes in Pakistan than Turkey and Germany respectively due to comparatively high volatile conditions. Further it is assumed that resilience is expected to be low for supply chain firms operation in Pakistan as compared to Turkey and Germany given to the differences in conditions. Supply chain global resilience depends upon the resilience of supply chain processes like manufacturing and transportation. Supply chain risk costs are determined by supply chain global resilience. In order to analyze the data for these assumptions, means of variables are compared for different groups of data. Compare means, in SPSS Version 20, is used to analyze the data for group differences regarding the variables of adaptive capability, disruption vulnerability and supply chain processes resilience, supply chain global resilience, and supply chain risk costs. The results are presented in Annexure B. Supply chain stage of manufacturing is compared for differences in group data of Pakistan and Turkey where garments manufacturing is carried out in location with unique conditions. Supply chain transportation stage is compared for differences for group data of Pakistan, Turkey, and Germany with specific conditions as transportation is carried across these countries.

6.5.1.1 Manufacturing Adaptive Capability Descriptives

Adaptive capability, for manufacturing stage, has four indicators. The first indicator measures the frequency of using alternate raw material source by the firms in different locations. Firms usually resort to this adaptive measure in case inability of regular supplier to maintain the flow of raw material. The comparative means of using alternate raw material sources for garments manufacturing firms in Pakistan and Turkey are 3.29 and 2.98 respective as reported in Annexure B. The frequency of using alternate raw material source is higher for manufacturing firms in Pakistan is higher as compared to Turkey. Similarly the indicator measuring frequent usage of alternate production methods has means of 3.44 and 3.10, the indicator measuring usage of alternate utility sources has means of 3.43 and 3.13 and the indicator measuring the adaptive measure of using lead time buffer has means of 3.69 and 3.40 for data groups Pakistan and Turkey respectively. All four indicators of manufacturing adaptive capability have variable means higher for Pakistan as compared to Turkey presented in Annexure B.

The differences among the groups for indicators of manufacturing adaptive capability are not statistically significant as shown in Annexure C. This suggests that conditions for manufacturing are not very different in Pakistan and Turkey. Supply chain entities, in these countries, resort to adapt to capability with a similar pattern.

6.5.1.2 Manufacturing Disruption Vulnerability Descriptives

The first assumption is that supply chain process disruption vulnerabilities are frequent in location with volatile conditions. Disruption vulnerability for manufacturing stage is measured through four indicators of procurement delays, worker shortages, machine stoppages, and utility breakdown. Manufacturing firms in Pakistan and Turkey encounter procurement delays with comparative means of 2.32 and 2.05. Workers shortages occur with mean of 2.11 and 2.00 in firms in Pakistan and Turkey respectively. Machine closures happens with a mean of 2.02 and 1.70. Utilities breakdowns are more frequent for Pakistan as compared to Turkey with means of 2.57 and 2.50 as presented in Annexure B .

Statically, the differences among the data groups for manufacturing disruption vulnerability are not significant reported in Annexure C. This suggests that conditions for garments manufacturing in Pakistan and Turkey are either not very different or the firms take adaptive measures more frequently that reduces the frequency of disruption vulnerability. The latter is assessed in the following section.

6.5.1.3 Transportation Adaptive Capability Descriptives

Transportation adaptive capability has three indicator variables including alternate cargo service, alternate shipping method and lead time buffer. The variables measures the frequency of resorting to these alternatives in Pakistan, Turkey, and Germany with different conditions. The comparative means for alternate shipping services are 3.64, 3.08, and 2.57, for alternate shipping method are 3.45, 3.05, and 2.75; and for extra time transportation are 3.80, 2.88, and 2.96 respectively for Pakistan, Turkey, and Germany as shown in Annexure B.

The group differences for all the indicator variables of adaptive capability are statistically significant as shown in Annexure C. This suggests that conditions for transportation process are different for Pakistan, Turkey, and Germany. The condition in Pakistan requires the firms to resort to frequent adaptive measures as compared to Turkey and Germany. Frequent use of adaptive capability is supposed to be the reason that Pakistan and Turkey shows not significantly different disruption vulnerability, as mentioned earlier.

6.5.1.4 Transportation Disruption Vulnerability Descriptives

Similarly, transportation disruption vulnerability is measured by four indicator variables namely shipping service delay, road haulage delay, shipment processing delay, and shipping delays including arrival/ departure or during traveling. The comparative means for data group of Pakistan, Turkey, and Germany are 2.27, 2.53, and 2.00 for shipping service delay, 2.58, 2.50, and 2.39 for road delays, 2.07, 2.30, and 2.07 for processing delays, and 1.98, 2.20, and 1.75 for shipping line delays as presented in Annexure B. The frequency of transportation disruption vulnerability is higher for Pakistan and Turkey as compared to Germany.

The data group differences are not statistically significant Annexure C. This suggests that transportation process is either having low disruption vulnerability or transportation disruptions are frequently responded by measures that reduces the occurrence of disruptions.

6.5.1.5 Manufacturing Resilience Descriptives

The third assumption is that supply stage carried out in a volatile conditions is expected to have low resilience. Supply chain process resilience for manufacturing and transportation have two indicators each measuring the aspects of resilience in terms of quality and quantity objective of the processes. Manufacturing process resilience is measured through negative keyed indicators of frequency of rejects and production working under capacity. The negative-keyed indicators are reversed those measuring the frequency of meeting quality and quantity objectives. The comparative means for meeting manufacturing quality objective are 3.98 and 4.05 and for meeting manufacturing quantity objective are 4.01, and 4.05 respectively for data groups Pakistan and Turkey (Annexure B).

The resilience indicators for Pakistan are comparatively lower than Turkey however these differences are statistically not significant as presented in Annexure C.

As suggests earlier, frequent use of adaptive capability by firms in Pakistan and Turkey reduces the frequency of disruption and therefore the data group shows similar level of resilience.

6.5.1.6 Transportation Resilience Descriptives

As mentioned above, the third assumption is that supply stage carried out in a volatile conditions is expected to have low resilience. The transportation stage resilience measures the frequency of meeting transportation quality and quantity objectives. The comparative means for these indicator variables are 4.18, 3.78, and 4.14 for meeting transportation quality objective and 4.07, 3.58, and 4.11 for meeting transportation quantity objective for Pakistan, Turkey, and Germany data groups respectively as presented in Annexure B.

The indicators of transportation resilience is almost the same for the data groups and therefore the group differences are not significant (Annexure C). This suggests that adaptive capability is effectively used to maintain the process of transportation across countries with unique conditions.

6.5.1.7 Supply Chain Global Resilience Descriptives

The fourth assumption was that supply chain processes carried in location with volatile conditions are expected to have low supply chain global resilience. The indicators for supply chain global resilience are the frequency of meeting manufacturing and transportation schedule objectives. The comparative means for meeting manufacturing schedule objective are 3.87 and 4.03 for data group of Pakistan and Turkey. The comparative means for meeting transportation schedule objective are 4.19, 3.78, and 4.18 for data group Pakistan, Turkey, and Germany respectively reported in Annexure B.

The differences among the groups for supply chain global resilience are not significant as reported in Annexure C. This suggests that adaptive capability is used where needed and thus contribute to resilience of supply chain process and ultimately to the overall supply chain global resilience. The supply chain global resilience is exhibiting similar pattern across countries with different conditions.

6.5.1.8 Supply Chain Risk Costs Descriptives

The fifth assumption made was that supply chain processes carried in locations with volatile conditions are expected to have high risks cost. The indicator variables for measuring the construct of supply chain risk costs are the frequency of excess cost incurred during manufacturing and transportation processes. The comparative means for manufacturing excess costs are 3.91 and 3.95 for data groups Pakistan and Turkey and for transportation excess costs are 4.01, 3.88, and 3.93 for data groups Pakistan, Turkey, and Germany as reported in Annexure B.

The difference among groups are not significant as presented in Annexure C. The use of adaptive capability contributing to resilience of supply chain processes and supply chain global resilience influences the excess costs and therefore show a similar pattern across countries with different conditions.

To summarize the group comparison, adaptive capability has a high frequency in case of manufacturing stage carried in Pakistan and Turkey. The occurrence of disruptive vulnerability during manufacturing and transportation stages is expected to be high for Pakistan data group compared to Turkey and Germany respectively. The results shows difference but none of these is significant. The explanation is that in case of high adaptive capability, the occurrence of disruption vulnerability is expected to show similar pattern for locations with different conditions. The assumption suggests that there is a direct causal relationship between adaptive capability and disruption vulnerability. Similarly, the use of adaptive capability used during transportation stage is not statistically significant, however the comparative means are higher for Pakistan data group than for Turkey. In case of transportation stage, comparative means are different for group data and use of transportation adaptive capability is higher for Pakistan than Turkey and Germany. The group differences are also statistically significant. The contextual explanation to this is the fact that the location conditions of Pakistan are more volatile as compared to Turkey, the gap widens between Pakistan and Germany as discussed in chapter 5. The assumption 2 is true for countries with significantly different conditions. As conditions are highly volatile for Pakistan, the use of adaptive capability is higher for Pakistan. This suggest that negative relationship between disruption vulnerability and adaptive capability. The frequency of disruptions is assumed to be low in the case of frequent use of adaptive capability.

The group difference for the indicators of supply chain processes resilience, supply chain global resilience, and supply chain risk costs are not significantly different for manufacturing stage carried out in Pakistan and Turkey and transportation stage spread over Pakistan, Turkey, and Germany. This is contrary to assumptions 3, 4, and 5 suggesting that there is an intervening variable that negatively affects the negative relationship between disruption vulnerability and resilience to an extent that resilience of the firms located in different countries with unique conditions are not significantly different. This suggests that there is moderation effect that changes the negative effect of disruption vulnerability on these constructs. Test for mediation is carried out in the preceding section that suggests partial mediation. The assumptions supports the proposed direct effect, mediation effect, and moderation effect examined in the preceding section.

6.6 Summary

This chapter is concerned with analysis outer and inner models. Structural equation modeling is used as a state of the art method for statistical analysis of supply chain resilience model. There is detailed discussion on the nature of outer model. The indicators of supply chain resilience model have been identified as formative indicators. Partial least square structural equation modeling is selected for model estimation. The outer model is evaluated against the measures of indicators weights and loading, their significance, collinearity, and suppressor effect. The evaluation of outer model suggests that all the indicators are to be kept in the model during further analysis.

The causal analysis evaluates the hypotheses suggested in the inner model. The model proposes direct effects between constructs, mediation effect, and moderation effect. The evaluation measured used are coefficient of determination, significance of path coefficients, predictive relevance and heterogeneity. The measures are considered for all the relationships and the hypothesis are found to be empirically supported by the data across different location. The assumption for causal relationships are discussed in detail and it was suggested that in the presence of adaptive capability, the frequency of disruption vulnerability is reduced. Adaptive capability is frequently used in locations with comparatively high vulnerability profile.

7 Summary and Conclusion

This chapter provides the link that connects empirical findings to its research objectives and theoretical propositions. The first section 7.1 discusses the response to research question and hypothesis. The second section 7.2 of the chapter is about conceptual framework and methodology. The next, section 7.3, summarizes the result of the study. Section 7.4 assesses the theoretical and empirical contributions of the study. The last section 7.5 concludes with opportunities for future research.

7.1 Research question and hypothesis

The research question posed in this study was whether country conditions influence the resilience of supply chain processes. Several hypothesis were derived in order to investigate the propositions. Country conditions are dual in nature that on the one hand causes disturbance and on the hand provide alternate resources to be used in response to disturbances. While disruption vulnerability negatively affects the supply chain processes, adaptive capability contributes to reducing disruption vulnerability of supply chain process in a unique locational setting. Model of international supply chain resilience was proposed and relationships were hypothesized to investigate the research question. The study is limited to investigate risks in supply chain processes, the adaptive capability used to take measures and the resultant functioning of supply chain process. The country conditions provide contextual explanation to the occurrence of disruptive events, availability of alternate resources, and resultant supply chain resilience. To include country conditions directly in international garments supply chain is not in the scope of the study.

The role of adaptive capability is that of mediation. The hypothesis assumes that adaptive capability mediates the relationship between disruption vulnerability and resilience. The assumption was that processes in volatile situation are exposed to high risks that reduces the resilience of the processes. However, in the presence of adaptive capability the influence is mediated and supply chain firms with high risks are expected to have high resilience given to strong adaptive capability of the firm.

7.2 Conceptual Framework and Methodology

Based on the studies of Ponomarov (2009), Pettit et al. (2010) and Blackhurst et al. (2011), supply chain resilience framework for the study was considered. The general agreement was that disruption vulnerability negatively affects the resilience and adaptive capability positively affects the resilience of supply chain process. This study extends the generic supply chain resilience framework into international supply chain resilience model. The model has the constructs of manufacturing and transportation disruption vulnerability, manufacturing and transportation adaptive capability, manufacturing and transportation resilience, supply chain global resilience, and supply chain risk costs. Indicators are assigned to the constructs by adapting the system approach to supply chain process in international context.

In order to validate the proposed causal model, an empirical study in three different countries was conducted. The results from empirical evidence strongly suggests that the answer to the research proposition is affirmative. The findings suggest that the constructs are well represented by indicators in the model. There evidence of direct relationship among the constructs as well the mediation and moderation effect suggesting that adaptive capability plays role in reducing the disruption vulnerability of garments supply chain process across the partnering countries that in turn helps in maintaining the resilience of the various stages and over all process.

Supply chain resilience has been studied over stages of supply chain and across countries in search of answer to the research question. The contextual aspects are summarized under theoretical assumptions that were discussed before causal analysis. The assumptions considers the effects of country conditions of upon the constructs of the model. Descriptive analysis presents the comparison of the means of constructs for data groups. The hypothesis based on generalizations were analyzed for international garments supply chains. The propositions and hypothesis suggesting direct causal relationship, mediation and moderation relationship among the constructs are evaluated empirically. The results give evidence of the hypothesized relationships among the constructs of the model.

The study scope is resilience that is determined by adaptive capability and disruption vulnerability. Disruption vulnerability is context based and occurs frequently in location with comparatively less developed infrastructure and volatile conditions in terms of both natural and human situations. The research finding are found true to international supply chain across stages of manufacturing and transportation. The study was limited to garments industry with unique input requirements and was carried only in three countries.

The study has conceptual challenges of incorporating the aspects of international supply chain resilience. For the purpose of investigating the research question, conceptual framework was defined for supply chain resilience. Supply chain resilience was defined as function of adaptive capability and disruption vulnerability exhibited in resilience of supply chain process and over all process. Adaptive capability is the availability and accessibility to alternate methods and resources within organization or in the location that may be invoked in order to tend the discontinuities caused by change events internal and external to organization. Disruption vulnerability is the frequency the organization is hit by adverse effects by disruption. Resilience is the frequency of successful completion of order determined by adaptive capability and disruption vulnerability.

A comparative research design was proposed to investigate whether supply chain resilience changes across samples from different countries and to find whether adaptive capability maintains the resilience despite change events frequently occurring in a location. Supply chain resilience is a contextual and multidimensional concept that considers the occurrence of disruption, responded by use of adaptive capability to maintaining resilience of supply chain process carried out in a locality.

Besides conceptual demands, the research is also having analytical challenges. The research detect and attempts to explain the causality between adaptive capability, disruption vulnerability and resilience. In order to respond to the challenges several measures have been adapted. First, the dimensions of adaptive capability, disruption vulnerability and resilience were operationally defined. The concepts were thus translated into observable and measureable indicators. Second, as first step the outer model was evaluated to examine the quality of indicators. Third, the relationships among constructs were validated through causal analysis. Fourth, the analysis was carried with PLS based approaches of structural equation modeling as the nature of outer model, characteristics of data, and testing of predictability was the purpose of research.

The challenges on data collection were addressed by suitable strategies. Data collection was focused on issues of interest for the reason to keep the number of questions limited and the length of questionnaire reasonable. It would help to get the consent of respondents to spare some minutes to answer the questions. Furthermore, personal meeting with relevant respondents was preferred to get the queries right and expedite the process. Additional information was educative but not in the scope of the study. The regularly quoted constraints of cost, time and logistics were also true to this study.

7.3 Research Findings

As a result of analysis of the links between theoretical framework and empirical evidence following research findings are summarized.

- Disruption vulnerability has negative impact on resilience of supply chain processes.
- Adaptive capability has positive impact on resilience of supply chain processes.
- Adaptive capability mediates negative impact of disruption vulnerability on resilience of supply chain processes.
- Adaptive capability moderates the relationship between disruption vulnerability and resilience of supply chain processes.
- Resilience of supply chain processes influence the overall resilience of supply chain.

- The overall supply chain resilience influence supply chain cost.
- The assumptions suggest that supply chain processes carried in location with volatile conditions are frequently disturbed and required to use adaptive capability in order to maintain the objective functioning or service level.

The study suggests that country conditions exhibit dualism that not only determine disruption vulnerability through negative events but also constitute adaptive capability through alternate resources. Conditions at a location are not the only determinant of supply chain resilience, it is rather an interplay among different factors.

7.4 Implications of the Study

The study is relevant both in academic and managerial terms. Theoretically the study departs from the concept considering capability, vulnerability and resilience as independent and competing concepts. The concept of resilience, presented in the study, encompasses the constructs of adaptive capability, disruption vulnerability and resilience. The construct of adaptive capability and resilience is extended to supply chain processes of manufacturing and transportation. The construct of resilience is detailed for supply chain process resilience, the overall supply chain global resilience and cost resilience as supply chain risk costs. Resilience is determined by adaptive capability of a supply chain entity and disruption vulnerability caused by external and internal change events and exhibited in the resilience at a specific time.

From managerial perspective, the location of facility and supplier are not straightforward tasks. A country with volatile condition and comparatively less developed infrastructure are deemed to be the least priorities for location facility or suppliers. The advantages of low cost labor, proximity of quality raw material, low operational costs, low tax rates, duties relaxation on import/ export, weak currencies and other factors are compromised due to perception of lack reliability. The study explores that supply chain processes show high resilience despite the occurrences of change events owing to the volatile conditions of supplier location. The garments supply chain process exhibits resilience across the countries with unique conditions.

The model can be used for designing and implementing a decision system for supply chain firms that would enable the right decision at right time by taking into consideration different factors. Lackes et al. has modeled the procurement, production and transportation processes of international garments supply chain with the objective of cost minimization[235]. The work aims at purchase, production and transportation optimization model in vulnerable situation that causes disturbances in these processes more often. In international markets, there is multitude of risks concerning delivery time, costs and quantity influencing the economic effects. For procurement, the study has considered the uncertain implications in decision making. The situation is analyzed by using a simple supply chain model with one enterprise that has the choice to cooperate with international instead of local suppliers. The model includes the situational considerations to decide about supplier to be either domestic or international.

Similarly, Lackes et al. also suggests production decision model by taking into consideration the fact the production process under constant pressure of disruptive event, is not able to deliver the produced goods in due time. For this purpose the production is suggested to be continuously monitored for produced quantity and remaining time in order to discover possible delays in production. The alternative in case of delays are to use safety stock, over production, intensity adjustment of production, overtime production, and subcontracting. A safety stock is only possible in a make-to-stock production policy. In the case of garments production, this is not an alternative because of the make-to-order production. The customer communicates on requirements in terms of design, color and sizes every time the order is placed. The study suggests that instead of using a safety stock, it is possible to plan with over production in advance so that potential disruptions do not lead to severe schedule problems. This risk management measure

[235] Lackes, Siepermann, & Khushnood, 2012, pp. 398-408

is not suggested to be used for production risks for the obvious disadvantage of in case no risk occurs the enterprise has produced too many products that cannot be sold or if sold after all that can only be at a lower price. When facing the problem to on schedule, the enterprise can switch to an intensity adjustment of production, overtime production or sub-contracting. The first measure is also not possible in the garments production because the stitching is handmade so that no machine intensity can be adjusted. The latter two measures lead to higher production costs and a possible lower quality. Thus, an optimization model is proposed to decide about what alternate method and at which point in time may be adapted.

Finally, Lackes et al. proposes a transportation model by considering disruption vulnerability of the process. The transportation decision deals with the use of the capacities that are built with the help of the strategic decisions in order to avoid risks. Risks may occur at different stages and risk measures are to be taken by enterprise by considering the different factors. The transportation process decision considers selection of means of transportation and transportation routes at the start and also at check points where there is possibility to switch to another route or mode of transportation. For this purpose, an enterprise has different possibilities. It can choose only one method or several methods in order to diversify the transportation risk.

The decision models for optimization of supply chain process suggest for further research with the purpose of developing systems that may help the firms to decide on procurement, production and transportation decisions. The purpose is to ensure supply chain resilience with the objectives of conforming to quality targets, meeting the required quantities, observing timeliness and minimizing cost. With such decision support system, supply chain firms coordinate such that despite vulnerabilities, supply chain process is optimized that enables the supply chain partners to gain competitive advantage. The main concern of all the stakeholders in supply chain is the attainment and maintenance of resilience that ultimately exhibits the resilience of supply chain stages and the process as a whole.

7.5 Outlook

The objective of the study is to empirically assess the influence of vulnerabilities and capabilities on supply chain resilience. Supply chain processes are carried over long geographical distances in the context of international supply chain. The factors related to location and organization pose threats and offer opportunities to supply chain entity for carrying out process. Manufacturing and Transportation processes are examined for international garments supply chain with partners in Germany, Pakistan, and Turkey. An extended model of supply chain resilience is developed that covers the stages of manufacturing and transportation. The overall resilience of supply chain is suggested as the accumulative effect of resilience of manufacturing and transportation processes. The aspect of supply chain cost is supposed to be influenced by the overall resilience of supply chain.

This area of study is open for further research. First, the study is covering garments supply chain that has specific inputs and operations. The chain depends on textile value chain that processes natural and synthetic fiber into fabric as an essential input for garments manufacturing. The operations are labor intensive and are greatly dependent on the conditions human resources. The operations are exposed to disturbances related to textile value chain, human resources, operations. The garment products are standardized for specific purposes in term of designs, sizes, quality of fabric, and color for example work wear garments. The model is to be extended to other industries for example automotive and industries with peculiar inputs and operations.

Second, as mentioned this study is covering manufacturing and transportation stages of supply chain. The study is to be extended to the further upstream and downstream for cumulative effect on the overall resilience of supply chain.

Third, the study covers international supply chains with partners located in Germany, Pakistan, and Turkey. Although, the conditions are unique and provide opportunity to study supply chain resilience still the world has greater variety. For this purpose, supply chain resilience is to be studied across more locations.

Fourth, the locational conditions provide a contextual background to the study. Ways are to be devised to include the location conditions directly in the conceptual framework of supply chain resilience. This needs resources in terms of time, cost, logistics and importantly experts.

The opportunities for further research are extension of study across industries like automotive and electronics; extension of study across supply chain processes like downstream and up stream, extension of study to more locations with unique conditions, and inclusion of locational conditions rather than providing only a contextual background to the study. Supply chain resilience is studied by including manufacturing and transportation. These investigation will help in the generalization of the framework across industries, supply chain processes, and geographical locations.

Bibliography

Adger, W. N. (2000). Social and ecological resilience: are they related? *Progress in human geography, 24*(3), 347-364.

Albino, V., & Garavelli, A. C. (1995). A methodology for the vulnerability analysis of just-in-time production systems. *International journal of production economics, 41*(1), 71-80.

Altaf, Z. (2008). Challenges in the Pakistan cotton, yarn, textile and apparel sectors. *Cotton-Textile-Apparel Sector in Pakistan*, 52-96.

APTMA. (2013). *Statistics: Pakistan Textile Statisics*. Retrieved from All Pakistan Textile Mills Association: http://www.aptma.org.pk/

Barroso, A. P., Machado, V. H., & Machado, V. C. (2011). Supply chain resilience using the mapping approach. (P. Li, Ed.) *Supply Chain Management*, 161-184.

Bhamra, R., Dani, S., & Burnard, K. (2011). Resilience: the concept, a literature review and future directions. *International Journal of Production Research, 49*(18), 5375-5393.

Blackhurst, J., Dunn, K. S., & Craighead, C. W. (2011). An empirically derived framework of global supply resiliency. *Journal of Business Logistics, 32*(4), 374-391.

Borsboom, D., Mellenbergh, G. J., Heerden, & van, J. (2004). The concept of validity. *Psychological review, 111*(4), 1061-1071.

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From metaphor to measurement: resilience of what to what? *Ecosystems, 4*(8), 765-781.

Cenfetelli, R. T., & Bassellier, G. (2009). Interpretation of formative measurement in information systems research. *Management Information Systems Quarterly, 33*(4), 689-707.

Chin, W. W. (2000). *Frequently Asked Questions – Partial Least Squares & PLS-Graph*. Retrieved from PLS Graph: http://disc-nt.cba.uh.edu/chin/plsfaq.html

Chopra, S., & Sodhi, M. S. (2004). Supply-chain breakdown. *MIT Sloan management review*.

Christopher, M., & Peck, H. (2004). Building the Resilient Supply Chain. *International Journal of Logistics Management, 15*(2), 1-14.

Christopher, M., & Rutherford, C. (2004). Creating supply chain resilience through agile six sigma. *Critical Eye, 24*(28).

Colicchia, C., Dallari, F., & Melacini, M. (2010). Increasing supply chain resilience in a global sourcing context. *Production planning & control, 21*(7), 680-694.

Coltman, T., Devinney, T. M., Midgley, D. F., & Venaik, S. (2008). Formative versus reflective measurement models: Two applications of formative measurement. *Journal of Business Research, 61*(12), 1250-1262.

Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply chain management: more than a new name for logistics. *International Journal of Logistics Management, 8*(1), 1-14.

Cororaton, C. B., Salam, A., Altaf, Z., Orden, D., Dewina, R., Minot, N., & Nazli, H. (2008). *Cotton-Textile-Apparel sectors of Pakistan: Situations and challenges faced.* International Food Policy Research Institute.

Costanza, R., Fisher, B., Ali, S., Beer, C., Bond, L., Boumans, R., & Danigelis, N. L. (2007). Quality of life: An approach integrating opportunities, human needs, and subjective well-being. *Ecological economics, 61*(2), 267-276.

Croom, S., Romano, P., & Giannakis, M. (2000). Supply chain management: an analytical framework for critical literature review. *European journal of purchasing & supply management*, *6*(1), 67-83.

Cutting-Decelle, A.-F., Young, B. I., Das, B. P., Case, K., Rahimifard, S., Anumba, C. J., & Bouchlaghem, D. M. (2000). Supply chain management: an analytical framework for critical literature review. *European journal of purchasing & supply management*, *6*(1), 67-83.

Dalziell, E. P., & McManus, S. T. (2004). Resilience, vulnerability, and adaptive capacity: implications for system performance. *International Forum for Engineering Decision Making, Stoos, Switzerland.*

DiLalla, L. F. (2000). *Structural equation modeling: Uses and issues. Handbook of applied multivariate statistics and mathematical modeling.*

Dou, Y., & Sarkis, J. (2010). A joint location and outsourcing sustainability analysis for a strategic offshoring decision. *International Journal of Production Research*, *48*(2), 567-592.

Ederer, P., Schuler, P., & Willms, S. (2007). *The European human capital index: the challenge of central and Eastern Europe.* Lisbon Council Policy Brief. Brussels: The Lisbon Council for Economic Competitiveness and Social Renewal.

Falasca, M., Zobel, C. W., & Cook, D. (2008). A decision support framework to assess supply chain resilience. *5th International ISCRAM Conference*, 596-605.

FAO UN. (2014). *FAOSTAT*. Retrieved from Food and Agriculture Organization: http://faostat.fao.org/site/339/default.aspx

Ferdows, K. (1997). Making the most of foreign factories. *Harvard Business Review*, *75*, pp. 73-91.

Fiksel, J. (2006). Sustainability and resilience: toward a systems approach. *Sustainability: Science Practice and Policy, 2*(2), 14-21.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change, 16*(3), 253-267.

GAIN, N. (2013). *Country Ranking*. Retrieved from Notre Dame Global Adaptation Index: http://index.gain.org/ranking

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global environmental change, 16*(3), 293-303.

Garmezy, N. (1973). Competence and adaptation in adult schizophrenic patients and children at risk. *Schizophrenia: The first ten Dean award lectures*, 163-204.

Gereffi, G., & Frederick, S. (2010). *The global apparel value chain, trade and the crisis: challenges and opportunities for developing countries.* World Bank Policy Research Working Paper Series.

Gereffi, Gary; Memedovic, Olga. (2003). *The global apparel value chain: What prospects for upgrading by developing countries.* United Nations Industrial Development Organization, Vienna.

Giunipero, L. C., & Eltantawy, R. A. (2004). Securing the upstream supply chain: a risk management approach. *International Journal of Physical Distribution & Logistics Management, 34*(9), 698-713.

Government of Pakistan. (2013). *Publications: Sector Breifs, Fabric Production*. Retrieved from Small and Medium Enterprises Development Authority: http://www.smeda.org/

Guba, E. G., & Lincoln, Y. S. (1994). *Competing paradigms in qualitative research* (Vol. Handbook of qualitative research 2).

Hair, J. F. (2009). *Multivariate data analysis.*

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *The Journal of Marketing Theory and Practice, 19*(2), 139-152.

Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, *40*(3), 414-433.

Heise, D. R. (1975). *Causal Analysis.* New York, London.

Hiles, A. (2007). *The definitive handbook of business continuity management.* John Wiley & Sons.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, 1-23.

Houlihan, J. B. (1988). International supply chains: a new approach. *Management Decision, 26*(3), 13-19.

Hoyle, R. H. (2012). *Handbook of structural equation modeling.* Guilford Press.

Hugos, M. H. (2011). *Essentials of supply chain management.* John Wiley & Sons.

Hussain, D., Figueiredo, M., & Ferreira, F. (2009). SWOT analysis of Pakistan textile supply chain. *Proceedings of IX Congreso Galego de Estatística e Investigación de Operacións*, (pp. 12-14). Ourense.

International Cotton Advisory Committee. (2013). *Economics and Statistics: Country Facts, Cotton Fact Sheet*. Retrieved from International Cotton Advisory Committee: https://www.icac.org/econ/Cotton-Facts

Iriondo, J. M., Albert, M. J., & Escudero, A. (2003). Structural equation modelling: an alternative for assessing causal relationships in threatened plant populations. *Biological Conservation, 113*(3), 367-377.

ISDR, U. (2004). *Living with Risk: A global review of disaster reduction initiatives.*

Jaehne, D. M., Li, M., Riedel, R., & Mueller, E. (2009). Configuring and operating global production networks. *International Journal of Production Research, 47*(8), 2013-2030.

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of consumer research, 30*(2), 199-218.

Kleindorfer, P. R., & Saad, G. H. (2005). Managing disruption risks in supply chains. *Production and operations management, 14*(1), 53-68.

Lackes, R., Siepermann, M., & Khushnood, M. (2012). Considering Internal and External Risks in International Supply Chains. In D. Ivanov, B. Soklov, & J. Käschel (Ed.), *Flexibility and Adaptability of Global Supply Chains-7th German-Russian Logistics Workshop DR-LOG 2012, St. Petersburg*, (pp. 398-408).

Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply chain management: implementation issues and research opportunities. *International Journal of Logistics Management, 9*(2), 1-20.

Lambert, Douglas M. (Ed). (2008). *Supply chain management: processes, partnerships, performance.* Supply Chain Management Institute.

Little, T. D., Card, N. A., Bovaird, J. A., Preacher, K. J., Crandall, & S., C. (2007). Structural equation modeling of mediation and moderation with contextual factors. *Modeling contextual effects in longitudinal studies, 1*.

MacCarthy, B. L., & Atthirawong, W. (2003). Factors affecting location decisions in international operations–a Delphi study. *International Journal of Operations & Production Management, 23*(7), 794-818.

Manuj, I., & Mentzer, J. T. (2008). Global supply chain risk management. *Journal of Business Logistics, 29*(1), 133-155.

Manyena, S. B. (2006). The concept of resilience revisited 30.4 (2006): 434-450. *Disasters, 30*(4), 434-450.

Masakure, O., Henson, S., & Cranfield, J. (2009). Standards and export performance in developing countries: Evidence from Pakistan. *The Journal of International Trade & Economic Development, 18*(3), 395-419.

Meixell, M. J., & Gargeya, V. B. (2005). Global supply chain design: A literature review and critique. *Transportation Research Part E: Logistics and Transportation Review, 41*(6), 531-550.

Mundi Index. (2014). *Infrastructure Indicators*. Retrieved 2014, from http://www.indexmundi.com/facts/indicators

Narayan, D., & Pritchett, L. (1999). Cents and sociability: Household income and social capital in rural Tanzania. *Economic development and cultural change, 47*(4), 871-897.

Pakistan Bureau of Statistics. (2013). *Agriculture Statistics*. Retrieved from Government of Pakistan: http://www.pbs.gov.pk/

Pakistan Economic Survey. (2012-2013). Ministery of Finance, Government of Pakistan.

Pakistan Textile Journal. (2012, Jun). APTMA makes Pakistan self-sufficient in cotton. *Pakistan Textile Journal*.

PCGA. (2013). *PCGA Facts and Figures*. Retrieved from Pakistan Cotton and Ginning Association: http://pcga.org/

Peck, H. (2006). Drivers of supply chain vulnerability: an integrated framework. *International Journal of Physical Distribution & Logistics Management, 35*(4), 210-232.

Peck, H., Abley, J., Christopher, M., Haywood, M., Saw, R., Rutherford, C., & Strathern, M. (2003). *Creating resilient supply chains: a practical guide.* Centre for Logistics and Supply Chain Management, Cranfield School of Management.

Pedhazur, E. J., & Schmelkin, L. P. (2013). *Measurement, design, and analysis: An integrated approach.* Psychology Press.

Petter, S., Straub, D., & Rai, A. (2007). Specifying formative constructs in information systems research. *MIS Quarterly*, 623-656.

Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). Ensuring supply chain resilience: development of a conceptual framework. *Journal of Business Logistics, 31*(1), 1-21.

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. *20*(1), 124-143.

Prasad, S., & Sounderpandian, J. (2003). Factors influencing global supply chain efficiency: implications for information systems. *Supply Chain Management: An International Journal, 8*(3), 241-250.

Prater, E., Biehl, M., & Smith, M. A. (2001). International supply chain agility-Tradeoffs between flexibility and uncertainty. *International journal of operations & production management, 21*(5/6), 823-839.

Rücker, U.-C. (1999). *Finanzierung von Umweltrisiken im Rahmen eines systematischen Risikomanagements.* Sternenfels.

Salam, A. (2008). Production, Prices, and Emerging Challenges in the Pakistan Cotton Sector. In C. B. Cororaton, A. Salam, Z. Altaf, D. Orden, R. Dewina, N. Minot, & H. Nazli, *Cotton-Textile-Apparel Sectors of Pakistan* (pp. 22-51). International Food Policy Research Institute.

Schoenherr, T. (2009). Logistics and supply chain management applications within a global context: an overview. *Journal of business logistics, 30*(2), 1-25.

Sheffi, Y., & Rice, J. B. (2005). A supply chain view of the resilient enterprise. *MIT Sloan Management Review 47, no. 1 (2005)., 47*(1).

Siepermann, M. (2008). *Risikokostenrechnung – Erfolgreiche Informationsversor- gung und Risikoprävention.* Berlin.

Stevens, S. S. (1968). Measurement, statistics, and the schemapiric view. *Science, 161*(3844), 849-856.

Swaminathan, J. M., & Sadeh, N. M. (1998). Modeling supply chain dynamics: A multiagent approach. *Decision sciences, 29*(3), 607-632.

Tang, O., & Musa, S. N. (2011). Identifying risk issues and research advancements in supply chain risk management. *International Journal of Production Economics, 133*(1), 25-34.

Taylor, D. H. (1997). *Global cases in logistics and supply chain management.* New York: International Thomson Business Press.

The Heritage Foundation. (2013). *Explore the Data*. Retrieved from Index of Economic Freedom: http://www.heritage.org/

The Hofstede Center. (2013). *National Cultural Dimensions*. Retrieved from The Hofstede Center: http://geert-hofstede.com/

The World Bank. (2013). Data, Indicators: *Country Ranking*. Retrieved from http://data.worldbank.org/

Timmerman, P. (1981). Vulnerability resilience and collapse of society. *A Review of Models and Possible Climatic Applications. Toronto, Canada: Institute for Environ-mental Studies.* University of Toronto.

Tse, Y. K., & Tan, K. H. (2011). Managing product quality risk in a multi-tier global supply chain. *International Journal of Production Research, 49*(1), 139-158.

Turkey Clothing. (2013). Ministry of Economy, Republic of Turkey.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., & Eckley, N. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the national academy of sciences 100*, (pp. 8074-8079).

UNDP. (2012). *Human Development Index Ranking*. Retrieved from Human Development Reports.

UNDP. (2014). *Data: Human Development Index*. Retrieved from Human Development Reports: http://hdr.undp.org

USDA. (2014). *Data and Analysis*. Retrieved from Foreign Agricultural Service: http://www.fas.usda.gov/psdonline/circulars/cotton.pdf

Von Bertalanffy, L. (1972). The history and status of general systems theory. *Academy of Management Journal, 15*(4), pp. 407-426.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social-ecological systems. *Ecology and society, 9*(2).

Waters, D. (2011). *Supply chain risk management: vulnerability and resilience in logistics.* Kogan Page Publishers.

Werner, E. E., & Smith, R. S. (1982). *Vulnerable but invincible: A study of resilient children.* New York: McGraw-Hill.

Westman, W. E. (1986). Resilience: concepts and measures. *In Resilience in Mediterranean-type ecosystems*, 5-19.

Woolcock, M., & Narayan, D. (2000). Social capital: Implications for development theory, research, and policy. *The World Bank research observer, 15*(2), pp. 225-249.

World Trade Organization. (2014). *Documents and Resources: International Trade and Market Access Data*. Retrieved from World Trade Organization: http://www.wto.org/

Yin, R. K. (2014). *Case study research: Design and methods.* Sage publications.

Annexures

1) Annexure A

Survey Questionnaire

The purpose of the survey is to investigate resilience across international garments supply chain stages carried out by partner organizations located in different countries. The survey uses questionnaire to study manufacturing and transportation stages of the international supply chain spread over Pakistan, Germany and Turkey.

The variables are measured on five point scale; 1= Very Low, 2= Low, 3= Moderate, 4= High, and 5= Very High.

Manufacturing Adaptive Capability

MAC1. How often alternate suppliers of raw material are used?

MAC2. How often alternate production methods are used?

MAC3. How often alternate utility sources are used?

MAC4. How often extra lead time is negotiated in the manufacturing plan?

Manufacturing Disruption Vulnerability

MDV1. How often delays in procurement of raw material are experienced?

MDV2. How often shortage of workers is experienced?

MDV3. How often machines are closed for repair/maintenance work?

MDV4. How often utilities break down occurs?

Transportation Adaptive Capability

TAC1. How often alternate shipping service providers are used?

TAC2. How often alternate shipment methods are used?

TAC3. How often extra lead time is negotiated in the transportation plan?

Transportation Disruption Vulnerability

TDV1. How often shipping requests are delayed at shipping service provider?

TDV2. How often shipping delays occur during road haulage to/from ports?

TDV3. How often shipping delays occur during processing of shipment?

TDV4. How often shipping delays occur in departure schedules of shipment?

Manufacturing Resilience

MR1. How often excess manufacturing rejects are experienced?

MR2. How often unmet manufacturing quantity targets are experienced?

Transportation Resilience

TR1. How often excess transportation losses are experienced?

TR2. How often shipping capacity limitations are experienced?

Supply Chain Global Resilience

SCGR1. How often unmet manufacturing schedule targets are experienced?

SCGR2. How often unmet shipping schedule are experienced?

Supply Chain Risk Costs

SCRC1. How often excess manufacturing costs are experienced?

SCRC2. How often excess shipping costs are experienced?

2) Annexure B

Comparative Means for Indicators (Descriptives)

Constructs	Indicators	Data Group	N (Sample)	Mean	Standard Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
							Lower Bound	Upper Bound		
Manufacturing Adaptive Capability	Alternate Raw Material Sources	Pakistan	91	3.29	1.08	.11	3.06	3.51	1	5
		Turkey	40	2.98	1.03	.16	2.65	3.30	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	3.19	1.07	.09	3.01	3.38	1	5
	Alternate Production Methods	Pakistan	91	3.44	1.01	.11	3.23	3.65	1	5
		Turkey	40	3.10	.96	.15	2.79	3.41	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	3.34	1.01	.09	3.16	3.51	1	5
	Alternate Utility Sources	Pakistan	91	3.43	.979	.10	3.22	3.63	2	5
		Turkey	40	3.13	1.02	.16	2.80	3.45	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	3.34	.98	.09	3.16	3.51	1	5
	Longer Production Time	Pakistan	91	3.69	.89	.09	3.51	3.88	2	5
		Turkey	40	3.40	.98	.16	3.09	3.71	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	3.60	.93	.08	3.44	3.76	1	5
Manufacturing Disruption Vulnerability	Procure-ment Delays	Pakistan	91	2.32	1.02	.11	2.11	2.53	1	5
		Turkey	40	2.05	.93	.15	1.75	2.35	1	4
		Germany	0	.	.	.	.	.	.	.
		Total	131	2.24	1.00	.09	2.06	2.41	1	5
	Workers Shortages	Pakistan	91	2.11	1.02	.11	1.90	2.32	1	5
		Turkey	40	2.00	.96	.15	1.69	2.31	1	4
		Germany	0	.	.	.	.	.	.	.
		Total	131	2.08	1.00	.09	1.90	2.25	1	5
	Machines Closures	Pakistan	91	2.02	1.06	.11	1.80	2.24	1	5
		Turkey	40	1.70	.69	.11	1.48	1.92	1	3
		Germany	0	.	.	.	.	.	.	.
		Total	131	1.92	.97	.09	1.76	2.09	1	5
	Utilities Break-down	Pakistan	91	2.57	1.24	.13	2.31	2.83	1	5
		Turkey	40	2.50	1.09	.17	2.15	2.85	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	2.55	1.19	.10	2.34	2.76	1	5

Transportation Adaptive Capability	Alternate Shipping Services	Pakistan	91	3.64	.93	.10	3.44	3.83	2	5
		Turkey	40	3.08	.73	.12	2.84	3.31	2	5
		Germany	28	2.57	.79	.15	2.27	2.88	2	4
		Total	159	3.31	.95	.08	3.16	3.46	2	5
	Alternate Shipping Methods	Pakistan	91	3.45	1.04	.11	3.23	3.67	1	5
		Turkey	40	3.05	.90	.14	2.76	3.34	2	5
		Germany	28	2.75	.84	.16	2.42	3.08	2	4
		Total	159	3.23	1.01	.08	3.07	3.38	1	5
	Longer Shipping Time	Pakistan	91	3.80	.83	.09	3.63	3.98	2	5
		Turkey	40	2.88	.75	.12	2.63	3.12	2	5
		Germany	28	2.96	.79	.15	2.66	3.27	2	4
		Total	159	3.42	.92	.07	3.28	3.56	2	5
Transportation Disruption Vulnerability	Shipping Service Delays	Pakistan	91	2.27	1.03	.11	2.06	2.49	1	5
		Turkey	40	2.53	.78	.12	2.27	2.78	1	4
		Germany	28	2.00	1.12	.21	1.56	2.44	1	5
		Total	159	2.29	1.00	.08	2.13	2.45	1	5
	Road Haulage Delays	Pakistan	91	2.58	1.20	.13	2.33	2.83	1	5
		Turkey	40	2.50	.88	.14	2.22	2.78	1	5
		Germany	28	2.39	1.26	.24	1.91	2.88	1	5
		Total	159	2.53	1.14	.09	2.35	2.71	1	5
	Shipment Processing Delays	Pakistan	91	2.07	1.03	.11	1.85	2.28	1	5
		Turkey	40	2.30	.65	.10	2.09	2.51	1	4
		Germany	28	2.07	1.15	.22	1.62	2.52	1	5
		Total	159	2.13	.97	.08	1.97	2.28	1	5
	Shipping Lines Delays	Pakistan	91	1.98	1.06	.11	1.75	2.20	1	5
		Turkey	40	2.20	.76	.12	1.96	2.44	1	4
		Germany	28	1.75	.97	.18	1.38	2.12	1	5
		Total	159	1.99	.99	.08	1.84	2.15	1	5
Manufacturing Resilience	Manufac-turing Quality	Pakistan	91	3.98	.94	.10	3.78	4.17	1	5
		Turkey	40	4.05	.85	.13	3.78	4.32	2	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	4.00	.91	.08	3.84	4.16	1	5
	Manufac-turing Quantity	Pakistan	91	4.01	.84	.09	3.84	4.19	2	5
		Turkey	40	4.05	1.01	.16	3.73	4.37	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	4.02	.89	.08	3.87	4.18	1	5
Transportation Resilience	Transpor-tation Quality	Pakistan	91	4.18	.85	.09	4.00	4.35	1	5
		Turkey	40	3.78	.86	.14	3.50	4.05	2	5
		Germany	28	4.14	.65	.12	3.89	4.40	2	5
		Total	159	4.07	.84	.07	3.94	4.20	1	5
	Transpor-tation Quantity	Pakistan	91	4.07	.84	.09	3.89	4.24	1	5
		Turkey	40	3.58	.87	.14	3.30	3.85	2	5
		Germany	28	4.11	.74	.14	3.82	4.39	2	5
		Total	159	3.95	.86	.07	3.82	4.08	1	5

Supply Chain Global Resilience	Manufac-turing Schedule	Pakistan	91	3.87	.93	.10	3.67	4.06	1	5
		Turkey	40	4.03	.86	.14	3.75	4.30	2	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	3.92	.91	.08	3.76	4.07	1	5
	Transpor-tation Schedule	Pakistan	91	4.19	.83	.09	4.01	4.36	2	5
		Turkey	40	3.78	.80	.13	3.52	4.03	2	5
		Germany	28	4.18	.67	.13	3.92	4.44	3	5
		Total	159	4.08	.81	.06	3.95	4.21	2	5
Supply Chain Risk Cost	Manufac-turing Risks Cost	Pakistan	91	3.91	.84	.09	3.74	4.09	1	5
		Turkey	40	3.95	.99	.16	3.63	4.27	1	5
		Germany	0	.	.	.	.	.	.	.
		Total	131	3.92	.88	.08	3.77	4.08	1	5
	Transpor-tation Risks Cost	Pakistan	91	4.01	.95	.10	3.81	4.21	1	5
		Turkey	40	3.88	.69	.11	3.66	4.09	2	5
		Germany	28	3.93	.81	.15	3.61	4.24	2	5
		Total	159	3.96	.86	.07	3.83	4.10	1	5

3) Annexure C

Comparative Means for Indicators (Analysis of Variance)

Constructs	Indicators	Variance	Sum of Squares	Degree of Freedom	Mean Square	F	Sig.
Manufacturing Adaptive Capability	Alternate Raw Material Sources	Between Groups	2.68	1	2.68	2.38	.13
		Within Groups	145.55	129	1.13		
		Total	148.23	130			
	Alternate Production Methods	Between Groups	3.20	1	3.20	3.23	.08
		Within Groups	128.02	129	.99		
		Total	131.22	130			
	Alternate Utility Sources	Between Groups	2.56	1	2.56	2.61	.11
		Within Groups	126.66	129	.98		
		Total	129.22	130			
	Longer Production Time	Between Groups	2.37	1	2.37	2.81	.10
		Within Groups	108.99	129	.85		
		Total	111.36	130			
Manufacturing Disruption Vulnerability	Procurement Delays	Between Groups	2.01	1	2.01	2.03	.16
		Within Groups	127.66	129	.99		
		Total	129.66	130			
	Workers Shortages	Between Groups	.34	1	.34	.336	.563
		Within Groups	128.90	129	1.00		
		Total	129.24	130			
	Machines Closures	Between Groups	2.88	1	2.88	3.09	.08
		Within Groups	120.36	129	.93		
		Total	123.24	130			
	Utilities Breakdown	Between Groups	.14	1	.14	.10	.75
		Within Groups	184.29	129	1.43		
		Total	184.43	130			
Transportation Adaptive Capability	Alternate Shipping Services	Between Groups	27.23	2	13.62	18.53	.00
		Within Groups	114.67	156	.74		
		Total	141.90	158			
	Alternate Shipping Methods	Between Groups	12.17	2	6.09	6.43	.00
		Within Groups	147.68	156	.95		
		Total	159.85	158			
	Longer Shipping Time	Between Groups	30.99	2	15.49	23.75	.00
		Within Groups	101.78	156	.65		
		Total	132.77	158			

Transportation Disruption Vulnerability	Shipping Service Delays	Between Groups	4.59	2	2.29	2.32	.10
		Within Groups	154.11	156	.99		
		Total	158.69	158			
	Road Haulage Delays	Between Groups	.81	2	.41	.31	.73
		Within Groups	202.81	156	1.30		
		Total	203.62	158			
	Shipping Processing Delays	Between Groups	1.62	2	.81	.86	.43
		Within Groups	147.86	156	.95		
		Total	149.48	158			
	Shipping Lines Delays	Between Groups	3.39	2	1.69	1.74	.18
		Within Groups	151.61	156	.97		
		Total	155.00	158			
Manufacturing Resilience	Manufacturing Quality	Between Groups	.14	1	.14	.17	.68
		Within Groups	107.86	129	.84		
		Total	108.00	130			
	Manufacturing Quantity	Between Groups	.04	1	.04	.053	.82
		Within Groups	102.89	129	.80		
		Total	102.93	130			
Transportation Resilience	Transportation Quality	Between Groups	4.65	2	2.32	3.43	.04
		Within Groups	105.59	156	.68		
		Total	110.24	158			
	Transportation Quantity	Between Groups	7.54	2	3.77	5.44	.01
		Within Groups	108.06	156	.69		
		Total	115.60	158			
Supply Chain Global Resilience	Manufacturing Schedule	Between Groups	.68	1	.68	.82	.37
		Within Groups	107.39	129	.83		
		Total	108.08	130			
	Transportation Schedule	Between Groups	5.03	2	2.52	3.97	.02
		Within Groups	98.91	156	.63		
		Total	103.94	158			
Supply Chain Risk Cost	Manufacturing Risks Cost	Between Groups	.04	1	.04	.051	.82
		Within Groups	101.20	129	.78		
		Total	101.24	130			
	Transportation Risks Cost	Between Groups	.55	2	.28	.37	.70
		Within Groups	117.22	156	.75		
		Total	117.77	158			

Eidesstattliche Versicherung und Erklärung gemäß § 11 Abs. 2 der Promotionsordnung

Hiermit erkläre ich an Eides statt, dass ich die Dissertation mit dem Titel

Causal Model and Analysis of International Garments Supply Chain Resilience with Partners in Germany, Pakistan and Turkey

selbständig verfasst und alle in Anspruch genommenen Quellen und Hilfen in der Dissertation vermerkt habe. Die den herangezogenen Werken wörtlich oder sinngemäß entnommenen Stellen sind als solche gekennzeichnet.

Hiermit erkläre ich, dass die Dissertation weder in der gegenwärtigen noch in einer anderen Fassung an der Technischen Universität Dortmund oder an einer anderen Hochschule im Zusammenhang mit einer staatlichen oder akademischen Prüfung bereits vorgelegt wurde.

Ort, Datum Unterschrift