Assessment Of Disruption Risk In Supply Chain
The Case Of Nigeria's Oil Industry

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ABSTRACT

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Thesis Title: Assessment of Disruption Risk in Supply Chain

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Keywords: Risk management; Disruption risk; Supply chain resilience; Analytical Hierarchy Process (AHP); Partial Least Squares Structural Equation Model (PLS-SEM); Coefficient of Regression; Analysis of Variance (ANOVA); Nigerian oil industry.

The aim of this study is to develop a consistent approach to analyse and evaluate disruption risks in the supply chain of petroleum production. This methodology is developed to formalise and facilitate the systematic integration and implementation of various models; such as analytical hierarchy process (AHP) and partial least squares structural equation model (PLS-SEM) and various statistical tests. The methodology is validated with the case of Nigeria's oil industry.

The study revealed the need to provide a responsive approach to managing the influence of geopolitical risk factors affecting supply chain in the petroleum production industry. However, the exploration and production risk, and geopolitical risk were identified as concomitant risk factors that impact performance in Nigeria's oil industry. The research findings show that behavioural-based mechanisms successfully predict the ability of the petroleum industry to manage supply chain risks. The significant implication for this study is that the current theoretical debate on the supply chain risk management creates the understanding of agency theory as a governing mechanism for supply chain risk in the Nigerian oil industry. The systematic approach results provide an insight and objective information for decisions-making in resolving disruption risk to the petroleum supply chain in Nigeria. Furthermore, this study highlights to stakeholders on how to develop supply chain risk management strategies for mitigating and building resilience in the supply chain in the Nigerian oil industry**.**

The developed systematic method is associated with supply chain risk management and performance measure. The approach facilitates an effective way for the stakeholders to plan according to their risk mitigation strategies. This will consistently help the stakeholders to evaluate supply chain risk and respond to disruptions in supply chain. This capability will allow for efficient management of supply chain and provide the organization with quicker response to customer needs, continuity of supply, lower costs of operations and improve return on investment in the Nigeria oil industry. Therefore, the methodology applied provide a new way for implementing good practice for managing disruption risk in supply chain. Further, the systematic approach provides a simplistic modelling process for disruption risk evaluation for researchers and oil industry professionals. This approach would develop a holistic procedure for monitoring and controlling disruption risk in supply chains practices in Nigeria.

Supervisors: Dr. Nejat Rahmanian, and Dr. Jose Eduardo Munive-Hernandez

Declaration

I Olatunde Olushola Aroge, declare that no part of this thesis has been taken from existing publication or unpublished material without due acknowledgement and that all secondary material used therein has been fully referenced.

Signed ------------------------

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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
ANOVA	-	Analysis of Variance
APICS	-	Association of Production and Inventory Control Society
AVE	-	Average Variance Extracted.
BBC	-	British Broadcasting Corporation
CB-SEM	-	Covariance-Based Structural Equation Modelling.
CIPS	-	Chartered Institute of Purchasing and Supply
CSR	-	Corporate Social Responsibility
DRP	-	Distribution Resource planning
EDI	-	Electronic Data Interchange
EFA	-	Exploratory Factor Analysis
EPR	-	Exploration and Production Risk
ERC	-	Environmental Regulatory Compliance
FMEA	-	Failure Mode and Effective Analysis
FPSO	-	Floating Production Storage and Offloading.
GAAP	-	General Acceptance for Accounting and Practices
GDP	-	Gross Domestic Products
HIPAA	-	Health Insurance Portability and Accountability Act
HPAI	-	High Pathogenic Avian Risk Influenza
ICWFM	-	International Conference on Water and Flood Management.
ISO	-	International Standard Organisation
JIT	-	Just in Time
KMO	-	Kaiser-Meyer Olkin
LG	-	Life is Good
MCDM	-	Multi-Criteria Decision-making
MENI	-	Mobil Exploration Nigeria Incorporation.
MODIS	-	Moderate Imaging Spectroradiometer
MRP	-	Materials Requirement Planning
MRP2	-	Material Resource Planning
NASA	-	National Aeronautics and Space Administration
NGL	-	Natural Gas Liquid.
NNPC	-	Nigeria National Petroleum Corporation

NOI	-	Nigeria's oil Industry
NOSDRA	-	National Oil Spill Detection and Response Agency
NT	-	Network Theory
OPEC	-	Organization of the Petroleum Exporting Countries
PIB	-	Petroleum Industry Bill
PLS	-	Partial Least Square
PLS-SEM	-	Partial Least Square Structural Equation Modelling
POMS	-	Production and Operations Management Society.
PV	-	Priority Vector
RAT	-	Risk Management Techniques
ROI	-	Return on Investment
SARS	-	Severe Acute Respiratory Syndrome
SC	-	Supply Chain
SCM	-	Supply Chain Management
SCR	-	Supply Chain Risk
SCRM	-	Supply Chain Risk Management
SCRMP	-	Supply Chain Risk Management Process.
SKU	-	Store Keeping Unit
UKCS	-	UK Continental Shelf
VICS	-	Voluntary Inter-Industry Commerce Standard
VLCC	-	Very Large Crude Carrier.
VW	-	Volkswagen
WIP	-	Work in Progress

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CHAPTER ONE

INTRODUCTION

ASSESSMENT OF DISRUPTION RISK IN SUPPLY CHAIN

THE CASE OF NIGERIA's OIL INDUSTRY

1.0 Background

Disruptive risks to businesses have become a great concern for industries across the globe and there is a consequential need to control these risks to ensure the future success of their investment. The core value derived from industrial risk control is driving business owners to intensify efforts on formulating risk management strategies for assessing and mitigating against the risk to shareholders' investment. Coulson-Thomas (2017), advocated the need for balance between enterprise and control, stakeholders need to put in place a mechanism for risk management processes. This is because the occurrence of risk and uncertainty are considered to be complex issues affecting the performance of shareholders' investment outcome. For example, research by Aberdeen Group (2005) found that more that 85% of executives experienced supply chain complexity causing disruption to their organisation. This study concluded that supply chain vulnerability will increase in the future.

Supply chain complexity involves the interconnectedness and interdependencies in the supply chain network (Christopher, 2010). A proportionate change in any of these elements of interconnectedness and interdependencies in the supply chain network can inversely affect other elements of the supply chain unexpectedly. The consequence of these unforeseen events may results in supply chain vulnerability, and adversely affects supply chain operational performance such as, customer satisfaction and responsiveness to demand (Tummala and Schoenherr, 2011).

In view of these trends there has been a proportional change in the interconnectedness and interdependencies of supply chain elements. Many global organisations have experienced complexities in their supply chains and several reasons accounting for these are complexities in the flow of materials and information in the supply chain network. Consequently, complexity results in variability and uncertainty, which affects the performance of a business. These complexities are due to organisational investment in research and development, global sourcing, fall in demand, supplier failure and continuity of supply as the top risk concerns, brand and reputation issues, regulatory compliance imposed by government, such as C-TPAT, or food security controls (Rice and Caniato, 2003). For example, Peck (2006) identified three fundamental issues that cause supply chain complexity in the food industry in relation to risk. These were attributed to lean supply and the consequential effect is less inventory; control is reduced over the process due to global supply chain and allocation of resources for mitigating the probability of disruption risk. Furthermore, stock holding policy is another variable that can trigger complexity in the supply chain. For instance, Argos had a strategic plan that supported the holding of large stocks of goods. Due to volatility in demand which affected their expansion, excessive stock sitting in supply chains became obsolete (Waters, 2011, p. 15). This resulted to a write-down of significant value and reduce profits.

Another example is Daimler Chrysler in Greenville, North Carolina which was struck by Hurricane Floyd, resulting in the motor manufacturing suspension plant being flooded and delivery of vehicle component parts disrupted. This consequently led to the shutdown of the company's plants for seven days across North America (McGillvray, 2000; Jutter, 2006 and Waters, 2011: P.16). Furthermore, many man-made disasters such as accident, war, terrorist attack, strike and sabotage, which affect the flow of materials and information across the supply network have significantly increased (Colema, 2006). For example, in 2010 the containership MSC Chitra sank after a collision with the bulk carrier Khalijia 3. Over 200 containers were missing, causing a serious threat to other moving ships in the busy Mumbai Coast (Waters, 2011: p.15). The Centre for Research on Epidemiology of Disasters, (2004), observed that, "disasters have increased exponentially worldwide over the past decades" (Bogataj and Bogataj, 2007; Myers et al., 2006). This assertion of disruption risk has become manifested in supply chain activities and this has consequentially reduced the efficiency of supply chain and organisational performance measures. For example, most recently, over 11million Volkswagen (VW) cars failed exhaust emission diesel test all over the world. This is because VW fitted a software that could cheat the test in diesel cars. The supply chain of VW was affected and diminished VW's reputation and their share value (Newman, 2015). Similarly, in 2014, the supermarket group (Tesco) experienced a slump in trading when its reported a significant drop in trading profits due to a scandal in its accounting system (Thetimes, 2015).

These examples have illustrated how a proportionate change in any element of interconnectedness and interdependencies in the supply chain network can significantly affect the whole supply chain. This can have a significant impact on a company's ability to get finished goods and services to the market or provide a critical service to customers (Jutter, 2006; Christopher and Peck, 2004). As the supply chain is a driver for building, sustaining, and gaining competitive edge (Hendricks and Singhal, 2005a), improved financial performance can be achieved by designing effective supply chains, and creating shareholder value (Chopra and Meindl, 2001; Anderson et al., 1997). Conversely, a supply chain network requires a high coordination of goods, services, information and cash across an organisation. Managing these significant elements of supply chain has resulted in disruption risk to organisational performance (Fredendall and Hill, 2001). However, understanding the interaction of change to interdependency and interconnectedness are critical to the management of any complexity in a firm (Perona and Miragliotta 2004; Goldratt, 2000). Complexity management and supply Chain). Arguably, the risk factors identified in this study were risks which cause disruption to a supply chain. It is this disruption risk variable that impacts the supply chain management. Hence, organisations which lack the ability to properly manage their supply network risks and uncertainties will run the risks of disrupting their materials and information flow, which in turn can wreak havoc on the company operation. For example, fire destroyed an electronics component plant in New Mexico in 2000. This plant was left with a supply shortage, which translated into a direct loss of sales estimated at $390m. Furthermore, businesses have many supply chain malfunctions (with substantial consequences) due to supply and demand disruptions (IBM, 2008). The affected companies reported on average 14% increase in inventories, 11% increase in cost, and 7% decrease in sales in the following year (Hendricks and Singhal, 2005). These examples help us better understand the challenges and problems confronting managers of supply chains.

Beside these global perspectives, which enable countries to utilise a better comparative advantage, introduce advanced technologies, foreign capital and management skills and competences. The global approach to risk management eliminates monopolistic behaviours and strengthens market competition. However, economic globalisation imposes unfavourable external forces on businesses, causing conflict between the external and internal economic equilibrium. This imposes a greater economic constraint on the macroeconomic policies and weakens the capability of macroeconomic policy regulation. Global economic activities have impacted business operations and national economic growth. For example, the global demand for petroleum products in Nigeria, pose some external constraints to the internal consumptions of the petroleum products and this is causing disequilibrium in the demand and supply for Nigeria petroleum products. This is as a result of the gap between the global oil demand and internal oil products supply, inadequate information capability and effective planning norms for global oil demand. These significantly impact the social economic and operational activities in Nigeria. This shows how disruption risk can devastate the global supply chain events at various levels of occurrences.

Further, risk dimension can also affect the trends of events at various levels in Nigeria. The categorisation of risk factors ranges from natural disasters, economics, regulatory compliance, technology, political and social conflicts (Frynas and Mellehi, 2003). For instance, social risk and uncertainty are belief, value and attitude (Frynas and Mellehi, 2003), such as social unrest, demonstrations, rioting, which are not business practices and could be a precursor to political and government policy risk (Miller, 1991). Hacked organisations can become a victim of cyber-fraud (Coulson-Thomas, 2017). The inadequate policy implementation on the deployment of multiple road checks on Nigeria’s highways has posed a greater bottleneck to the free movement of goods and services (Ubogu et al., 2011). Consequently, these risk factors can grossly disrupt logistics operations and impacts the economic development of a nation. The relevance of these associated risk factors to the context of a global perspective of the oil industry in Nigeria will be fully explored in the literature review of this study (see chapter 3).

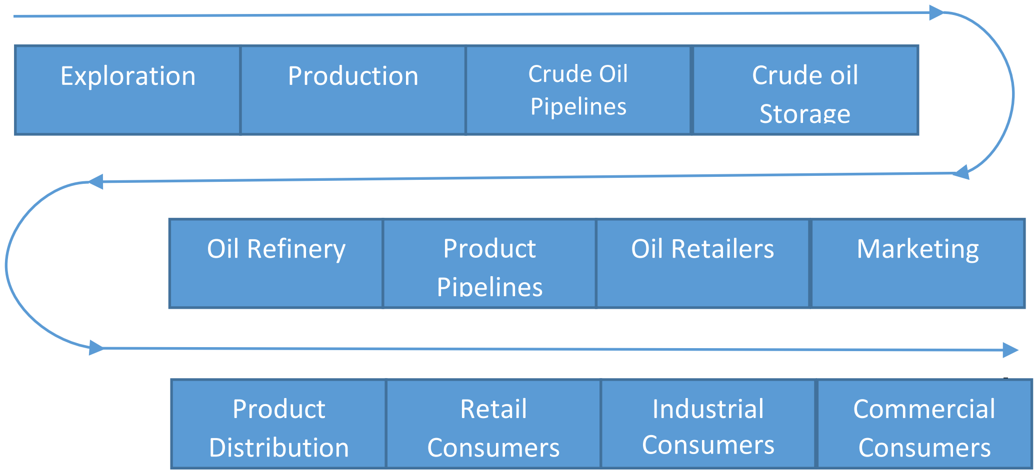
1.1 Rationale and Justification for this Study

The oil industry plays an important role in the economic development of Nigeria; with over ninety (90) percent of the nation's foreign exchange earnings being realised from the sale of crude oil and constitute about sixty-five (65) percent of government budget and revenues (Omenikolo and Amadi, 2010). The oil industry is the main source of energy for Nigerian industries, especially for those industries based on motor driven machines, such as marine engineering, transportation companies, breweries, production and agriculture processing and domestics users.

The priority of the oil and gas industry is to achieve optimum exploration, production and efficient processing of oil and gas products. This aim is to increase the global competitiveness of the producing community and reduce the operating costs of the participating industries (Praxis-Global, 2014). To realise the value of oil and gas industry, supply chains have proven an important means for achieving the optimisation of the value chain in the oil industry. Value chain involves the stages at which the products/services pass through before they get to the final consumers. Porter (1985), highlighted the various stages of product supply and the physical transformation from input to output; and other input support services (technology, procurement, R&D, finance, sales and marketing etc) to ensure the output is delivered to the final consumers. The input creates value which aggregately benefits society and differentiates businesses. However, the value chain involves the suppliers, third party logistics, sellers and consumers, all these functions (upstream and downstream activities) are linked together and in aggregate create values for a given product in the chain.

Supply chain is responsible for the coordination of the upstream and downstream of the oil and gas operation with the aim of satisfying the needs of the consumers and the community as a whole. The oil supply chain aims to deliver the right petroleum products to customers and users at the right time and at the right place to meet customers' needs and expectations with the aim of pursuing tangible outcomes which focus on the effective utilisation of assets, growth in revenue and profitability. The oil supply chain operations are segmented into the upstream and downstream supply chain operations (Gainsborough, 2006). The oil supply chain segmentations are briefly described in figure 1.1 below:

Upstream Supply Chain



Downstream Supply Chain

Figure: 1.1. Crude oil Supply Chain

The upstream oil supply chain involves all the logistics activities through feedstock of exploration, production and transportation into the refineries for refining operations (Enyinda et al., 2011; Nnadili, 2006). While the downstream oil supply chain is the refinery point where the conversion of the crude oil into products, which include the process of forecasting, production and logistics management of the crude oil to consumers around the globe (Enyinda et al., 2011).

The management of oil and gas supply chains is imperative for the economic wellbeing of a nation, in either developing or developed economies. Oil supply chains provide significant value to economic growth and improvements to the standard of living in Nigeria (Enyinda, et al., 2011). A number of various supply chain initiatives have been implemented, such as 'Just in Time' (van Weele, 2002; Heard, 1987 and Ohno, 1978), outsourcing (van Weele and van Raaij, 2014, Browne and Allen, 2001; Button, 1993), global sourcing (van Weele and van Raaij, 2014; Johnson et al., 2006), supply base reduction (Baldwin, et al, 2001), regulatory compliance imposed by government, supply chain quality management, product safety, technology management, capacity planning, external environment management. All these initiatives are to optimise the value chain activities in the oil and gas industries in order to contain costs, focus on core competencies, promote close working relationships with supply chain partners and ameliorate operational efficiency (Kannan and Tan, 2005). These initiatives aim to make supply chains more efficient and responsive to the needs of all players in the chain. However, these same trends have rendered the current supply chain practice less resilient to vulnerability that occurs through sudden disruption risks in the supply chain (Petrostrategies Inc., 2015; Makharia, et al., 2012 and Hussain et al., 2006). Thus the challenge for business is to mitigate risk by creating more resilient supply chains that can help build an effective value chain for managing and responding to the dynamic micro and macro-economic environment in which the global oil industry operates. These backdrops have initiated the need for this study to 'develop a methodology for the assessment of disruption risk in supply chain in Nigerian Oil Industry'.

1.2 Identification of Research Problem

The central ideal of oil supply chain management is to systematically integrate and coordinate the optimum exploration, production, and processing of the value chain activities. This consequently contributes to the economics of the upstream oil development. These improve customer service, identify substantial cost savings and promote improvements in the performance through the implementation of supply chain management initiatives (Chopra and Meindl, 2001). This given purpose of supply chain has failed to integrate the demand and supply for petroleum products in the Nigerian oil industry. The management of supply chain in the Nigerian oil industry is confronted with a wide range of disruption risks which includes, natural disasters, economics, regulatory compliance, technology, political and social conflicts (Frynas and Mellehi, 2003). Similarly, Enyinda et al. (2011) and Briggs (2010) identified exploration and production risk, geopolitical risk, environmental and regulatory compliance, transportation risk, oil resource availability risk and reputation risk as oil industry risks affecting supply chain management. Besides, the mentioned risks and uncertainties, it is evidenced that the upstream and downstream oil supply chain are distorted as a result of uncertainty in the oil reservoir resources discovery, uncertain reserve volume pronouncements, physical constraints in the reservoirs, and huge investment commitments (Mumby, 2014). Furthermore, oil resources are being exploited in the deep water of dangerous territory water of the Gulf of Guinea. Furthermore, petroleum exploration facilities and equipment are being damaged by militants. The disruptive events to petroleum production facilities has threatened crude oil overhead costs and investor profits in Nigeria. For example, Wall Street Journals, (2016) itemised the overhead costs breakdown for producing a barrel of crude oil in Nigeria as gross tax ($4.11) 14.2%, capital expenditure ($13.10) 45.2%, production cost ($8.81) 30.4% and administration/transport ($2.97) 10.2 %. Moreover, at times, oilfield employees are held hostage with the aim of receiving a pay-out ransom to secure the release of hostages held in captivity. These attributes have negatively affected the supply chain network of petroleum products in the Nigeria. This has resulted in a disproportionate value in the aggregate oil supply chain performance. This makes the oil supply chain remain uncoordinated and lacking in a governing mechanism for controlling vulnerability in the supply chain. For example, crude oil output fell by 25% from 2005 to 2010 due to attacks on oil infrastructure, oil theft, corruption among government and oil companies' officials and environmental damage in Nigeria (OPEC, 2014). However, the current practice to identify risk factors involving the use of a range of methods and techniques within the context of a supply chain paradigm in Nigeria, are yet to be documented.

To date, some limited substantive literature has explored risk management perspectives in supply chain management in Nigeria (Aniki et al., 2014). Agorzie et al. (2017), assessed supply chain risk factors within the context of the pharmaceutical industry in Nigeria. However, this study focused on the perspectives of organisational risk factors. Although, very few research studies have been conducted on risk management, those that have are fairly limited and have not really addressed the broader issues of oil supply chain risk management in Nigeria. This has created a vacuum for the categorisation of supply chain risk in Nigeria. Frynas and Mellehi, (2003) assert that documentations of risk categories within the context of supply chain paradigm in Nigeria, remain scant and unexploited due to the slow response of Nigerian researchers to the context of supply chain risk management. Kuperman, (2010) modelled a competitive dynamic which seek to establish a reality features for geopolitical risk classification. The model was innovative and robust, it however, lack holistic view on geopolitical risk occurrences, and the model cannot predict geopolitical risk occurrences. For example, Adeleye et al., (2004), investigated risk management practices in information systems outsourcing in the commercial banks in Nigeria; through an extensive literature review and survey. This study did not address issues related to the perspectives of the upstream (sales) and downstream (accounts payable) supply chain in the Nigerian banking industry. This study revealed that a significant proportion of commercial banking do not have a documented and structured outsourcing strategy or policy for risk management in Nigeria. Information technology (IT) is an integrative process for coordinating the upstream and downstream of value chain in the banking industry. It is observed that this research study omitted the significant contribution of IT as a coordinative tool in the value chain of the Nigerian banking industry. Consequently, this study concludes that risk management practices in Nigeria lack the procedural guidance for outsourcing of IT services in Nigeria (Adeleye et al., 2004). Furthermore, a study was conducted to investigate the development of poultry farm risk assessment tools for influenza in Nigeria. This study confirmed that the stakeholders do not have enough resources to monitor and ensure compliance to poultry farm activities in Nigeria (Obinani et al., 2014).

The findings of the "IT Outsourcing in Nigeria Banking Industry" (Adeleye et al., 2004), and "Investigation on the development of Poultry Farm Risk Assessment" (Obinani et al., 2014) have highlighted the nature of vulnerabilities, and the extent of risk exposure in Nigeria. Stakeholders have not invested (resources) time and money in establishing a high profile corporate brand to devote resources to risk management in the various facets of businesses in Nigeria (Obinani, et al., 2014). Furthermore, Enyinda et al., (2011) responded to supply chain risks in the Nigerian oil and gas industry through the use of AHP to reduce the risk, share the risk, avoid risks and retain risk. This approach adopted AHP to mitigate supply chain risk in the Nigerian oil industry. These assertions have evidenced that disruption risk management practices in Nigeria, lack the assessment framework for mitigating disruption risk in supply chain in Nigeria. This absence of a risk management framework is due to inappropriate identification of the sources of supply chain disruption risk and its prioritisation.

Risk identification is the first stage for risk management (Kleindorfer and Saad, 2005). It is the process for identifying the source of risk, cause of an event which negatively impacts performance (British Standard Institute, 2010). The essence of risk identification in the context of supply chain, involves a formal approach to capturing the appropriate risk and uncertainty to the supply chain. This triggers an early judgement for deciding whether such identified risk elements can pose any threats to supply chain events. The identification of risk is necessary for establishing the probability of risk occurrence. The establishment of risk occurrence helps organisations understand how disruption risks give businesses the ability to design a responsive supply chain system. Risk prioritisation is the mapping out of the identified risk elements with a view to spotting critical risk elements that need to be focused upon in the supply chain. Critical risk is the high rating risk based on an established rating threshold. Low risk is the risk that has very little impacts on an event. Therefore, risk prioritisation would provide both "High and Low Risk" (Singh, 2013; Kleindorfer and Saad, 2005). Based on prioritisation of risk, organisations are able to formulate a governing mechanism that can help to address the dimension of such probabilities and their severity. However, very little is known about the approach of risk identification and prioritisation in Nigeria. Among the emerging research questions (RQ1) this study is to identify the critical risk that affects supply chain management in the Nigerian Oil Industry.

Developing a modelling approach that will measure the responsiveness to understanding disruption risk impacts, has been globally used in various risk management studies. This evaluation approach to risk management helps organisations to minimise the occurrence and severity of risk to business performance. Various methodologies and approaches are used by researchers in their studies in order to assess the impact of risks to their business performance. Zsidisin et al. (2000) asserted that risk management requires continuous communication, gathering and analysis of relevant information that can enable development of appropriate risk management strategies. Cucchiella and Gastaldi (2006), developed a framework for the management of uncertainty in the supply chain in order to minimise firm risk. Furthermore, Gaudenzi and Borghesi (2006), used an analytic hierarchy process (AHP) model to identify supply chain risk factors with the aim of improving supply chain performance. This study proposed to use AHP for assessing disruption in supply chain. This research intends to integrate the output of partial least square structural equation modelling (PLS-SEM) into AHP which a “Microsoft Excel Software” will be use to calculates the normalised priority vector**.** Wu et al., (2006) examined phases of risk identification and prioritisation of supply chain risk and selected the critical risks for evaluation through risk factor ratios. Moreover, Shi et al. (2004) adopted derivative methods to manage supply chain risks that show how derivative methods can improve supply chain coordination and performance. This study shows that derivation is an efficient means of managing and mitigating risk associated with demand uncertainty. Therefore, the application of models, shows how modelling can help businesses focus on a holistic process which identifies, prioritises and quantifies organisational risk. Consequently, the use of models enables businesses to organise and conduct a simulative exercise for the coordination of supply chain risks (Foreman and Peniwati 1998). Through this reality, firms can identify, assess and manage vulnerability in their supply chain. Considering the advancement of the global risk management process through risk management modelling in Nigeria. There are no thorough quantitative research methodology used for the study of supply chain risk management in Nigeria. For example, Enyinda et.al. (2011) and Adebayo, (2012), employed a survey method in their study, these studies did not address the existing trends of risk assessment methods that are currently adopted for operationalising risk in Nigeria. Moreover, Obinani, et al. (2014) identified the development of a poultry farm risk assessment tool for avian influenza in Nigeria. Indeed, avian influenza is caused by viruses in birds. The spread of avian influenza has a high risk of 'Pathogenic Avian Risk Influenza" (HPAI) which can significantly disrupt the supply chain for the distribution of poultry products. However, no literature or methodology has been located to link the consequential impacts of 'Pathogenic Avian Risk Influenza" (HPAI) on the supply chain in Nigeria. This dimension can be a subject for future study because its consequences to human life can be devastating and scandalous effects to global supply chain.

In addition, Nkeki et al., (2013), assessed the impact of flooding in the Niger-Benue basin in Nigeria. The study employed a "moderate resolution imaging spectroradiometre" 'MODIS', (Running et al., 1994; Brakenridge et al., 2003; Zheng et al., 2008; Islam et al., 2009; Irimescus et al., 2010); data from NASA's Terra Satellite and developed a geospatial methodology to identify the flood risk areas and the populations vulnerable to flooding within the basin in Nigeria. The researcher of this study felt that the adoption of "moderate resolution imaging spectroradiometre" 'MODIS' techniques, were too complex for other researchers from other fields to understand and adopt in their research as a methodology or modelling tools. MODIS techniques cannot provide visualised results that can quickly be displayed. However, "risk being a catastrophic phenomenon, it conducts and interpretation should be simple and comprehensive to the generality of the entire world" (Researcher - Reflective Quotes). Simplicity in understanding the phenomenon of risk and uncertainty enhances knowledge and communicates the best approaches for tackling disruption risk in supply chains. For example, Osagie (2015) asserts "that attainment of knowledge needs not be too difficult and comprehensive; keeping things simple helps in the process of understanding and enlightening people concerned. A simplistic understanding of disruption risk in supply chain would boost the ability of supply chain practitioners to effectively group their skills, resources and adapt to the prevailing change to investment (Chinta, 2017a).

This illustrates how most of the conducted studies on risk management in Nigeria, lack understanding, reliability and generalisability for adoption into other research fields, due to the complexity of the existing current risk evaluation process in Nigeria. Thus the instrument used by these researchers are unreliable because the justification of the approach that underpin these methodologies are too complex to understand by researchers coming from non-scientific disciplines and findings cannot be generalised for further development. This implies that supply chain risk management is still struggling with the development of appropriate risk modelling techniques. Therefore, supply chain management research methodology and design in Nigeria lack consistency and is inadequate. To address the inconsistency in risk evaluation techniques, a framework needs to identify the trigger for supply chain events and its modes of occurrence (levels of disruption) and the mitigation strategy that can be generated to address these risks. However, risk management strategies should involve decision-making related to risk alternative such as, reducing risks, avoiding risks, transferring this risk, controlling risk or accepting the risk. Enyinda et al., (2011) identified approaches to responding to supply chain risks in the Nigerian oil and gas industry through the use of AHP to reduce the risk, share the risk, avoid risks and retain risk. Although, Enyinda et al., (2011), research was based on the responding to supply chain risk through AHP approach in the oil and gas industry in Nigeria. Hence, this study exploit a systematic approach to analyse and evaluate disruption risk in supply chain of petroleum production. Developing a model to address the phases of risk evaluation in this study will help in the decision-making process for the best risk management strategy for supply chains in the Nigerian Oil Industry (Simon, 1957).

It is important to note that most of the various works have used inductive and deductive research methods to produce their empirical results indicating the proportion of research work done through qualitative and quantitative methods. These researchers have their justifications for the choice of the applied methods. This research study will adopt a quantitative research methodology. This chosen methodology will enable the author to evaluate supply chain risk and validate the supply chain risk management constructs in the Nigerian oil industry. This study intends to adopt multi-criteria decision making methods (AHP) developed by Saaty (1980) and multivariate techniques of partial least squares structural equations modelling (PLS SEM) to evaluate the supply chain risk management constructs in order to establish the current risk management practice and provide the appropriate risk management strategy that will be efficient for supply chain management in the Nigeria Oil Industry. This approach will help to address the related research question (RQ2 and RQ4) and the specific objectives posed in this study.

In fact, the context of supply chain risk management has received little attention and most of the operations management researchers in Nigeria have not explored the context of risk management. However, risk management literature outside the scope of supply chain management has developed a generic typology of events that initiate risks (Reason, 1990; Shrivastava et al., 1988). This initiated risk event has created transversal capabilities which affect the implementation of supply chains in Nigeria. This is as a result of the appropriate risk management theories that could be used to advance further research in other fields of practice. Most of the findings from the previous studies cannot be replicated by studies in other research disciplines, this is because of the difficulty in understanding the applied methodologies and approaches. For example, the adoption of "moderate resolution imaging spectroradiometre" 'MODIS', to identify flood risk within the basin in Nigeria (Irimescus et al., 2010; Islam et al., 2009; Zheng et al., 2008; Brakenridge et al., 2003; Running et al., 1994). This type of study cannot be replicated or conceptualised to study supply chain risk in the Nigerian industries or petroleum exploration sectors. Most of these identified studies have been isolated from one another (Miller, 1991). This consequently led to a poor definition of risk management and hindered the implementation of supply chain risk management in Nigeria. Furthermore, findings from other research studies have concluded that risk management in Nigeria, lack the policy framework that should guide managers in managing risk processes (Adebayo, 2012). The lack of a policy framework is as a result of managers not devoting strategic and tactical resources and investment in risk management compliance, identification, prioritisation and reporting variances and threats in Nigeria. These have impacted supply chain performance and consequently increase vulnerability to shareholders' investment in Nigeria. This has presented a great problem in identifying the appropriate risk management strategy for supply chains in the Nigerian oil industry. These challenges have led to supply chain operational problems which have emerged through an inappropriate risk management strategy and decision-making process for identifying the best suitable approach to managing risk and building supply chain resilience in Nigeria. These resulted to internal processes, supply chain failure, capability of the executives, infrastructure inadequacy and high cost (CIPS, 2012). However, the oil industry supply chain operational risk can be categorised as losses due to errors in operations such as; failure to distribute products in real time and failure to comply with the regulatory requirements (Ravindran et al., 2010; Tang, 2006a). These operational attributes of the oil supply chain can significantly impact performance of oil industry players.

1.3 Research Gaps

Disruptions to the petroleum industry have been prominent in Nigeria for over five decades. However, previous studies have been slow to replicate and conceptualise supply chain risk management. The limitations of previous research have hindered the development of appropriate guidance for risk management strategies and techniques for managing supply chain, in particular,

- understanding the current supply chain risk management approach in Nigeria.
- defining and conceptualising supply chain risk management approach in Nigeria.
- Providing guidance for building supply chain resilience in Nigeria.

Unfortunately, very little understanding of the extent to which these rationale corresponds to current global supply chain risk management practices. Besides, this little thoughtfulness in supply chain risk management. The proposed systematic approach will help this study to align with the current identified rationale of global supply chain risk management perspectives. The reality of this study is to employ a survey questionnaire for the investigation of problems in the management of supply chain risk and develop methodologies and approaches for evaluating disruption risk to supply chain management and building resilience into the supply chain of the Nigerian oil industry.

1.4 Research Aim

The aim of this study is to develop a modelling approach for understanding and responding to disruption risks to supply chain in the Nigeria oil industry. To accomplish this aim, a systematic approach is used to analyse and evaluate disruption risks in the petroleum supply chain. This novel approach will facilitate the validation of data through cross verification from more sources, with a bid to understanding the responsive approaches to disruption risks in the petroleum supply chain. Integrated quantitative methods would ensure consistency to evaluating supply chain risk management and responding to supply chain risk in the petroleum production. The integrated systematic approach for this study incorporate analytical hierarchy process (AHP) which allow for risk assessment and prioritisation. A partial least square structural equation model (PLS-SEM) is developed to measure the significance of the influencing factors of risk management strategy, risk sources and their correlations with supply chain and performance measures. By applying the proposed integrated systematic approach to evaluate disruption risk to supply chain, the gap between current supply chain risk management practices will be thoroughly defined. As a result, a decision-making method for optimising supply chain risks and creating supply chain resilience will be accomplished

1.5 Objectives of this study

In order to achieve the research aim, this study will focus on the following research objectives:

1. To carry out a literature review on risk management in the context of supply chain management in the Nigerian oil industry.
2. To conduct a literature review on the oil industry in Nigeria in order to understand the various disruption risks affecting the petroleum supply chain.
3. To define a theoretical framework for this study in order to examine the impacts of associated oil industry risk on supply chain management and performance in Nigeria.
4. To develop a methodology to evaluate disruption risks in the petroleum supply chain. Several model such as AHP, PLS-SEM will be integrated. This methodology will be validated for Nigeria.
5. To define a research methodology for developing risk management options that could provide resilience in the supply chain of Nigeria's oil industry.
6. To analyse the results of the implementation for disruption risk management in the context of supply chain.

1.6 Research Questions

The aim of this project is to develop a systematic approach to analyse and evaluate disruption risks in the supply chain of petroleum production. This methodology will be develop, formalise and facilitate the systematic integration and implementation of different models to analyse and evaluate risks, such as AHP, PLS-SEM and various statistical tests. This methodology will be validated with the case of Nigeria's oil industry. To accomplish the objectives of this study, the following research questions are formulated so as to inform the directions of this study.

RQ1 How are supply chain risks currently managed in the Nigerian oil industry?

RQ2 What are the oil industry risk factors that could affect supply chain management practices in Nigeria?

RQ3 To what extent do risks associated with the oil industry in Nigeria impact significantly on supply chain and performance measurement?

RQ4 What are the risk management strategies that can provide resilience to the supply chain management in the Nigerian oil industry?

RQ5 What are the overall impacts of the implementation of disruption risk management on supply chain practice in Nigeria oil industry?

1.7 Contribution of this Study

The major strength of this study is based on systematic method for developing the assessment of disruption risks in supply chain in upstream petroleum industry in the Nigeria. This explicitly recognises the need for risk analyses and develops a conceptual model for expanding the scope of supply chain risk management in Nigeria. The management of risk is not only restricted to the identification and assessment of risks, but rather includes a strategic approach for addressing the occurrence of risk disruption in the supply chain in the Nigerian Oil Industry. The formulation of risk management response in the supply chain network for this study will enable corporate decisions-makers to expand their choice of possible responses to supply chain risk management.

The findings from this study will provide useful insights into the management of risk in other similar industries that have similar settings to the oil industry. For example, the supply chain in commercial aviation, defence, agriculture and biotechnology business all share similar complex environment as the oil industry. It is observed that very little research in supply chain risk management has addressed this area globally. These industries will benefit enormously from the outcome of this study. The proposed recommendation for risk management in the petroleum exploration supply chain would hugely benefit the supply chain of the other mentioned industry. For example, Leveson (2011) identified how system safety engineering was applied to successfully manage safety risk in commercial aviation, nuclear power and defence are a testament to the effectiveness of risk management. Leveson (2011) further observed the latest risk occurrences and successive enquiries in the offshore oil industry was evidence that some of the stakeholders in the petroleum exploration have failed to use the basic and appropriate engineering technologies and practices. The findings from this study will spark more researchers' interest to explore the success stories of the mentioned industries and advance their studies in the investigation of risk in the supply chain management in Nigeria.

This study will conceptualise supply chain risk management of the Nigerian oil industry. This will provide the mechanism through which risk practices can be managed in the Nigerian oil industry. Furthermore, this study will add to the current body of knowledge and literature on logistics and supply chain risk management and provide the guidelines through which risk can be identified, prioritised and evaluated in accordance with risk management practices. Consequently, this study will establish a risk management profile which will optimise a significant return to shareholder investment in Nigeria. This will enable managers to recognise the best fit techniques for assessing and mitigating risk in their supply chain. The emerged risk management framework will help Nigerian policy makers to achieve transparency in the management of public affairs and this will positively impact on the economic development in

Nigeria. It is reported that supply chain activities contribute to the GDP and provide employment to the people of Nigeria.

The conceptual model for this study will serve as a starting point for the development of theory for coordinating the various categories of risk management literatures. The development of theory will help to elucidate the approaches for managing risk in other fields. For example, agency theory has a strong reputation for developing behavioural based mechanism (Elkins et al., 2005; Eisenhardt, 1989), to manage uncertainty in supply chains. This theoretical development is needed to elaborate, the role of supply chain risk management in Nigeria.

The approach used in this study is different from previous research in assessing supply chain disruption in Nigeria. Previous studies have presented limited quantitative approaches for assessing and evaluating supply chain disruption risks in the Nigerian operating environment. These limited quantitative approaches were not rich enough to develop a comprehensive theoretical foundation for understanding and improving disruption risk. Furthermore, the previous research methods cannot be applied to other studies as they lack simplicity. Therefore, this study purposely adopted a systematic integrated method to assess and evaluate disruption risks in the petroleum production industry supply chain. This novel approach will be developed to formalise and facilitate the systematic integration for different approaches to assess disruption risk in the Nigerian oil industry. The systematic approach will help to keep things simple in the process of understanding and informing supply chain practitioners and stakeholder or business investors on disruption risks.

1.8 Thesis Outline

This thesis consists of eight chapters. The chapters present the structure of the research work.

Chapter 1 introduces the context of the research problems and motivating factors for the study. The context of this chapter includes, the research aim, objectives, research questions and contributions of the study.

Chapter 2 addresses the academic literature on supply chain, competitive advantage, supply chain risk and uncertainty and their impacts. This chapter highlights the global context as it relates to supply chain risk management practices in Nigeria. The insight gained leads to the formulation of the research questions.

Chapter 3 discusses the importance of the oil industry to the economic survival of Nigeria. The typology of disruption risk affecting the petroleum resources and production capacity in Nigeria. This chapter presents the current improvement strategies been practiced by some multi-national oil firms.

Chapter 4 highlights the conceptual framework and model for defining and explaining the risk typology in supply chain and risk management strategies for the study. The insights gained from this review will help this study to address the research questions.

Chapter 5 deals with the methodology used in this study. The chapter describes the abstract process for designing and evaluating the conceptual model. This involves survey methods, pre-testing and pilot testing of questionnaire survey, ethical issues and confidentiality and data collection methods with the research respondent in Nigeria's oil industry.

Chapter 6 presents the field survey data for analysing the research subject views on the risk management strategy for mitigating supply chain disruption risk in Nigeria oil industry. The field data is validated and reliability confirmed.

Chapter 7 discusses the results of the quantitative methodologies and approaches. The quantitative approaches create an understanding on the theme of supply chain risk management practices in Nigeria's oil industry. The insight gained through the understanding of supply chain risk management practices suggest the direction for improving supply chain risk in the Nigerian oil industry.

Chapter 8 presents the findings from the study assembled for the thesis to address the research gap and answer the research questions which were presented in chapter one (1) of this thesis. The findings from this study are used to generate the conclusions, implications and recommendations. The limitations are discussed and future research is proposed.

CHAPTER TWO

Literature Review and Theoretical Framework

2.0 **Introduction**

This section includes a review of the literature on supply chain and risk management, which reviews the current knowledge, generates and refines the research ideas and critically appraises the current knowledge on global issues that are related to risk management strategy and supply chain management in the Nigerian oil industry. The theories and methodologies of the previous research studies will be used to inform this study and enable the development of the theoretical framework relevant to the background and research aims and objectives of this study.

2.1 Supply Chain

A supply chain is defined as an interlinked network of suppliers, manufacturers, distributors and customers that have been set up to supply products or services to customers (Karantana et al., 2006). The supply chain incorporates the processes from receiving the initial raw materials to the ultimate consumption of finished products linking users and companies (Supply Chain Council, 2005; Cox, et al., 1995). However, supply chain is the function within and across a company that enables the value chain to make products and provide services to customers.

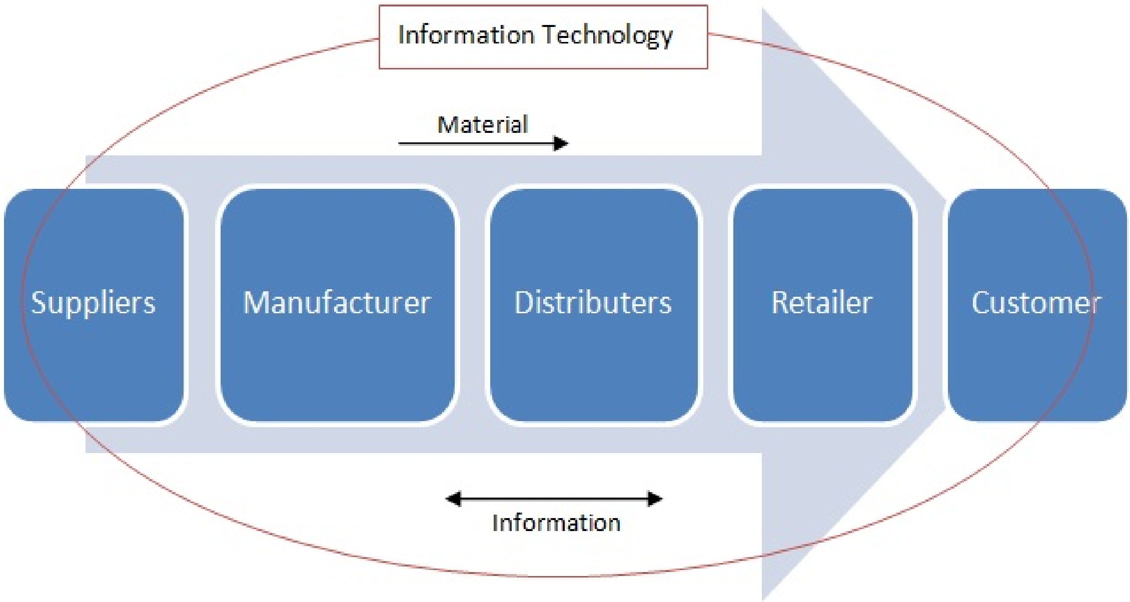
The value chain is the sequence of business activities through which value is added to products or services produced by a firm. However, the value chain relates to the organisational functions such as purchasing, production, research and development, marketing and sales, logistics and finance (Figure 2.1). These functions significantly add value to those products and services, which organisations provide or sell to their customers (Fredendall and Hill, 2001; and Porter, 1985). The concept of value chain helps businesses to identify and understand specific sources of competitive advantage (CIPS, 2012). It systematically maps organisations into strategically relevant activities in order to understand the interactive behaviour of costs, the existing and potential sources of product differentiation from competitors (CIPS, 2012).

In the current environment, supply chain management involves the flows of materials, information and finance in the network comprising of suppliers, customers, manufacturers and distributors (Oracle 2010; Lee, 2000 and Christopher, 1998).

- Material flow involves the physical movement of products from suppliers to customer through the linkage and reverse flows via products/services return, recycling and disposal (Lee, 2000).
- Information flow is a system within a given environment that brings together supply chain components into a finely tuned network that is synchronised, high performing, agile and responsive to change (Hoffmann, 2013). Information flows can also be a process for transmitting orders and delivery in a supply chain network (Lee, 2000). Information flow is a critical ingredient for integrating and managing business processes across the supply chain. Figure 2.1 illustrates how supply chain processes involve the flow of information between supply chain partners. The flow of information in the supply chain network also implies the flow of products in the pipeline. The flow of products and services is the primary purpose of the firm to create customer satisfaction and maximise profits. Information flow helps companies to optimise demand and supply within the network.
- Financial flows involve credit terms given to suppliers, payment schedules and ownership arrangements within the supply chain actors.

Furthermore, supply chain management can be viewed in another dimensions as the buying of raw materials to managing suppliers, warehousing, operation transport fleets, taking orders, collecting payments, repairing products and even answering telephones at calls centres (Markillie, 2006; Karantana et al., 2006). In addition, supply chain management can be described as the "integration of key business processes from the end user through original supplier that provide products, services and information that add value for customers and the stakeholders" (Lambert et al., 1998: p.1).

Supply chain integration is a process which enables businesses to capture supply chain elements, such as business processes, integration management and structure (Amue, et al., 2014; Lambert, et al., 1998). Supply chain integration enables businesses to achieve the primary aims of providing services/products satisfaction to their customers and maximising returns to shareholders investment. These aims can be achieved through the following dimensions:



Source: http://www.mbaskool.com/images/stories/transforming_supply_chain_flow.jpg. (Accessed 22nd November 2018).

Figure 2.1: An Overview of Supply Chain - Material and Information Flows

Dimensions for Attaining Supply Chain Integration

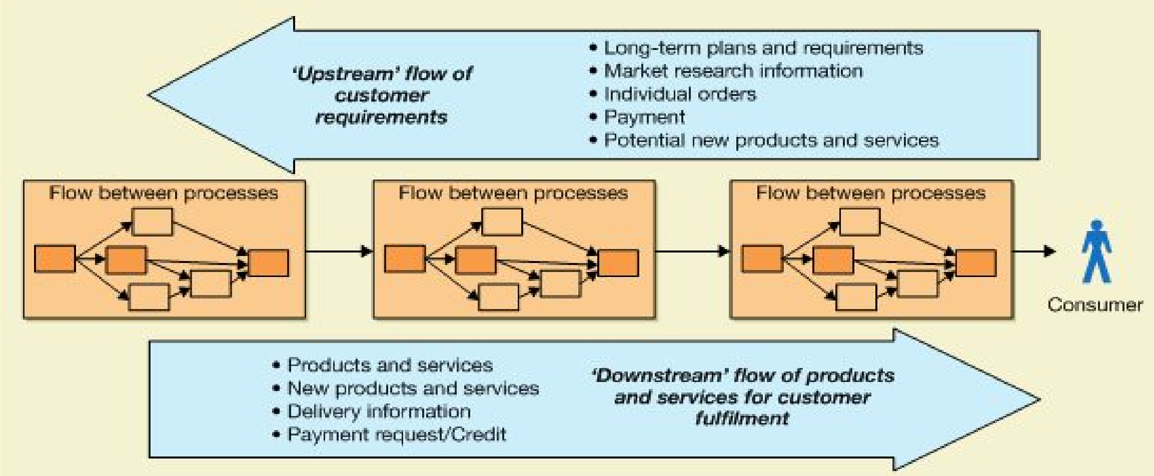
1. The building of cooperation and relationships across the supply chain so that the whole chain works together to add value for the end customer in a profitable, risk-managed and competitive way (Jespersen and Skjott-Larsen, 2005).
2. The focus on effective business processes. Supply chain process improvement involves the planning process and management of supply chain sequences of activities. This involves the supply chain strategy, such as buying, making, and selling that provides value to customers (Markillie, 2006).
3. Another feature of supply chain management is integration, which involves the coordination of activities across the functional organisational boundaries. Lee (2000), asserts that coordination is the redeployment of

decisions, rights, works and resources in order to position the supply chain. This involves the process for considering organisational structure (such as cross organisational teams and interface or points of contacts); systems (related to information system), and planning (which includes, exchange of planning and control data with the supply network) (Jespersen and Skjott-Larsen, 2005).

These components are the constituents that glue the working process of the upstream suppliers and downstream customers with all the organisational activities that are involved. The upstream supply chain consists of organisational functions that deal with planning of requirements based on customer demand. The upstream activities deal with the process of materials search and extraction of raw materials. Thus, any industry that relies on the extraction of raw materials commonly has an upstream stage in its production process. In a more general sense, "upstream" can also refer to any part of the production process relating to the extraction stages. For example, upstream processes of the petroleum industry are located through under water oil reserves (Bass, n.d).

The downstream functions involve the process of order, while the upstream activities aim to ensure that supply chain stakeholders are responsible for ensuring that customer orders are addressed without delay. The downstream activities are involved in the processing of raw materials collected from the upstream stage from conversion to the finished products. The downstream involves the marketing and distribution of petroleum products (Bass, n.d).

The constituents of supply chain integrations improve the working process of the upstream and downstream flow in the supply chain and minimise bottlenecks, which might hinder the efficient movement of materials and information flows. Figure 2.2 describes the activities that are performed at the upstream and downstream of the supply chain.



Source: Slack *et al*. (2006), pp.209.

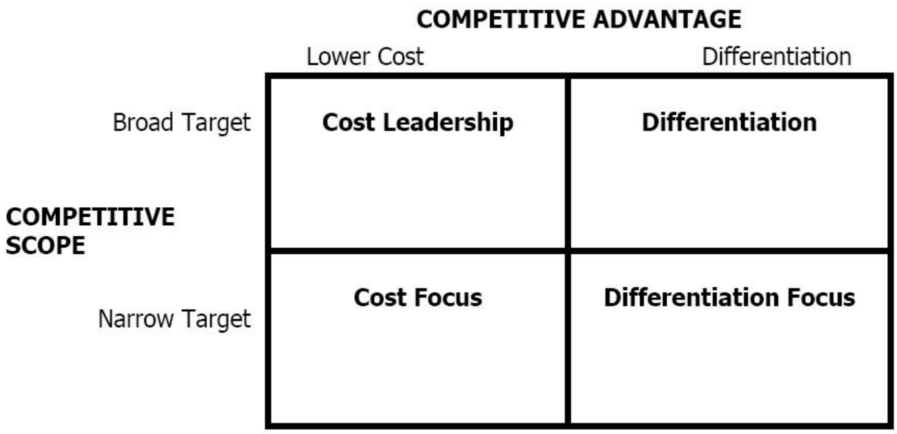
Figure. 2.2: The upstream and downstream flows in the supply chain

2.2 Supply Chain Management and Competitive Advantage

The essence of supply chain management is to develop the process of interaction and collaboration of a number of companies with different organisational infrastructures, in order to fulfil business objectives by delivering the appropriate value to customers and companies (Ismail and Sharifi, 2006). The supply chain interactions helps business to reduce costs, increase revenue and boost profitability (Li et al., 2006; RMA., nd). These derived benefits from supply chain initiatives have helped companies to gain more advantages than other competitors. The management of supply chain initiatives improves organisational competitiveness (Singh et al. 2005, Li, et al. 2006, Gunasekaran et al. 2008).

To realise the potential benefits of supply chain management, organisations are required to make fundamental changes to their business focus (Kopczak and Johnson 2003). These changes include the effective management of the flow of physical goods through suppliers, manufacturers, distributors and retailers and increased value to end customers (Jammernegg and Reiner 2007). Indeed, the past decades have exemplified how some global companies such as Wal-Mart and Dell, have re-engineered their supply chain in order to boost their competitive advantages over their competitors (Markille, 2006). For example, Dell sells its computers products directly from its own websites and call-centres. This direct contact enables Dell to build and customise its computer products at the request of their customers, it also compresses the Dell distribution channel and cuts the lead-time for delivery of customer orders. Furthermore, Dell is able to receive payments upfront which improves Dell's balance sheet transactions by improving the efficient flows of working capital. This approach places Dell in a more competitive position than Hewlett-Packard in the same personal computer business. Dell became a market leader because its ability to use its supply chain to respond efficiently to customer demand (Sheffi, 2006; Hackward and Shore, 2004).

The concept of competitive advantage means that a firm is gaining superiority over a competitor in terms of customer preference. However, customer preference implies that an organisation was able to distinguish itself through cost leadership, differentiation and focus (Porter, 1985). Indeed, competitive advantage is a superiority which a firm has gained over its rival. Porter, (1985) claimed that the four generic approaches through which an organisation can attain a competitive advantage are quality, cost leadership, focus and differentiation. Figure 2.3 shows how the process of competitive advantage can be achieved when greater value is offered to a consumer through the different generic strategies. For example, Aldi creates value to their customer through cost leadership on grocery products and this proportionally increases their pre-tax profits in 2013/2014 financial year (BBC News, 2014). This superior performance of Aldi, is based on the low costs strategy in the grocery retail industry. Aldi, was able to increase revenue, boost their profits and attain competitive advantage over their rivals through cost focus in their supply chain.



Source: Porter's Generic Strategy, (1985).

Figure 2.3: Porter's Generic Strategy

In Porter's view, competitive advantage consists of an organisational ability to increase earnings over the investments of shareholder's capital (Singh, 2012). However, companies gain competitive advantage when they implement a value creation strategy. For example, a supplier delivering high quality products to their customer in the value chain would ensure that the process is coordinated to enable them to outperform their rival supplier in a supply chain network. The implementation approach enhances superiority in performance and guarantees competitive advantage. For example, a supplier to food manufacturing company may use its resources, such as knowledge and skills, to negotiate a low cost with their first tier supplier in the supply chain, in order to effectively compete through cost leadership which is attained through the implementation of their resources.

The implementation of the value creating strategy helps an organisation to effectively and efficiently sustain its competitive advantage. This approach helps businesses to exploit opportunity (Barney, 2001), which consequently eliminates threats to supply chain performance. For example, a firm with a low cost and differentiation strategy over their rival, (Barney, McWilliams and Turk, 1989), suggested that these strategies should not be implemented simultaneously. However, competitive advantage remains sustainable if efforts to duplicate such strategy by rivals are unsuccessful (Rumelt, 1984). Furthermore, a competitive advantage should last over a period of time in order to make it more sustainable. For instance, Dangote Nigeria Plc., is a conglomerate company that trades in sugar, rice, cement and other products, which are common items in the Nigerian market. Dangote penetrated the Nigerian market with low cost which made Dangote gain superior performance over their rivals. However, other manufacturers of cement are still struggling to compete with Dangote, because other rivals in the Nigerian cement manufacturing industry find Dangote's competitive strategy too expensive or costly to copy or imitate. The strong hold of Dangote's conglomerates are due to the non-substitutable cement and its integrated logistics systems. However, Dell competitive strategy was less expensive and substitutable, this makes it easier for competitors in the electronic industry such as Hewlett-Packard (HP) etc., to imitate Dell competitive strategy. This relegated Dell position as a market leader in the electronics.

The dynamics of the environment have highlighted the need to enhance the approaches to supplier management through closer integration so as to incorporate the suppliers and customers (Bowersox and Closs, 1996). Pursuing this value creation strategy in the supply chain influences the successful performance. However, competitive advantage depends on business process and structure development (see Figure 2.1), that enables an organisation to respond to customer needs through an integrated flow of information and materials. Supply chain integrated behaviour involves the mutual sharing of information for planning and monitoring processes (Tyndall et al., 1998). This promotes the sharing of intelligence on inventory status, promotion and marketing strategies. This enables the supply chain members to deal with the consequences of both excess and stock-out inventory, because replenishment decisions in the supply are achieved through a collaborative effort between suppliers and customers (Ribas et al., 2011). This enhances firm capabilities, resources and saves businesses from risk and costs. Moreover, this reduces uncertainty between supply partners and results in enhancing performance (Hallika et al., 2007; Salcedo and Grackin, 2000) and boosting competitive advantage for the supply chain members.

2.3 Risks and Uncertainties in Supply Chain

The appearance of the word risk as a performance variance in the supply chain management literature have sparked debate among researchers for almost a decade and half (Wiengarten et al., 2015; Blome and Schoenherr, 2011; Kern et al., 2010; Ritchies and Brindley, 2008; Khan and Burnes, 2007; Chopra and Sodhi, 2004; Zsidisin, 2003; Juttner et al., 2003; March and Shapira, 1987). Risk originates from the Arabic word "Risq" which implies "the gift from Allah or God" (Norrman and Lindroth, 2004). Risk is defined as a variability that reduces performance predictability (Miller, 1991; Jemison, 1987).

The variability and interpretation of risk have been examined from various perspectives including business, science and engineering (Rithies and Brindley, 2008; Khan and Burnes, 2007; Chopra and Sodhi, 2004; Zsidisin, 2003). Uncertainty is the probability distribution of variability that might significantly impact corporate performance (Mile and Stone 1978), for example, demand, price, exchange rates, availability of resources, cost of resources, quantity and quality output from a transformation process, cost of transforming input into output. Risk is the downside of uncertainty and can result in either loss or profitable outcome (Storrud-Barnes, 2010; Norrman and Lindroth, 2004). For instance, a low demand leads to high inventories, or high demand leads to lost sales and reputation.

Lowrence, (1980), described risk as the measure of the probability and severity of an adverse effect. The concept of risk has led to the investigation of corporate activities, such as decisions-making process tools (Stone, et al;

2002), operations (Khan and Burnes, 2007) and strategic management tools (Sitkin and Pablo, 1992; Bettis and Thomas, 1990). Risk is the 'effect of uncertainty on corporate objectives' (ISO 31000: 2009), and the probability of an unwanted outcome (CIPS, 2012; p2). However, probability is the measure of likelihood that a given event or result might occur. Melny et al. (2005) define risk as the probability (chances of an event occurring) and impact (the ultimate effects created by the events). Previous researchers have linked these various definitions of risk to supply chain. Harland et al. (2003), defined risk as a probability of damage, loss, injury or any other undesired consequences. Indeed, many notable definitions of 'risks' have been provided by (Manuj and Menzer, 2008; Tang, 2006; Christopher and Peck, 2004; Norrman and Lindroth, 2004; Juttner et al., 2003). Mitchell (1995), described risk as the likelihood of loss and the consequences of losses that affect an individual or organization.

Mitchell, (1999) developed the principle of risk as a probability of loss (P) and significance (I) of loss. This definition indicates that risk constitutes elements of loss associated with uncertainty, which significantly impacts shareholder values and organisational performance. For example, a fire that destroys a supplier plant can affect production over a certain period of time and this can impact the corporate existence of such an entity. For example, an over-optimistic products forecast could result in a huge build-up of stock aimed to meet market demand that never happens. In 2006, "the weaver Camillario lost 60 percent of sales when its main customer moved their business to China, and it almost immediately went into liquidation" (Water, 2011: p.2). These consequences indicate that 'risk' is an internal and external, uncertainty, environmental variables that shrink the outcome of events prediction (Juttner, 2003).

The supply chain literature has been extensively debating the perception of risk. For instance, March and Shapiro, (1987: p1404) stated that risk is a variation in the probability distribution of possible outcomes, likelihood and detectability of a subjective value. In addition, Mitchell (1995) argued that risk might be purely a potential danger or an opportunity for an entity to achieve its corporate objective. ZandHessanni and Savoji (2011), supported the assertions that risk acts as a strategic lever in organisations' competitive process. In the context of supply chain management, risk is a process which businesses use to produce a better quality and list cost and enhancing their competitive power (Wiengarten et al., 2015; Blome and Schoenherr, 2011; Zurich Insurance Company, 2010; Rithies and Brindley, 2007; Christopher, 2010; 2004; Khan and Burnes, 2007; Chopra and Sodhi, 2004; Zsidisin, 2003; Juttner et al., 2003) argued that risk practices increased supply chain complexity and various categories (section 2.4 and Figure 2.4) of risks have helped organisations to identify the best key practices for achieving optimal performance. This is linked to the review in section 2.1 of this study.

Risk is any unforeseen event from the perspective of business, science and engineering that might disrupt the movement of materials within and outside an organisation and significantly impact corporate performance. The occurrence of risk might prevent deliveries of goods to the supply chain members or affect the smooth operation of the supply chain (Water, 2011). An effective supply chain design will enable an organisation to provide the relevant contingency plan that could be used to confront any disruption in the supply chain. For example, "Li and Fung changed its supply chain plan in a flash to meet customer demand during a currency crisis" (Tang, 2006: p37).

2.4 Supply Chain Risk

Risk in supply chain is an intervening events or variables that negatively influences the flow of information, materials, products, resources from the original supplier to the user of the final products (APICS, 2011). In other words, supply chain risk is the process for assessing the occurrence of disruptive events within the supply chain and its negative impacts on organisation’s business processes (Stemmler, 2006; Kersten, et al., 2006). Indeed, supply chain risk is associated with disruption of business working capital resulting from inappropriate planning for safe levels of stock-keeping, lead times and over-time. Furthermore, disruption risk may arise from natural or man-made disasters such as earthquakes, hurricanes, and terrorism (Manuj and Mentzer 2008; Miller, 1991). The impact of risks on the supply chain depends on its design and implementation. The effects of inappropriate design and implementation are referred to as supply chain vulnerability. Vulnerability is the exposure to serious disturbance, arising from risks within the supply chain as well as risks that are external to the supply chain (Thun and Hoenig, 2009).

Despite the importance of the concept of risk in supply chain, there is much disagreement among academics about the appropriate definitions of supply chain risk. Table 2.1 presents a summary of the different definitions of supply chain risk management in the risk management practice literature.

Table 2.1: Definitions of Supply Chain Risk Management (SCRM)

Authors	**Definitions Of SCRM**
Norman and Lindroth (2002)	SCRM is collaborative process for dealing with supply chain risk and related uncertainty impacting supply chain performance.
Juttner et al., (2003, p.201) and Juttner (2005, p. 124)	The identification and management of risk for the supply chain and implementing appropriate actions to avoid supply vulnerability.
Tang (2006a, p.453); Ritchies and Brindley (2007).	"The management of supply chain risk through the coordination or collaboration among the supply chain partners so as to ensure profitability and continuity".
Goh el al., (2007, pp. 164 – 165	"The identification and management of risks within the supply chain network and externally through coordinated approach amongst supply chain members to reduce supply chain vulnerability as a whole".
Manuj and Mentzer (2008)	The identification and evaluation of risks and consequent losses in the global supply chain and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following - losses, probability, speed of event, speed of losses, the time outcome that, in turn, lead to close matching of actual cost savings and profitability with those desired.
Thun and Hoenig (2011, p. 243)	"Characterized by a cross-company orientation aiming at the identification and reduction of risks not only at the company level, but rather focusing on the entire supply chain",

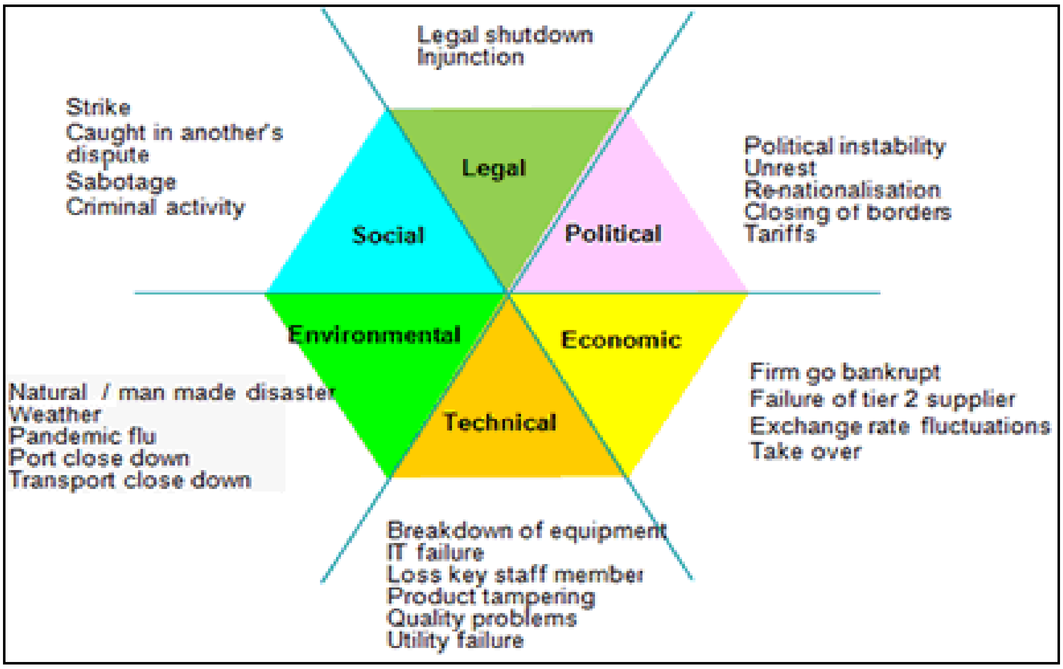
The definitions in table 2.1, clearly illustrate the different concepts of risk in the academic literature of supply chain risk management. This diverse conceptualisation is supported by Argote, (1982: p.420) who claimed that there are many definitions of risk events as a phenomenon as there are treatments for such a subjects. Stone and Yate (2002) echoed this, claiming that if we read ten or more books/articles on the subject of "risk", we should not be surprised to see that risk is described in 10 various disparate ways. This assertion on the definition of risk shows the difficulty in the academic conceptualisation of risk in supply chain management literature. This implies that there is no an accepted basis for a consistent definition of supply chain risk management (Lipshitz and Strauss, 1997). Nevertheless, it is widely acknowledged in this literature that risk is inherit in supply chain management. The implication this has for supply chain management literature is discussed further in section 2.6. This is specifically linked with research question (RQ 2) and it will be dealt with in the process of developing the research hypothesis for this study.

2.5 Sources of Global Supply Chain Risks

Risk involves losses which negatively influence lives, property and investment (Wagner and Bode, 2008). Risk can be categorised as internal or external to the supply chain. The internal risk, are risk which emerged within an organisation, i.e communication infrastructure failure (Stecke and Kumar, 2009).

The external risk emerges as a result of environmental forces affecting the performance of a business. External risks are characterised with disruptive events occurrences with various magnitudes influence on the management supply chain. For example, the outsourcing of production by global businesses across the world is challenged by the many potential hazards and vulnerability; such as political and economic instability (Signal et al., 2011; Kumar el al., 2010), security risks (such as terrorist attack in the USA - 11th September 2001). Many businessess are challenged with risks associated with regulatory and legal non-compliance with anti-terrorism trade and shipping guidelines (Yang, 2010; Sanchez-Rodrigues et al., 2010). These challenges adversely impact on organisation's supply chain.

Disruptive events such as fire and natural disaster might impact, for example a component supplier factory, which then can lead to shutdown of manufacturing and business operations. For example, between June 2007 and June 2012, Toyota's recalled approximately 802,000 vehicles globally as a result of faulty break system (Ravindran et al., 2010; Oke and Gopalakrishnan, 2009; Shi et al., 2004; Stickles, 2002; BBC News; 2014; https://www.bbc.co.uk/news/business-29625734; (Accessed 22nd November 2018). Other categories of risk that might affect the supply chain network include, power failure or blackout (Siyan and Ekhator, 2001), equipment breakdown, production quality problems, production failure, errors in forecasting and production stoppage due to faulty machineries (Manuj and Mentzer, 2008), demand volatility, (Huang et al., 2009), supplier delay (Ravindran et al, 2010). These hazards can be grouped as internal and external supply chain risks (Christopher and Peck, 2004). Managerial approaches are applied to control internal risks, while the external risk factors are uncontrollable (Christopher and Peck, 2004). Figure 2.4 illustrates the risk threats to a supply chain.



Source: Maclean - Bristol (2008).

Figure 2.4: Sources of Supply Chain Risk

However, external risks are anticipated and strategic plans are provided in advance in order to address the occurrence of external risk phenomenon.

Table 2.2 exhibits a list of supply chain risk variables which are frequently discussed in the supply chain management literature. These potential disruption risks are classified into three categories vis-à-vis; organisational risk, network risk and environmental risk. Each of these risk classifications involves numbers of risk components. These components will be described along with their individual risk classifications.

Table 2.2: Categorisation of Risk Sources in Supply Chain

Risk Categories		Risk Sources	References
Organizational Perspective		Breakdown in production machineries	Stecke and Kumar (2009); Manuj and Mentzer (2008); Sodhi and Lee (2007); Cucchiella and Gastaldi (2006); Zsindisin, et al., (2004).
		IT Systems Failures	Faisal et al (2006); Sutton (2006).
		Error in forecasting	Deleris and Erhun, (2007); Cucchiella and Gastaldi (2006).
		Employee uncertainty (strikes)	Stecke and Kumar (2009); Quinn, (2006); Kleindorfer and Saad, (2005); Christopher and Towil (2002); van der Vorst and Beulens, 2002.
Network Perspective	Demand Side	Volatility in Demand	Huang et al; (2009); Canbolat et al (2008); Cucchiella and Gastaldi (2006); Tang (2006a and 2006b); Chopra and Sodhi, (2004), Sodhi (2005); Lee et al., (1997).
		Communication breakdown	Faisal et al., (2006); Sutton (2006), Spekman and Davis, (2004).
		Delivery breakdown	Ravindran et al., (2010).
		Poor Coordination	Wagner and Bode, (2008).
	Supply Side	Quality problem from raw materials	Huang et al., (2009).
		Supplier variability	Huang et al., (2009); Hendrick and Singhal, (2005a and 2005b).
		Capacity constraints	Hendrick and Singhal, (2005a & b).
	Logistics/ Transport	Third party bankruptcy	Chen (2007).
		Delay in delivery	Nagurney et al., (2005).
		Industrial action	Mckinnon, (2006); Kleindorfer and Saad, (2005); Christopher and Lee (2004); Rothstein, (1997).
		Infrastructural problem	Stecke and Kumar (2009).
Environmental Perspectives		Natural Disaster	Knemeyer et al, (2009); Oke and Gopalakrinan (2009); Stecke and Kumar (2009); Ravindran, et al., (2010).

	Legal and Regulatory compliance	Schoenherr et al, (2008); Knemeyer et al., (2009); Kumar et al., (2009); Oke and Gopalakrishnan (2009); Stecke and Kumar (2010); Ravindran, et al., (2010); Sanchez-Rodrigue et al., (2010) and Yang and Yang (2010).
	Political Uncertainty	Kumar et al, (2010); Matook et al., (2009); Ratick et al., (2008), Schoenherr et al., (2008); Wu el al, (2006), Papadakis (2006), Aron et al., (2005); Hale and Moberg (2005).
	Macroeconomic problems	Kumar et al., (2010); Matook et al (2009); Manuj and Mentzer (2008); Miller, (1991).
	Social instability	Aron et al., (2005); Cucchiella and Gastaldi (2006); Miller (1991).
	Infrastructure breakdown	Kumar et al., (2010).
	Terrorist attacks	Chen, (2007); Quinn, (2006).

2.5.1 Organizational Related Risks

Organisational risk involves breakdown in production, information technology systems failures, errors in forecasts and employee crisis. These associated risk perspectives have been examined in various research studies. Among the associated organisational risk is production failure, which involves a variation in production, factors that can result in breakdown such as machines failures, change in production schedules, overcapacity, these prevents the supply chain from attaining customers' satisfaction (Manuj and Mentzer 2008).

Information technology (IT) systems are an effective mechanism used for the coordination of activities in the supply chain. Companies benefit from information technology innovations, such as electronic data interchange (EDI), material resource planning (MRP 2) and distribution resource planning (DRP). These systems help businesses to effectively assimilate supply chain information, such as costs and control process transactions, which facilitate the smooth running of the supply chain (Lee et al., 1997). Information asymmetry (irregularities) is the main source of distortion in supply chain management (Guo et al., 2006). In addition, poor information sharing between the upstream and downstream supply chain is a critical factor that hinders the flow of materials in the pipelines. However, the lack of security in information technology system can impact significantly on supply chain coordination (Blackhurst et al., 2008; Guo et al., 2006 and Chopra and Sodhi, 2004). In view of the significant of the mentioned technologies, supply chain executives are placing more emphasis on the potentials of big data analytics. It is confirmed that big data analytics are more valuable than the previously mentioned technologies; big data is superior than internet, cloud computing and 3D printing technology (Information Technology, 2012). Manufacturing are adopting big data strategies to manage a wide range of disruption risk factors within the supply chain.

Forecasting is the ability to predict the demand requirements for customers in the supply chain. An effective demand forecast helps businesses to minimise materials usage in the value chain. The maximisation of resource usage improves the management of companies' working capital.This eliminates excess inventory storage and this consequentially maximises profits. Errors in forecasting involve companies' inability to project business needs. These trends are traceable to information systems’ failure, resulting from insecurity (Chopra and Sodhi, 2004; Blackhurst et al., 2008). Moreover, a company’s inability to analyse and communicate demand with their supply chain members may results in wider variability in coordination of the supply chain. Most recently, United Airlines, experienced demand planning problems due to errors in forecasting customer flight bookings. The organisational impact of this negative experience was made visible to most of the entire world through various global social media channels. This exposure resulted in customers calling for a boycott of United Airlines. The United Airlines’ market capitalisation dropped by more than $250 million as a direct aftermath effect of poor customer satisfaction emerging from poor demand planning (Oti-Yeboah, 2017).

2.5.2 Network Related Risk

The network supply chain risks are characterised by demand side, supply side and logistics and transport side risk. Demand side risk is affected by forecasting, product variability and lead times set for given orders to get to the marketplace (Fisher, 1997). The interplay of these variables (volatility in demand, communication breakdown, delivery lead time and poor coordination) affects supply chain management. This results in a mismatch of a company's demand and supply (Fisher, 1997). However, Sheffi and Rice (2005) asserted that the primary source of risk in the supply chain are demand variability, which can be traced to changes in interdependent demand, seasonality, short product life-cycles, intense competition on innovation pricing such as (petroleum products), demand volatility and uncertainty in the marketplace (Cousins et. al., 2008; Wong et. al., 2005; Toy Industry Association Inc., 2004; and Fisher, 1997). Beside these assertations, researchers have identified associated demand side risk, such as forecasting errors (Deleris and Erhun, 2007; Fisher, 1997), volatile demand (Canbolat et al., 2008; Chopra and Sodhi, 2004), communication breakdown (Faisal et al., 2006) and poor coordination (Vanany et al., 2009; Wagner and Bode, 2008). Responding to volatile market demand, there is a need for flexibility, innovation and speed of delivery and collaboration between the upstream and downstream supply chain members (Wong and Li., 2008; Fisher, 1997).

Supply side risk involves the failure of inbound suppliers to meet demand requirements of the upstream customers. Harland et al., (2003) define supply risk as any input that adversely affects the inward flow of any resources in order to enable operations to take place. The over-dependence on JIT suppliers has been more harmful than beneficial and has exposed businesses to risks which originates from the supply base. Reliance on a supplier without a buffer oriented mechanism (Eisenhardt, 1989), can result in stock out, quality problems, delivery failure and business reputations being affected (Sodhi and Lee, 2007). Research studies have identified and assessed issues in supply risk as poor quality (Huangs et al., 2009; Talluri et al., 2006), late delivery (Ravindran et al., 2010) and poor teamwork (Wagner and Bode, 2008).

Logistics Risk. The goal of logistics is to link the marketplace and its distribution channel members to procurement and manufacturing operations, in order to achieve and maintain competition. The potential threats that hinder the effectiveness of the supply chain activities are described as logistics risks, which are hindrance to the smooth flow of goods, information and funds. Chopra and Sodhi (2004) also identified labour disputes and infrastructural failures as variables that have the propensity to disrupt the flow of goods and services in transit, which consequentially impedes the delivery of goods and services to customers. Storage (Hauser, 2003), transport connectivity (Sanchez-Rodrigues, 2008) and delivery delays (Pujawan and Geraldin, 2009), are also trends militating against the effectiveness of supply chains.

2.5.3 Environmental Related Risk

This involves the potential threats of adverse consequences arising from human and business interactions with environmental effluences, such as emissions, waste, resource depletion and so on. This nature of risk can arise as a result of supply chain activities; "planning and marketing strategy, purchasing, production planning, materials handling, inventory management and transportation" (Wareham, 1991: p. 7) with the environment. It is evidenced that environmental factors such as political, economic and social have significantly impacted on supply chain management (Kumar et al., 2010; Stecke and Kumar, 2009). This shows how supply chain have been challenged and affected by environmental risk. The probability of environmental risk impacts one or more elements of the supply chain management mix, where supply chain efficiency becomes less resilience to the environment. The outbreak of "Ebola" is one of the environmental risks which have affected the efficient flow of materials in recent times. For example, in year 2014/15, people and materials were restricted from crossing the geographical boundaries of West African regions (Nigeria, Ghana, Liberia, Sierra-Leone, etc) within and to other parts of the world (Europe, North America etc). These restrictions due to the "Ebola" epidemic outbreak, distorted the flow by goods and services leading to a significant downward change to the interconnectedness in supply chain networks. Research studies have highlighted environmental risk to supply chain management resulting from natural disaster, (Revindran et al., 2010); political change (Matook et al., 2009); regulatory policies (Kumar et al., 2010; Oke and Gopalakrianan, 2009); macroeconomic risk (Manuj and Mentzer, 2008); social risk (Cucchiella and Gastaldi, 2006); terrorist acts (Chen, 2007; Quinn, 2006).

2.6 Impact of Risk in Global Supply Chain Management

The interdependence of supply chain activities and the occurrence of risk events have widened their implications for supply chain networks and across organisations. These widening consequences of supply chain disruption might have a negative influence on financial, corporate image or reputation which eventually results in loss of demand as well as damages to the security and health of the organisation (Juttner et al., 2003). For example, the impacts of the subprime lending crisis had devastating consequences on the US economy and the global market (Ray et al., 2008).

The management and coordination of risk practices are usually based on a company's risk management strategy, the severity and probability of risk occurrence (Knemeyer et al., 2009).

The probability of risk occurrence has been noted as the consequential impact of supply, breakdown in production machineries or equipment, transportation, inaccuracies in demand forecasting and suppliers failing to comply with procurement procedures and requirements (Chopra and Sodhi, 2004). These events impact supply chain performance, and the probability of their occurrence is predicted to impact the supply chain.

Businesses try to balance the impact of risks occurring and opportunities by increasing the level of buffer stock of products /people in order to manage risk (Wiengarten et al. 2015; Squire, 2010). Although, buffering at the time might involve huge costs on working capital which significantly affects shareholder returns on investment. Although the true costs of any supply chain disruption can be difficult to quantify precisely, at least one firm surveyed by Rice and Caniato (2003) estimated that the daily cost impact of a disruption to a supply chain network is estimated to be around $50–$100 million. Supply chain risk is the damage assessed by its probability of occurrence caused by an event within a company, within its supply chain or its environment negatively affecting the business processes of at least one company in the supply chain (Kersten et al., 2006).

Most of the widely used supply chain management approaches increases the risk in the event of natural phenomenon. For instance, Just-in-Time practices and lean supply chain management requires suppliers to frequently deliver to supplier plants or manufacturing warehouses in order to minimise non value added activities, and inventory holding costs. This helps to maximise the interdependency between firms and correspondingly the rise in the probability of supply chain disruption (Ye and Abe, 2012). For example, most of the companies that practices Just-in-Time (JIT) in Japan have the aim of lowering their operating costs and increasing efficiency in manufacturing.

Companies suffer from the severity of natural disasters and production activities are equally hurt in their overseas production network. Figure 2.4, shows how Toyota operates in 26 countries and regions, including 50 overseas manufacturing operations. Before the 2011 Tsunami it suspended the supply of work in progress (WIP) parts to these region and production capacity reduced. This resulted in a loss of $210 US Dollars representing a proportional reduction of 3.8 percent in Japan's Gross Domestic Product (EM-DAT, 2012).

Events in the global marketplace, such as political instability in Ukraine, have significantly impacted the financial performance of an entire global group of companies (operating across the world). Companies such as Erickson, Hershey, Apple, Wal-Mart, and a host of other major companies who rely on timely delivery of products and services to meet customer needs, have incurred major losses due to supply chain disruptions (Kern et al., 2010; Hendricks and Singhal 2005). For example, Erickson reported a $400 million loss because it did not receive computer chip deliveries from a Philips plant in a timely manner (Latour, 2001). Besides the consequences of global marketplace events, businesses are challenged with a continuous increase in regulations with which companies must comply, and for which stakeholders and managers are accountable for implementing. Some of these regulations which companies are obliged to comply with include, the Sarbanes-Oxley Act 2002, Health Insurance Portability and Accountability Act of 1996 (HIPAA), Basel II, General Acceptance for Accounting and Practices (GAAP), Corporate social responsibility (CSR), to name a few.

The adoption of information technology (e-business technology) in supply chain management, have led organisations to practice collaboration in their supply chain (Devaraj et al., 2007; Sanders, 2007; Ordanini and Rubera, 2008). This enables businesses to share significant amounts of information with their supply chain network. Information sharing is the medium through which supply chain members have access to information related to supply chain operations (Barratt and Oke, 2007). For example, the use of Web-Based Information Technology with upstream supply chain members has enabled real time collaboration and integration with their downstream supply chain partners. This approach has enhanced production planning, inventory management and efficient distribution system (Sanders, 2008). For example, Subramani (2004) investigated the indirect impact of IT adoption in inter-organisation networks and concluded that IT use in inter-firm relationships enhances closer cooperation relationships. The use of Web-based technology for inter-firm cooperation, reduces transaction costs in terms of coordination costs and transaction risk (Sanders, 2007; Cooper et al., 1997). These approaches drive improvements in category management, shelf-life of products, storekeeping units (SKU), rationalisation and new products development. The outcome of this supply chain practices improves revenue, return on investment (ROI) and profit margins.

Source: Toyota (2012).

Figure 2.5: Toyota Global Production Network

Table 2.3 a representation for figure 2.5 in Appendix 2, which presents the continental locations (1 - 50) of the global production network for Toyota automotive productions plants across the universe.

Other environmental events have impacted global supply chain networks significantly disrupting supply chains and producing major losses to many companies (Tang 2006). This is a disruption on supply chain and this exposes organisations to vulnerability with the attributes to factors of natural disasters for example, earthquake in Kobe, Japan in 1995, tsunami in Japan 2011; terrorist attack on the World Trade Center in 2001; Severe Acute Respiratory Syndrome (SARS in 2002–2003)

Recently, the spread of volcanic ash from Iceland caused Nissan and BMW to suspend some of their production in Japan and Germany respectively, because supplies of a critical sensor from Ireland had been disrupted (Hu et al., 2013, BBC News, 2010). Similarly, Samsung and LG in South Korea, were unable to airfreight more than 20% of their daily electronic exports. Furthermore, many Hong Kong hotels and restaurants faced shortages of French cheese and Dutch fresh-cut flower (Hu et al., 2013). The occurrence of such natural phenomena and the impact on supply chains disrupt operations significantly impacting customers, organisational reputation, profits and shareholder investment. For example, the bankruptcy of Chrysler supplier Plastech, driven by liquidity and cash flow problem, led to the temporary shutdown of four Chrysler plants in 2008 resulting in Chrysler losing millions of dollars (Trkman and McCormack, 2009). More recently, the failure to deliver chickens to the fast food chain - KFC from a strategic supplier DHL resulted in the closure of over 70% of outlets. The supply chain failure consequentially impacted KFC’s key performance indicators (Telegraph 2018).

This section has shown how poor risk management and control have resulted to significant downward trends on supply chain management and impacts on overall business performance. This indicates the importance and ongoing interest in supply chain risk management in the public and industrial domain. This further highlights the need for empirical investigation of risk management strategies for supply chain management in the oil industry. Therefore, the next section will show the appropriate risk management approaches that researchers have adopted in order to maximise the efficiency in the flow of materials throughout the supply chain in various industries.

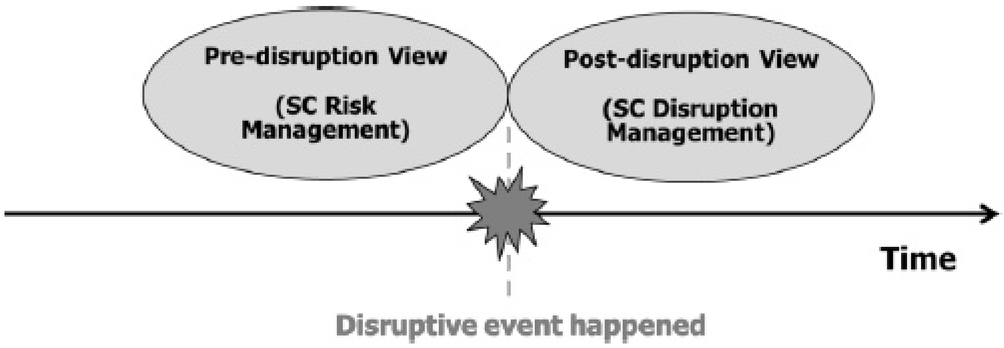
2.7 Risk Avoidance/Mitigation Practices in Global Organisations

Risk is an organisational strategy with profound implications for the success or failure of any business. The occurrence of disruption risk may severely influence the success or the reputation of an organisation. For example, the inappropriate promotion of formula milk by Nestle in underdeveloped countries as a good substitute to breast feeding, had led to a wide boycott of Nestle products. This boycott has lasted for 10years and has negatively impacted Nestle's profitability and competitiveness (Schwartz and Gibbs, 1999).

Risk taking is an integral part that constitutes the features of business (Smallman, 1996). The traditional perception of risk management views human risk taking as the source of accidents (Adams, 1995), in light of this view businesses and individuals trade-off risk and benefits on a daily basis and simultaneously perform a balancing of the elements of risk outcome (Adams, 1995). The definition of the concept of risk outcome is the expected outcome for investors while risk is the estimated variance which is unfavourable to investors. However, investors may adopt investment portfolios as a risk management strategy. Efficient portfolio management improves the tendencies for risk reduction without reducing the expected return (Rao and Goldsby, 2009). This model has been applied in various practices including supply chain management in order to explore and understand the management of vendor portfolio and all related risks (Kim et al, 2011; Gan et al., 2005). However, Gaonkar and Viswanadham (2004) claimed that portfolio selection models could be utilised for supplier selection, similar to the way it is applied in portfolio investment analysis for investment selections. Moreover, risk management falls within the category of financial management and is described in the financial literature as the identification and management of exposure to financial risk (Kaen, 2005). This definition indicates however, that financial risk is the variability in cash flows and market value which result in unpredictable change in commodity price, interest rate, etc., (J.P. Morgan et al., 1997).

2.7.1 Handling vulnerability in supply chain disruption

Disruption risk impacts organisational performance, which consequently impacts shareholder investment and prevents organisations from meeting their corporate objectives and responsibilities. To manage disruptive risk in their supply chains, organisations need to classify the various risks activities that need to be addressed prior to managing the identified disruptive risk. For example, Sheffi, (2001) classified disruption in supply, transportation, facilities, communications, demand and freight as a possible mode of failure in the supply chain. Hence, these risk response approaches can be classified as "Pre-Disruption" vs "Post-Disruption". However, (Makheria et al., 2012; Thun and Hoeing 2009) described these distinctive approaches as **'Preventive' 'Response'.** Figure 2.6, shows the perspectives for handling disruption risk in the supply chain.



Source: Thun and Hoeing (2009).

Figure 2.6: Two perspectives on handling disruptions in supply chains

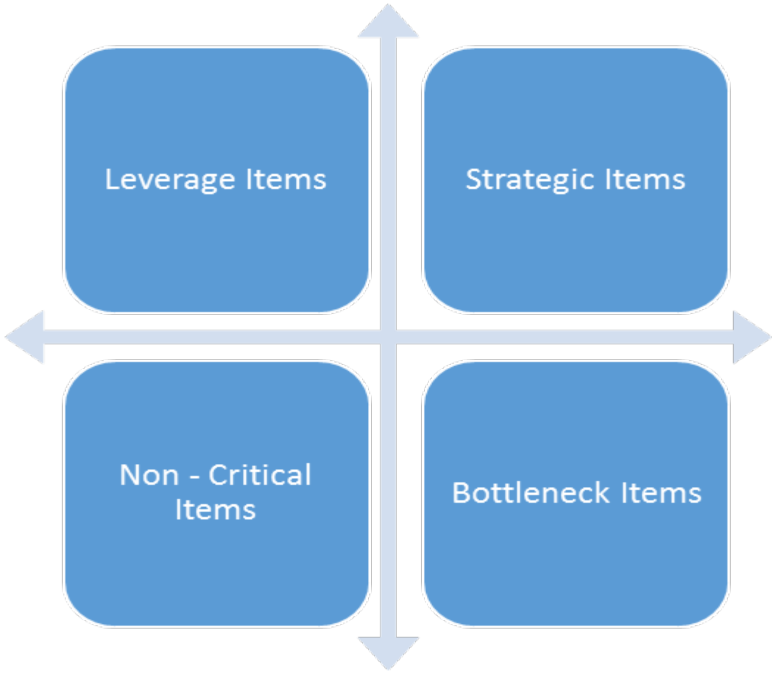
Moreover, the approaches for managing supply chain disruption risk are classed as 'Proactive' and 'Reactive' (Dani and Deep, 2010). Proactive risk management involves a preventative measure to handle vulnerability before disruptive risk occurs. This approach however, helps organisations to build resilience in their supply chain and take into account all identified risk impacts and commit resources for early-warning detection and response to minimise potential damages (Makheria, et al., 2012). To commit resources to tackling disruptive risk events would require companies to build redundancy or slack into the business in the form of inventory, creating excess capacity and prequalified backup suppliers in different geographical locations who can be relied upon for a bailout in the event of disruptive risk. Kaku and Kamrad (2011) advocated that building flexibility into supply chain systems can be accomplished by developing better working relationship with suppliers and improving supplier capability. However, flexibility building should not be within the same geographical zone prone to experience the same disruption risk at the same time, through the same natural disasters. Furthermore, using a proactive approach, such as risk response minimisation strategy, creates incentives for customers and employees of organisations that practice proactive approach. For example, General Motors in September, 2009, provided financial assistance to an America Axle and Manufacturing Holdings Inc., with a view to preventing them from going into administration (Kaku and Kamrad, 2011).

A reactive indicates the approach to react with agility to expedite actions as soon as disaster strikes in the supply chain. This approach is a supply chain risk analysis (Sinha et al., 2004), which is primarily concerned with pre-disruption activities - identification; assessment and mitigation of potential disruption (Oehmen et al., 2009). Other studies have (Wiengarten et al., 2015; Blome and Schoenherr, 2011; Manuj and Mentzer, 2008) identified supply chain risk management as an integrated process for identification, analysis and mitigation of disruption risk in supply chain. Risk identification involves practices of supplier evaluation programmes, and contingency planning whereas risk mitigation are practices that consider re-thinking and re-evaluating existing processes in the management of the upstream and downstream of supply chain strategy (Wiengarten et al., 2015). Blome and Schoenherr (2011) explored this strategy through the use of postponement, facilities location and supplier capabilities development. The post-disruption activities viewed supply chain disruption management as an approach which provides support for managing disruption as it materialises (Xiao and Yu, 2006). Companies manage risk by anticipating, understanding and controlling disruption risk (CIPS, 2012). These processes enable risk managers to communicate and interact with stakeholders and monitor, review and control in order to correct any observed consequences in their supply chain.

2.7.2 Systematic Methods

In addition, a systematic method can be further used to classify the potential nature to managing supply chain disruption risk. The systematic approach helps companies to categorise its supply chain activities. Kraljic (1983) categorises risk according to its propensity associated with sourcing of products or services in the supply chain. The individual item group is managed based on the individual proportional consequences as illustrated in figure 2.7. This associated risk is categorically grouped as; strategic; bottleneck; leverage and non-critical supply chain disruptive risk (Kraljic, 1983).

High



Low Supply Risk High

Source: Kraljic Matrix (1983)

Figure 2.7: Systematic - Handling Supply Chain Risk

This systematic categorisation helps organisations to identify the nature of the risks and the appropriate resources that can be used to handle such disruption risk in the supply chain. For example, companies can support their strategic item category decisions with a series of techniques, such as market analysis, risk analysis, simulation and optimisation modelling, forecasting, and microeconomic analysis. These techniques are aimed at controlling and preventing the adverse consequences of risk and reacting to such an event (Kaku and Kamrad, 2011; Oehmen, et al., 2009). For example, AKZO, a Dutch chemical giant asserted that classification allows for better product differentiation and more focused approach to supply market data analysis (Kraljic, 1983). This approach enables the frequent updating of a supply chain risk profile.

2.8 An Integrated Approach for Managing Disruptive Risk in Supply Chain

Some researchers have advocated for an integrated approach for managing disruption risk in the supply chain (Figure 2.8). Considering this assertion, Dani and Deep (2010) developed an integrated risk management approach, which embraces a broad spectrum of practices that encourages the sharing of operational information such as inventory status, collaboration for new product development or innovation (Van der Vaart et al., 2012). However, integration in supply chains allows alliances with supply chain members and this enables parties in the network to gain formidable access to new knowledge which helps companies to pool supply chain risk data that are crucial for building risk predictive models (Ray et al., 2008). Sharing this modelling enables supply chain members to benchmark and advance the development and use of more useful predictive models for supply chain risk management (Ray et al., 2008). Gaining speedy access to this type of advancement in new knowledge, requires network alliance efforts that differ from investment in research and development projects (Tsai, 2001). This approach requires supply chain members to provide learning support to achieve joint work or collaborate with learning institutions by identifying risk issues affecting supply chain management. Ray et al., (2008) exemplified how IBM accelerated its collaboration by supporting university graduate scholars to work on risk related topics that are relevant to their operations in the form of mini-symposia on risk analytics for invited professionals from industry, academia and public organisations. Furthermore, in his conceptualisation of an organisation as a network arrangement, Tsai (2001) argued and affirmed that both external knowledge and internal learning ability are paramount for new product development or innovation and performance.

Knowledge access in network alliances allow supply chain members to integrate and connect to partners in the supply chain network paths, in order to ensure efficient flow of materials between the upstream and downstream supply chain actors. This efficiency is as a result of integrative connectivity in the supply chain network. Exploring integration to manage supply chain disruption risk, ensures cost effectiveness, time compression and speedy dissemination of information in the supply chain network (Kajikawa et al., 2010). For example, Daimler Chrysler utilised a shorter path for delivering materials in their supply chain network and this improved Daimler Chrysler's production systems (Kim et al., 2011). While shorter paths within the connected nodes increases exchange relations between firms, this process is costly. For example, the power of information technology was used by Dell and Amazon to eliminate the traditional retail distribution model and deliver finished products direct to the final consumer. In a related study of a Japanese automaker, Dyer and Singh (1998) claimed that a closer link with vendors improves the impact on specific assets (investment), lowers transaction costs and enhances superior performance. Therefore, integration in supply chain leads to higher performance outcomes resulting from greater knowledge accessibility exchange, complementarily and lower transaction costs (Wiengarten et al., 2016).

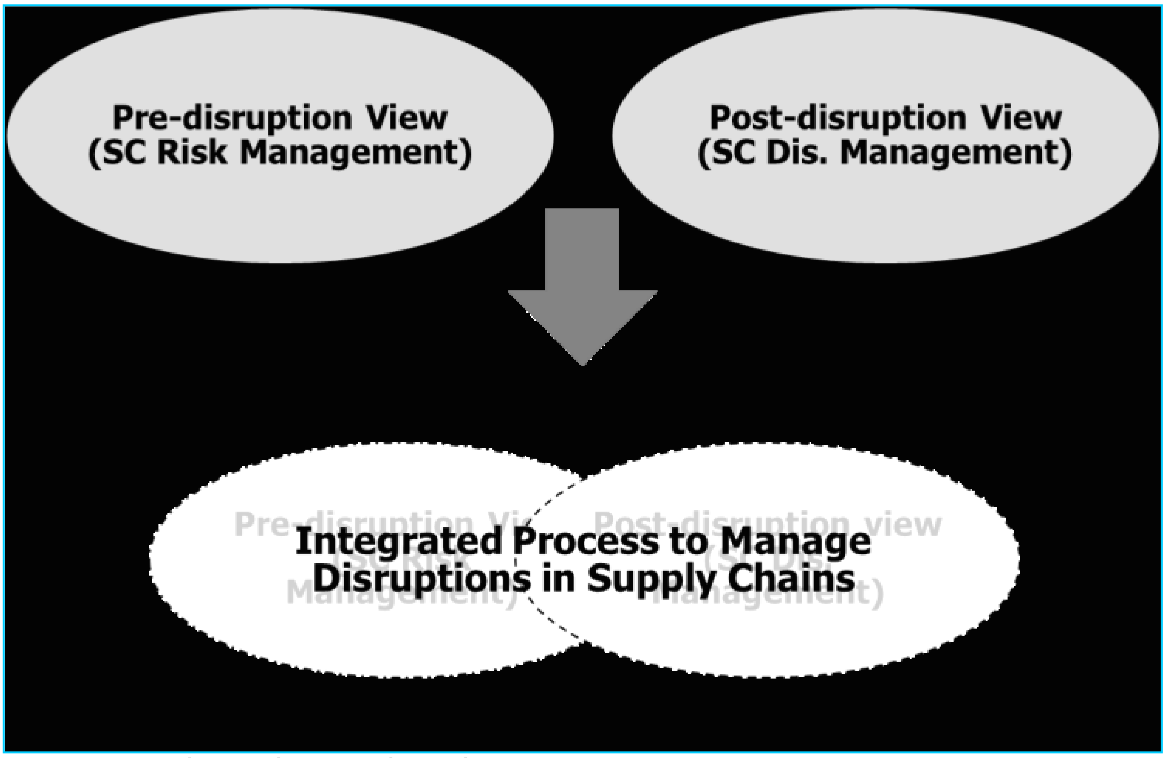
The performance benefits derived by exploring integration for managing supply chain risk management are associated with underpinning theoretical perspectives of a resource based view which claims that the source of competitive advantage is a function of how a company utilises its specific internal resources capabilities and competences to achieve their strategic objectives and goals. Barney (2001) asserted that a firm's strong reliance on its internal resources can be a source for competitive advantage as against positioning itself against the external environment. However, the relational view emphasises the network and dyads of a firm as an approach to creating relational rents i.e., superior firm performance within the supply chain network (Dyer and Singh, 1998; Wiengarten and Pagell, 2012). Some researchers (Wiengarten et al. 2016; Wiengarten and Pagell, 2012), have asserted these notional views as sources of attaining: (1) relation – a specific asset; (2) knowledge sharing routines; (3) complementary resource/capability and (4) effective governance. The significance of the above assumptions are described as:

- the espousal of specific competences and skills by supply chain members for the mutual benefits of all parties in the network (Callaway and Dobrzkowski, 2009). Therefore, the supply chain partners rely strongly on others for core as well as ancillary services.

- emphasis on organisational knowledge sharing, which comprises ideas drawn from a series of sources to mitigate supply chain risks and improve performance. For example, Zeneca pharmacy shared information on new products discoveries and licences. Stakeholders in the company were responsible for identifying the appropriate data and incorporating such data to manage the supply chain information.
- the assumptions that combined resources help organisations to adequately address the ever increasing challenges confronting their efficient access to information. For instance, Kmworld (2006), claimed that companies' complementary resources or capabilities and distribution channels allows for better performance.

These capabilities enhance organisations with predictive intelligence and real-time supply chain reconfiguration (Blackhurst et al., 2005). The acquisition of these dynamics capability, affords organisations the ability to gain superiority over their rivals if they combine both the internal and external firm specific resources and design something novel to address the business environment (Teece, 1997). Furthermore, Nelson and Winter (1982) view the firm as a mutually dependent entity of operations and administrative routines that gradually involves performance feedback. Companies respond to the dynamic nature of integration and reconfigure firm internal and external resources. This approach is difficult to imitate or copy by rival firms and this reconfiguration can be used to substitute with the existing strategy. This approach helps firms to generate superior performance and provides the relevant corresponding metric for managing the supply chain (Hendricks and Singhal, 2005). This enhances communication within the supply chain loops and enhances stronger foundation for designing plans for managing vulnerable disruption risk and helps to allocate risk management resources adequately.

An integrated management approach to mitigating supply chain disruptive risk creates the agility that improves expediting recovery from supply chain vulnerability. Integrated management exploration helps firms to maximise their profits long-term by increasing the level of supplier and customer interaction, which may be advantageous to organisations in relation to reducing production costs and improving stock turnover rate, which builds a sustainable competitive advantage over rival firms in the external market. The shared strengths achieved through integration adoption in managing supply chain risk, further enhances joint development of skills which help businesses to earn a return on shareholders' investment in proportion to the cost of capital invested (Porter, 1985). Achieving these benefits requires huge resources to be committed by investors in order to train and develop experts on skills needed to achieve risk response professionals. Figure 2.8, illustrates an integrated approach for managing disruptive risk in supply chain.



Source: Pyke and Tang, (2010)

Figure 2.8: Integrated Perspective for Managing Supply Chain Disruption

2.9 Risk Management Practices in Nigeria

Risk as an emerging contributor to the field of business decisions and control has significantly helped improve the practices of global supply chain management. An extensive search on the practice of risk management in the Nigeria context. This search revealed that risk management is still in the rudimentary stage and the capability to predict the trends of risk are still lacking. The context of risk in the supply chain involves the distribution of performance outcome that is expressed as the functions of losses, occurrence, gravity, detection of events and frequency of occurrence (Manuj and Mentzer, 2008). Risk practices can be understood as a state of uncertainty where a specific threat of occurrence exploits one or more vulnerabilities resulting in loss or other unbearable consequences (British Standard Organisation, 2010; Enyinda and Briggs, 2009). Risk management practice is an approach that helps global corporate organisations to develop performance measurement and metrics through qualitative and quantitative methods so as to guide the strategic and operational direction of a firm (British Standard Organisation, 2010).

Having established the relevance of risk management to the context of supply chain, various researchers have explored risk management practices in different areas of organisational practice in Nigeria. For example, Leopoulos et al. (2006) examined the possibilities of using a computer aided quantitative risk analysis tool in a project environment and suggested that this would benefit Small and Medium Enterprises (SMEs). The study concluded that the tool primarily focuses on the analysis of analytical tools and suggests that research efforts should be concentrated on the implementation of a risk management approach in SMEs.

Adeleye et al., (2004) investigated risk management practices in information systems outsourcing in commercial banks in Nigeria through an extensive literature review and survey. The study revealed that a significant proportion of commercial banks have no documented and structured outsourcing strategy or policy. Consequently, there was no procedural guidance that is available at any level of risk management process. However, these findings were contrary to risk management practices in developed countries. This study concluded that regulatory authorities in Nigeria are yet to formulate substantive procedural rules to adopt risk management in Nigeria (Adeleye, et al., 2004).

Obinani et al., (2014) identified in their review of literature, the development of a poultry farm risk assessment tool for avian influenza in Nigeria. This study maintained that poultry farms contributed to the spread of avian influenza by failing to adhere to bio-security measures that would have prevented the spread of the virus in Imo State in Nigeria. Ubogu et al. (2011) evaluated the rank-order and magnitude of operational constraints associated with cargo haulage from Nigerian seaports to the hinterland. The study revealed the rate at which bottlenecks are increasing within the road haulage system in Nigeria. The study suggested the need to regulate the activities of truck operators to concentrate on more attractive short haul operations where roads have short comparative advantage. Ubogu et al. (2011) concluded that the situation was due to government deploying a multiplicity of checkpoints for security reasons and so there is a need for government to substantially reduce these checkpoints.

Adedokun et al., (2013), evaluated the adoption of qualitative risk management analysis in construction companies in Nigeria. This study employed mixed methods to gather data. This study revealed a low level of qualitative risk analysis is inherent in construction project in Nigeria. This study further revealed that inadequate training and record-keeping in risk management (Abraham and Rafael, 2004), strongly contributed to the factors affecting the use of qualitative risk analysis techniques in construction projects in Nigeria.

Nkeki et al. (2013) assessed the impact of flooding in the Niger-Benue basin in Nigeria. The study employed a "moderate resolution imaging spectroradiometre" 'MODIS', (Running et al., 1994; Brakenridge et al., 2003; Zheng et al., 2008; Islam et al., 2009; Irimescus et al., 2010); data of NASA Terra Satellite and developed a geospatial methodology for detecting the flood risk areas and the population that was vulnerable to flooding within the basin in Nigeria. The analysis demonstrated the contribution of geo-spatial method in mitigating and monitoring the effects of flood disaster along the Niger-Benue basin in Nigeria. Hence this study suggests that government agencies and policy makers should employ 'MODIS' to synthesise information, which is a vital component of flood risk assessment and planning (Jayesselan 2004; Ishaya et al., 2009; Irimescu et al., 2010).

The essence of risk management review in section 2.6, is to ascertain the practice of disruption risk assessments in supply chain management in Nigeria. The research objectives for addressing this purpose is to carry out a literature review in the context of current supply chain risk management practice in Nigeria’s Oil Industry. It is evidenced from the literature on risk management and the methodology for demonstrating risk practices in Nigeria, which have been inconsistently addressed by researchers. Comparing the global risk management practices with current risk management practice in Nigeria, it is evident that none of the empirical risk management processes have been consistently adopted. Risk management involves an integrated process for identification, analysis and mitigation of risk disruptive constructs in the supply chain (Wiengarten et al., 2015; Blome and Schoenherr, 2011; Enyinda, 2008; Manuj and Mentzer, 2008). These divergent views of risk by practitioners and academics in Nigeria, have reduced the propensity to formerly establish the framework for identifying, prioritising and mitigating risk in Nigeria. This has affected the availability of empirical literature on supply chain risk management and risk conceptualisation in Nigeria (Ho, 2002). This assertion leaves a large gap for supply chain literatures and methodology to be filled.

The academic and practitioner literature review on risk management in section 2.6, has identified a gap in the existing literature that needs to be addressed through RQ1 and RQ2. These research objectives will produce details on risk management strategy for the supply chain in the Nigerian Oil Industry. Moreover, the dearth of literature on risk affects the appropriateness and methods for addressing a given category of risk in supply chain management in Nigeria.

Turning to the rationale for this research study in section 1.1, the development of systematic methodology that will help to identify and prioritise risk categories is significant for this study. Based on this identification and prioritisation, the critical supply chain risk among these categories will be evaluated on the petroleum supply chain management in the Nigeria's oil industry. As none of these researchers have used the proposed systematic research process (Figure 5.1) previously, this study aims to fill the identified research gaps through the implementation of the systematic approach to analyse and evaluate disruption risk in supply chain in the upstream petroleum industry. This novel method will build a formalise and facilitate systematic integration and implementation of various models such as analytical hierarchy process (AHP), partial least squares structural equation modelling (PLS-SEM) and statistical tests. The methodology will be validated with the case study of Nigeria's oil industry.

2.10 Supply Chain Risk Management: Decision-Making Models and Techniques

The adoption of models and methods has been explicitly explored to manage risk and uncertainty in supply chain management. Model application has generally contributed to the advancement of organisational supply chain risk management. Modelling risks involves the use of a mathematical approach and tools to broadly address risk-related issues within the domain of an enterprise. Modelling risks enables researchers to narrow the conceptual definition issues of a specific field (Ray, et al., 2008; Poirier and Walker, 2005). For example, mathematical models are frequently used in the engineering field to identify the distinctive nature of reliability and safety of complex systems, such as nuclear reactors or the strengths of materials properties (Stamatis, 2003). Other examples from the medical profession (Crawford-Brown, 2001), explored mathematical models for human health risk evaluation, such as exposure assessment, pharmacokinetic modelling and dose-response modelling. Furthermore, Gleason (2000) exemplified the adoption of mathematical models to identify and manage risks in their business due to fluctuation in the financial markets. These examples of the application of modelling have shown that models can help businesses to focus on holistic processes which identify and quantify organisational risk. The use of models enables businesses to manage their supply chain risks and uncertainties. A supply chain risk management process helps companies to identify, assess and manage vulnerability in their supply chain.

2.10.1 Risk Identification

Risk identification enables companies to identify potential supply chain risk through qualitative and quantitative techniques. Table 2.2 identifies sources of supply chain risk which have been identified though qualitative and quantitative assessment approaches. Various risk identification techniques have been employed for this risk categorisation. Tsai et al., (2008) used analytical hierarchical process (AHP) to identify potential supply chain risk in the retail chain. However, critical risks affecting strengths of oil pipelines in Nigeria were identified through Failure Mode Effective Analysis (FMEA) (Shafiee, and Dinmohammadi, 2014; Enyinche and Nwosu, 2011).

2.10.2 Risk Assessment

The assessment of risk is the probability of occurrence and severity of consequence in the supply chain performance. Several risk assessment techniques are used to model supply chain risk. Risk assessment involves the uses of mathematical programming methods to determine production activities such as heuristic algorithms for scheduling production and distribution operations in an assembly supply chain network. This approach aims to determine the minimum costs of production and scheduling delivery from a given distribution centre to customers. Brun et al. (2006) developed supply chain networks to evaluate advanced production scheduling and supply chain implementations. Deterministic modelling techniques can be applied to the sourcing of raw materials, facility locations, inventory level settings, replenishment of lead times, specifying the economic order quantities (EOQ) and allocating resources with the aim of minimising risk and uncertainty. The focus of production, distribution and inventory planning systems is to integrate the segments of the supply chain that comprise storage/locations and customer demand planning (Hekmatpanah et al., 2011). This improves the process of decision-making and offers insights into supply chain connectivity. Bogataj and Bogataj, (2007) developed a parametric linear programming model to evaluate supply chain cost, based on net present value (NPV) of projects. This improves the management of supply chain processes and strengthens supply chain network connectivity. Wu et al. (2006) adopted disruption analysis network techniques to assess the change to a supply chain and evaluated the impact of this on supply chain networks. However, assessing the sources of supply chain risk provides a comprehensive approach to incorporate the composition of risk as it relates to demand, production capacity and constraints. Voudouris (1996) developed a mathematical model to design efficient supply chain responsiveness to demand and production constraints. This helped to maximise flexibility and efficiently allocate resources in terms of inventory and workforce in the supply chain.

Assessing the relationship with supply chain players, strongly relates to buyer-supplier relationships (Department of Transport, 2003). Evaluation of the supply chain risk and strategies can impact business performance. For example, the adoption of a relationship positioning matrix (Cousins, 2002; Kraljic, 1983), was explored to identify circumstances under which types of individual collaborative relationships are needed. The circumstance for developing relations spans from a "high to low" capability and are captured within Kraljic's (1983) the matrix, where the high risk capability is categorised as strategic critical and strategic security, and the low risk capability as tactical acquisitions and tactical profits (See figure 2.7).

Research has suggested the various modelling approaches for these categories of relationship matrix and their respective strategies. Craighead et al. (2007) advocated the practice of supply base reduction (Baldwin et al., 2001), global sourcing (Johnson et al., 2006), outsourcing (Browne and Allen, 2001), supply chain quality management and regulatory compliance imposed by government. Wang et al. (2011) applied unconstrained and constrained mathematical modelling to evaluate the prevailing relationship between various supply chain strategies and regulated imposed trade barriers. The study concluded that profit increases in contexts of non-regulated trade barriers and significantly lower prices.

2.10.3 Mitigating Supply Chain Risk

Mitigating the consequences of supply chain risk entails the estimation of the probability of risk outcome within a given forecast threshold of risk occurrence in the supply chain. Mitigating the estimation of supply chain risk involves the process of complying with a given probability distribution. Researchers have estimated ranges of risk outcomes with analytical modelling processes that assumes risk probabilistic distribution. For example, Lee, et al. (1993) adopted a stochastic, periodic review, order-up to inventory model to develop a procedure for process localisation in the supply chain. Stochastic modelling is applied in the supply chain for replicating inventory and producing scheduling problems where a represented demand outcome are randomised in the supply chain (IBM, 2008).

Towill and Del Vecchio, (1994) categorically identified supply chain variables and estimated supply chain responses and randomised demand patterns. These aggregated were compared through a simulating process with the aims of indicating the minimum required buffer stock that can help firms to achieve customer satisfaction. Fisher et al. (1997) developed a stochastic programme to minimise underproduction and overproduction costs, which was identified from the imbalance between supply and uncertainty demand in the supply chain. Similarly, Lee et al. (1997) examined the bullwhip effect resulting from variances in the distorted customer demand, which consequently created an imbalance between supply and demand in the supply chain. Lee et al., (1997) built a dynamic programming model to minimise the expected cost of production, inventory carrying costs and lead time penalty based on production capacity constraints. Besides, businesses have explored cooperative game scenarios for decisions-making processes in their supply chain to them resolve multiple supply chain conflicts. Sheu (2011) employed 'asymmetrical bargaining' game theoretical model to resolve issues between producers and reverse logistics vendors to arrange government subsidies on financial intervention to enhance the environmental supply chain among players.

Furthermore, a mathematical simulation can be used to evaluate the effects of dynamic supply chain strategy. However, others (Towill et al.,1992; Towill 1991) evaluated the effects of various supply chain strategies on demand amplification. Towill et al. (1992) explored simulation techniques to investigate the effects of five different supply chain strategies; "eliminating the distribution echelon in supply chain; information flow integration throughout supply chain; Just-in-Time (JIT) policy implementation to improve responsiveness in supply chain and creating efficiency to intermediary products with suppliers through adjustment to inventory order quantity processes” (Williams, 1981). Consequently, they identified that a Just-in-Time (JIT) strategy and eliminating supply chain echelon are the most appropriate supply chain strategies for smoothing demand variances in the supply chain. Wikner et al.’s (1991) preliminary research investigated how the adjustment of existing decisions rules; compression of supply chain lead time; direct delivery from manufacturer to consumers; improvement to every stage of existing decisions procedures in the supply chain and integrating the flow of information to categorise demand, can improve supply chain strategy. Further, Wikner et al. (1991) emphasised that integrating the flow of information to categorise orders are an effective improvement strategy for a supply chain. A number of studies (Thomas and David, 2008; Sohn and Lim, 2008; Jammernegg and Reiner, 2007; Labeau et al., 2000) have validated a series of vulnerability mitigating approaches and trade-offs in a simulated seasonal environment, level of information sharing, customer satisfaction level and net profits.

2.11 Petroleum Supply Chain Risk Management

The main purpose for this research is to manage supply chain risk in the petroleum industry. This theme involves the process of exploring quantitative risk analysis techniques for coordinating and controlling risk. Modelling and statistical tools that help firms to analyse risk and assess the various risk which influence the supply chain performance perspective of the global oil and gas industry. Skogdalen et al., (2011) explored quantitative risk analysis (QRAs) to evaluate the frequency of blowout occurrences in a variety of drilling operations. A drilling operation is iterative in nature and requires frequent monitoring and amendments to existing procedures in the exploration and production of crude oil. The amendment process is a corrective strategy for adjusting human, industrial, technical, and environmental risk factors influencing the management of supply chain risk and related operational practices.

Quantitative risk analysis (QRAs) has proved to be an effective risk management technique for managing risk in the petroleum and related industries (Royal Society, 1983). Among the particular attributes of quantitative risk analysis, is to help in the decision-making for business policies and implementations on business metrics - such as profits and losses, returns on investments, environmental and geopolitical impacts of uncertainty. Quantitative risk analysis simplifies the planning process through optimisation of algorithms to develop petroleum exploration and production portfolio management. The portfolio management approach guides risk managers in the management of exploration and production programmes (Suslick et al., 2009).

However, well-structured portfolio decisions on investment mix and strategic match with resources, can help firms to allocate assets and equate risk against objectives. These linkages help petroleum exploration and production projects to meet the set objectives for risk management of investments and a relevant portfolio of events (Suslick et al., 2009; Walls, 2004). These attributes facilitate improvements to business planning norms and firm performance (Walls, 2004).

The assessment of an upstream petroleum investment portfolio with a real option approach as it relates to exploration and production of hydrocarbon, involves series of decision-making processes. The individual stage involves project scheduling, relative success and failure occurrence. For example, some studies (Paddock et al., 1988; Siegel et al., 1987) have evaluated offshore oil investment leases. This idea widened the application of real option to several economic investment and research practices. Real option builds on net present value (NPV) and reduces the existing uncertainty that emerges from the delay or postponement of an investment portfolio; change or flexibility instituted on an already made decisions. In other words, real option is the alternative to exploiting the future prospects which can be derived from a project. Real option is a risk mitigation strategy that is used to exploit the upside outcome and disregards the downside of the investment. Indeed, the real option model has been applied with the intent to show how options can effectively help to mitigate associated risk with demand uncertainty and improve overall supply chain efficiency (Cucchiella and Gastaldi, 2006). Others have similarly, explored real option to analyse and identify uncertainty in the implementation of supply chain risk strategies (Harland et al., 2003).

Galli et al. (1999) adopted real options, decision tree and Monte-Carlo simulation in petroleum exploration and production projects. Monte-Carlo simulation is based on randomising the probability distribution of predicted outcome, and the decision tree method emphasises the use of diagrams to analyse risk and identify the alternative decisions process for mitigating such risks. Combining these methods improves the ability to predict risk decision outcomes, where a Monte-Carlo simulation predicts the chances of risk occurrence in the upstream petroleum exploration and production projects (Davis, et al., 2008). The identified failure risk mode is mitigated based on the risk occurrences in the upstream crude oil productions. For example, the statistical probability style was used to forecast production (Spencer and Morgan, 1998), but the application of the statistical probability style for decisions explicitly exhibits uncertainty affecting crude oil export decisions (Macmillan, 2000).

Furthermore, game theory emphasises modelling and handling of supply conflicts arising as a results of incongruence in the supply chain agent or partner events. The use of game theory helps businesses to choose appropriate alternative solutions among events, this enhances coordinating processes among supply chain partners (Cachon and Serguei, 2004). Zhao et al., (2012) explored the mechanism for displaying lifecycle carbon emission to aid the choice of clients. This provides the signals to prospective manufacturers to respond to environmental signals. This serves as a monitoring mechanism which enables manufacturers to comply with the environmental standard of the management of supply chain events, which embeds coordination and control in supply chain decision-making processes. For example, Barari et al. (2012) explored a dynamic evolutionary game theory to examine the coordination links with the manufacturers and retailers by exploiting profits while implementing environmental supply chain practices. This process helped the coordination of supply chain risk management by identifying intervening incongruence, assessing the risk severity and mitigating the strategy for handling the disruptions (Carbone and Tippet, 2009).

2.12 Critiques for Modelling Supply Chain Risk Management

These analytical taxonomies for a supply chain risk analytical modelling approach is considered the most versatile for general application for supply chain risk management. This suggests that modelling can be used in so many different areas of life, from economic puzzles, social issues to industrial and military matters. However, the generalisation of modelling applicability may result in disarray for supply chain management decisions. This is because of the complexity to maintaining and abiding to the formulating modelling rules. This limitation deters the system to design variables for itself (Ohbyung et al., 2007). To overcome this inadequacy other deterministic models are usually embedded into frameworks that stimulate uncertain phenomenon and their interacting procedure (Mele et al., 2007). Embedding other deterministic elements to resolve simulation problems make this approach more expensive to identify, assess and mitigate risk management in supply chain. For example, some studies (Ohbyung et al., 2007; Mele et al., 2007; Chatzidimitriou et al., 2008) have adopted this approach to examine a range of strategic and operational practices, such as collaboration under demand and supply uncertainties, role of information sharing, inventory levels, robust and optimal designs. These approaches were identified as complex and resource consuming.

However, a further disadvantage to supply chain risk management modelling include the fact that usually all of the compelling variables, which have to be considered for solving supply chain problems, cannot be quantified in a linear pattern. For example, linear programming or simulating assumptions processes in modelling supply chain trends or risks might be unrealistic because factors never really change in a linear relationship modelling phenomenon. Among one of the objectives of this study is to determine the risk management strategies that can provide resilience to the supply chain management in the Nigerian oil industry (RQ4). In investigating this assertion, this study intends to explore the various approaches that can help to create positive change to the supply chain management in the Nigerian Oil Industry (see Appendix 1). To fill the research gap identified in section 1.3, this study specifically emphasises methodological techniques to address the research questions. The inherited problems and complexities identified as factors militating against the development supply chain disruption risks modelling, have motivated this study to explore the benefits of systematic approach as more relevant for addressing the research objectives for this study. The development of the systematics methodology for assessing disruption risks in supply chain will significantly contribute to the advancement of future research in supply chain management.

2.13 Conclusion

This study is an attempt to explore the context of supply chain risk management in organisations. The literature review examined issues related to supply chain, competitive advantage, risk and uncertainty in supply chain and its impacts. Further, the research addresses the global context as it relates to supply chain risk management practices in Nigeria. The subsequent chapter examines the perspectives of petroleum exploration in Nigeria within the context of global petroleum resources and its disruption risk.

CHAPTER THREE

A Global Perspective of the Oil Industry in Nigeria

3.0 Introduction

The emphasis of this section is on global petroleum resources and its disruption risk. The characteristics of petroleum resources/reserves and dimensions of resource disruption risk on production capacity were briefly highlighted, along with the current improvement and mitigation strategies for addressing disruption risk in Nigeria's oil industry. In view of the global perspectives of the petroleum industry, this study focuses on the upstream activities of the Nigerian oil industry. The implications of this section to supply chain risk management are discussed.

3.1 Petroleum Resources and Reserves

Resources are defined as all petroleum quantities naturally occurring in a reservoir, discovered and undiscovered, both recoverable and unrecoverable (Society of Petroleum Engineers, 2008). The task of estimating resource reserves is highly demanding and derived outputs can have deep consequences on the world's markets. Therefore, estimating reserves always encompasses some degree of uncertainty (Zaydullin, 2008).

3.2 Classification of Petroleum Exploration Resources and Reserves

The classification of oil resources are summarised in Figure 3.1. Resources are the quantities of petroleum estimated to be initial-in-place, that is, the sum of petroleum initial-in-place (petroleum initial-in-place) + uncoverable portions (defined as reserve contingency and prospective reserves), (www.spe.org; Accessed 12th Oct 2015).

Reserves are the expected quantities of oil and gas that are commercially recoverable from an identified reservoir at a specific mentioned date (World Bank Group, 2009). Due to the uncertainty of ascertaining the equivalent quantity of oil and gas in a reserve, a probabilistic approach needs to be used to determine the available quantities of oil and gas in the reserve. However, probability estimation at times may be prone to uncertain outcomes and reliability. Hence, global oil resources are classified viz-a-viz; reserves, contingent and prospective resources. The categorisation of reserve resources are described as follows:

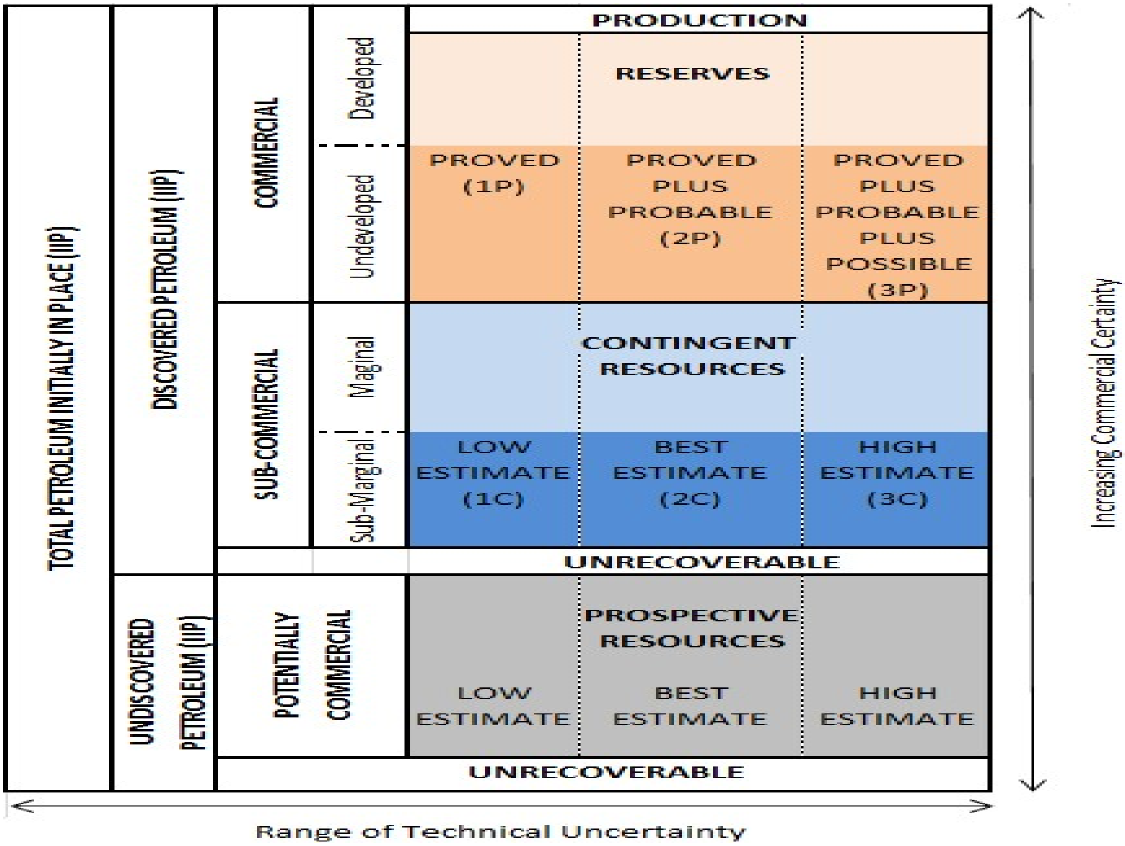


Figure 3.1: Petroleum Resources Classification

Source: Mumby (2013) and www.spe.org

Reserves

Proved reserves are recoverable with a high degree of certainty under prevailing economic circumstances, operating methods and governance policies. This implies that probabilistic estimation guarantees a recovery of 90% and this can be equal to or over the initial estimation of a proved recovery. Proved recovery are described as P90 reserves, IP reserves or proven reserves. However, a future pronounced volume of uncertainties such as reserves are classified as probable (P50 or 2P) or possible (P10 or 3P) reserves (Mumby, 2013). Proved (1P) and proved plus (2P) reserves are most commonly referred to in the oil and gas industry which is compelled by regulation to report the quantity of petroleum in the reserves. The compelling reason for oil and gas industry to give a report for the 1P and 2P reserves is to enable the regulatory authorities to evaluate the costs involved in exploration of the deposit and compare this to the benefits which the oil and gas industry will derive from the investment in proved (1P) and proved plus (2P) reserves. For example, in Canada under the NI-51-101 regulations, reporting 1P and 2P is mandatory. However, no regulation is required to compile reports for 3P reserves.

Contingent Resources

This involves oil and gas resources that are not fully formed for production processes. The contingent resources are yet to be considered for commercialisation due to some environmental, technological and investment uncertainty militating against the achievement of the present value. For the production process to commence on the contingent resources, all impeding obstacles need to be removed and the viability of returns on investment ascertained. The removal of risk factors which affect the contingent resources qualify them as proven reserves.

Prospective Resources

Estimated volumes of oil and gas resources associated with undiscovered deposits are termed prospective resources. These estimated deposits are expected to be recoverable at a specific given time based on preliminary evidence to establish that the prospective oil and gas resources yet to be drilled are hindered by environmental, economic and/or policy issues affecting the exploration of production of the resources (Finley, nd). In order for contingent resources to be classified as prospective resources, significant evidence of hydrocarbon volume or quantity must be present in the prospective resources deposits. Equally, the deposits must be evaluated and the probabilistic estimated proof must be known.

Some of the prospective oil and gas resources are grouped as 'Uncoverable' or the volume of oil and gas that are not producible for any foreseeable reasons (Munby, 2013). Therefore, the proportions of this unrecoverable resource in the future are based on changes to the prevailing environmental, technological and/or governing policies. The oil and gas industry should frequently review their respective reserves programmes to ensure that existing constraints in the reservoirs are eliminated.

3.3 Supply Chain of Petroleum Industry

The value chain plays a significant role in the transformation process of the petroleum resource. The value chain for oil and gas resources includes the exploration process, which involves measuring the physical properties of the reservoir rock through observation on the surface structure and composition, in order to conclude about any likelihood for the availability of hydrocarbon in the reservoir. This process of exploration and production (E&P) is the first stage for transforming the petroleum resource. The exploration and production are the upstream activities that involve the oilfield services that consist of seismic surveys, well drilling, engineering equipment and supply (World Bank Group, 2009).

The midstream of the oil and gas value chain are the links between the production and the processing facilities and the final product delivery to the consumers. Furthermore, the downstream is where the oil refining and gas processing of hydrocarbons are extracted into the final stage, where products are distributed to the wholesalers or retailers who are responsible for delivery of oil and gas products to the final consumers Blackstone and Cox, 2005; Fredendall, 2001: p.3). The oil and gas supply chain is related to the supply chain of other sectors with some variation in their structural configuration. Indeed, the oil and gas supply chain comprises upstream, midstream and downstream activities (Schweitzer et al., 2011; Gainsborough, 2006). See illustrated figure 1.1 of section 1.1.

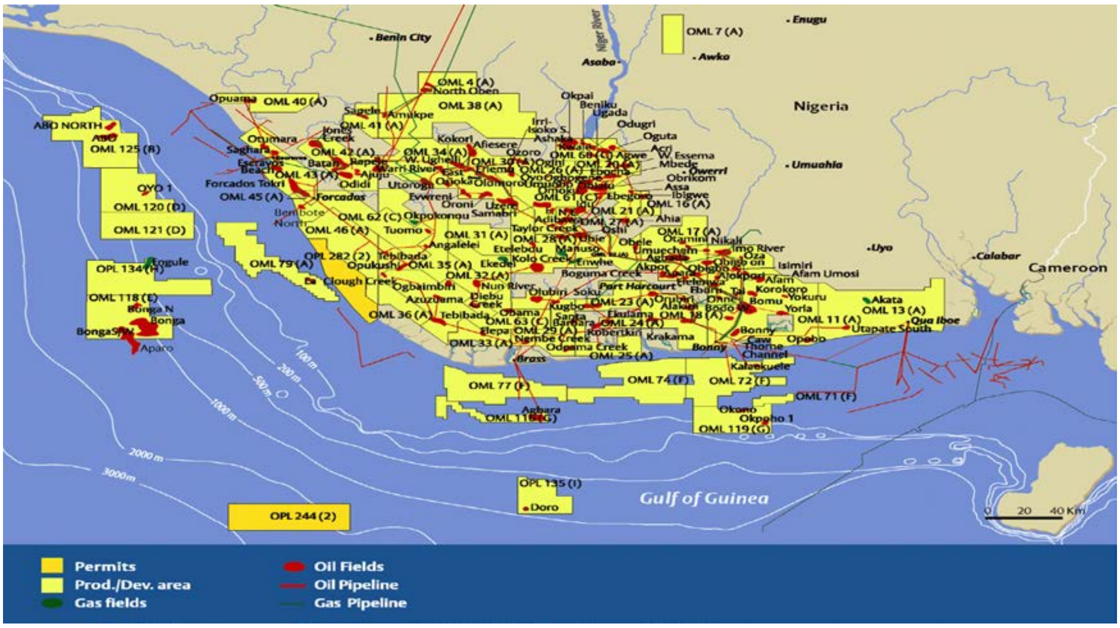
Regardless of these taxonomies, some in the oil and gas industry pursue one or more stages in the value chain activities (Mansur, 2010). This implies that integrated oil and gas businesses are multidimensional. For example, Exxon Mobil, pursue both upstream, downstream activities, and vertical integration of multiple oil and gas successive operations, which involves the exploration and production (E&P) and refining and marketing (R&M). However, organisations like Chevron and Schlumberger are involved in the upstream oil and gas activities, hence this approach is described as horizontal integration in the oil and gas industry. For example, Chevron, spans across many stages of the oil and gas exploration to service outlets, but does not span across the entire value chain (Energy Scoop, 2013). Fifty (50%) percent of crude oil is sourced from other oil and gas producers, and thirty-five (35%) percent are sold through other retailers. However, some oil and gas products symbolise the feedstock to some petrochemical industry, and this linkage explains the antecedent and proximity between the petrochemical industry in the upstream and downstream of the value chain. Figure 1.1 illustrates the linkage of internal processes with service delivery in the value chain (Fredendall, 2001: p.3). This shows that the petroleum supply chain commences from the exploration and production of crude oil, which is subsequently delivered downstream through the coordination of logistics processes. It also shows the interface within the petroleum companies and their materials flows in the supply chain. Indeed, various suppliers are involved in the movement of materials across the supply chain.

In view of the particular attributes of the upstream and downstream activities in the petroleum industry. The theme of this study will focus on the upstream supply chain disruption risk in the petroleum industry in Nigeria. Disruption risk issues relating to supply chain in the upstream petroleum industry in Nigeria, will be examined. All other issues that are related to both the midstream and downstream supply chain risk management in Nigeria oil industry are beyond the scope of this study and can be a subject for future research.

3.4 Nigeria Economy and Petroleum Resource Disruptions.

3.4.1 Nigeria Economy

Nigeria is one of the most populous countries in Africa, and one of the most abundantly blessed with human and natural resources in the African continent. Oil and gas activities dominate Nigeria's economy and the multinational oil stakeholders in the production and exploitation of crude oil in Nigeria, comprise of Agip, Chevron, Texaco, Exxon-Mobil, Shell Petroleum Development Company, Total, ELF and NNPC. These multinational oil companies operate over six hundred (600) oilfields and five thousand, two hundred and eighty four (5,284) onshore and offshore wells (See Figure 3.2).

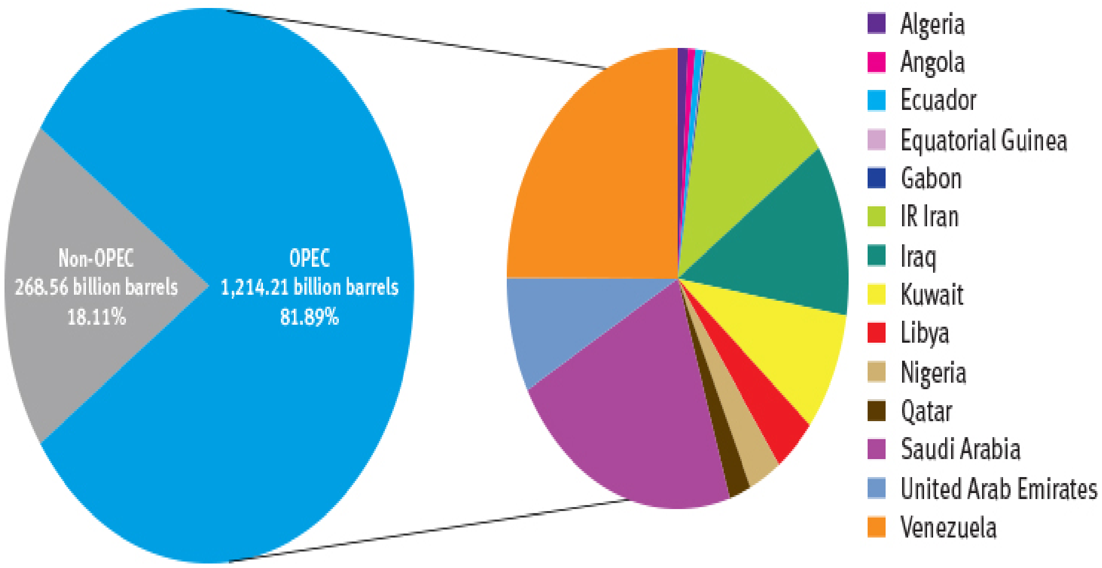


Source: Crudeoildaily (2013)

Figure 3.2: Map of Nigeria's Oilfields and Reserves

The participation of the multinational oil companies, have substantially helped to boost the Nigerian oil reserves estimated at 37.45 billion barrels (OPEC, 2018) and representing 3.1% of the world's oil production (See Figure 3.3).

OPEC share of world crude oil reserves, 2017



OPEC proven crude oil reserves , at end 2017 *(billion barrels, OPEC share)*

Venezuela	302,81	24,9%	Kuwait	101,50	8,4%	Qatar	25,24	2,1%	Gabon	2,00	0,2%
Saudi Arabia	266,26	21,9%	UAE	97,80	8,1%	Algeria	12,20	1,0%	Equat. Guinea	1,10	0,1%
IR Iran	155,60	12,8%	Libya	48,36	4,0%	Angola	8,38	0,7%			
Iraq	147,22	12,1%	Nigeria	37,45	3,1%	Ecuador	8,27	0,7%			

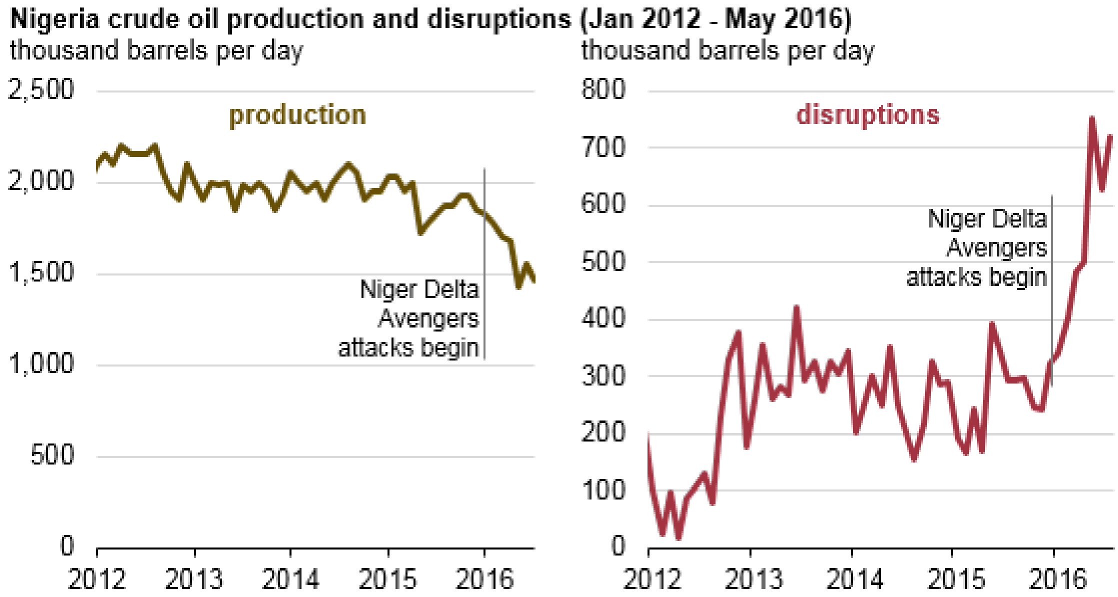
Source: OPEC Annual Statistical Bulletin 2018.

Figure 3.3: Crude Oil Reserves

Oil exports account for 95% of receipts, which represent 15% of GDP and over 80% of Nigeria's annual revenue are obtained from the oil industry (NNPC, 2013). For example, the production of oil resources over the years represented 90% of the national revenue. The petroleum resources have sustained the Nigerian economy. Oil resources and reserve are the amounts of crude oil resources believed to be physically available in the source rock. The oil resource expected may not be available in commercial quantities because of some technical and geological formations failure.

The unprecedented increase in oil revenue led to a variety of economy phenomena, which resulted in the problems of coordination of inflation, price levels, growth rates, national income, gross domestic product, change in unemployment and decline in manufacturing production.

This Nigerian overdependence on petroleum resources as a major source of revenue, reduced the country's intensification of agricultural production. The dependence on petroleum resources makes Nigeria's economy more vulnerable to socio-economic problems such as, oil price and crude oil production volatility, operational problems, environmental damage, policy compliance and geopolitical inadequancies. For example, Salami (2015) observed that a significant change in the oil price in 2013, negatively affected Nigeria's current account balance which reduced by 69.3 percent (from $3.14trillion in 2013 to $964 billion in 2014). Similarly, the first quarter of 2012 to mid-2016, crude oil production shut-in reached 750,000 barrels per day, which represented the sharpest drop in production since January 2009. This figure is traceable to the current account deficits of $723.8 billion a reduction of 212% from a surplus of $641billion as at the first quarter of 2014. (See Figure 3.4). Furthermore, failure in achieving the projected oil revenue in Nigeria, have led the Central Bank of Nigeria (CBN) to devalue the Nigerian currency (Naira) twice in 2015. The devaluation of Nigeria's currency has led to a proportional downward trend in the foreign reserves and stagnation of the Nigerian economy.



Source: U.S. Energy Information Administration, (2016).

Figure 3.4: Crude Oil Exploration and Production Disruptions in Nigeria

3.4.2 Petroleum Resource Disruption Risk in Nigeria

The estimated oil reserve in Nigeria has remained stagnant and slow and surrounded by uncertainty (Zaydullin, 2013). The amount of reserve tracks has become unaccounted for and updating investors on predictions of future market gains has become volatile. The pace of oil exploration and production has resulted from long production lead times; uncertainty in the oil reserve; geo-technological constraints and huge investment in oil infrastructures. For example, Nigeria planned to increase the oil reserve to 40 billion (Nwilo and Badejo, 2005). The various approaches to increase oil exploration and production have been unsucessful due to impeding effects of risks and uncertainties caused by political instability, corruption, damage to oil facilities, macroeconomic mismanagement, environmental issues, lack of visibility in oil demand; poor allocation of oil revenue; environmental damage caused by oil spills; as well as religious and cultural tensions. Consequently, oil production has suffered from supply disruption and low value chain performance, which resulted in unplanned outage as high as 500, 000 barrels per day (bbl/d) (OPEC, 2015).

This has proportionately led to the reduction in Nigeria's foreign reserves. The over dependence on oil has impacted the value chain of the oil industry. This reliance on oil leads to global market events in the energy market arena and the Nigerian domestic market supply having a significant impact on the Nigerian microeconomic risk assessment over a period of time (KPMG, 2013). This implies that economic factors influence the demand volatility of oil investment over a given period.

3.5 Oil Production Capacity in Nigeria

The volume of crude oil production which can be generated by the petroleum industry in Nigeria, using the available resources have reached the peak of 2.44 million bbl/d in 2005 (EIA, 2015). Thus oil production in Nigeria is declining significantly, as a result geopolitical conflicts and the insurgent violence from militant groups (See figure 3.4). This is forcing many in the oil industry to declare force majeure, withdrawing staff and drilling equipment from the oil rigs and closing down their operations. These fragilities in the oil production capacity adversely affect the production of oil in Nigeria and are due to inequitable distribution of oil revenue, environmental degradation from oil spills, and geopolitical crises.

As pointed out earlier in the literature review, Nigeria's net oil export had upward trends between 1986 and 2009. The disruption to oil exploration in 1999, 2005 and 2008 significantly reduced oil production to half of 1.8million barrels of oil per day (bbl/d). This proportional reduction in the production capacity grossly affected the net annual crude oil exports in Nigeria. Martin de Wit and Crookes (2013) observed that with the proportional reduction of oil production in Nigeria, exports of refined oil also declined, invariably Nigeria also became an importer of refined oil. For example, the overall refinery utilisation rate dropped to 22%, which led to the import of petroleum products into Nigeria. Hence, the nameplate capacity exceeded the domestic oil demand (OPEC, 2014). The shortfall in production capacity was due to operational failures, fires, theft, sabotage, poor maintenance, militant attacks on oil infrastructures and enviromental damage. These challenging parameters have led to lowered oil production outputs in Nigeria. This invariably accounts for the variability in demand for domestic consumption, where approximately, 85 percent of Nigeria's oil needs were imported (Oil and Gas Journal 2015; and Martin de Wit and Crookes, 2013).

The considerably decline of Nigeria's export revenue also resulted from the shut-in of oil production. For example, Shell incurred outsized shut-in oil production (477,000 bbl/d). Similarly, Chevron and Agip experienced a huge shut-in of (70,000 bbl/d and 40,000 bbl/d) respectively. This dropped the US import of Nigerian oil by more than 90% in volume in 2010. This significant drop ranked Nigeria as the 10th exporter in 2014 (US Energy Information Administration, 2015). For example, Alison-Madueke, (2011) claimed that the onshore oil reserves are declining at the rate of 10-25% per annum due to the aging oil fields and sluggish investment in oil projects. This suggests the gradual decline in Nigerian oil production capacity from 3.23 million bpd to 2.5million bpd at 25% from 2005 to 2009, (See Figure 3.5).

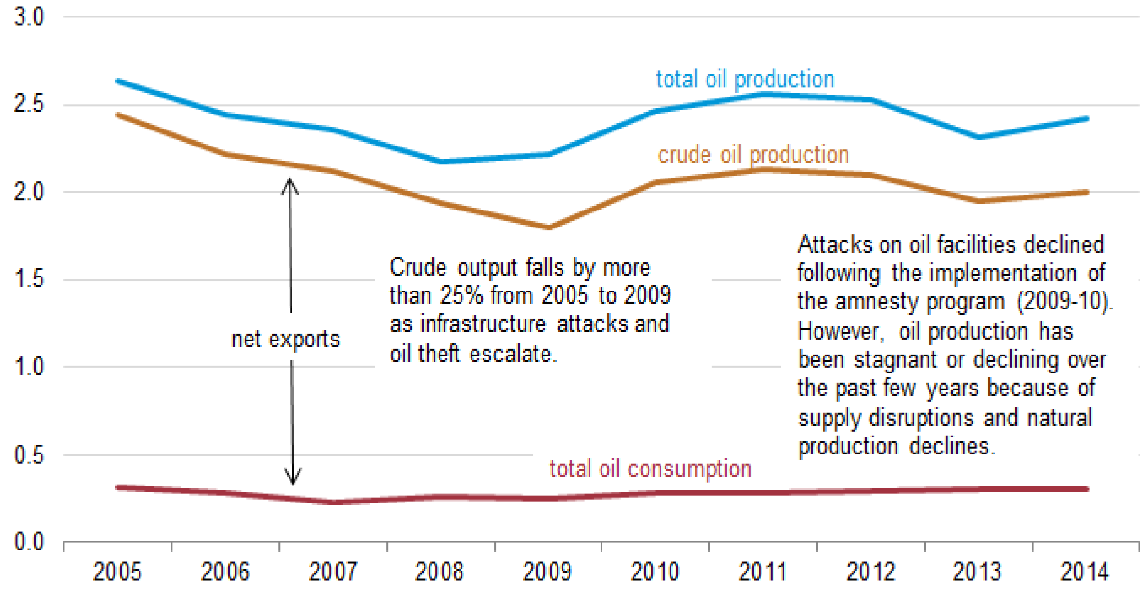


Figure 3.5: Nigeria Oil Productions

Source: US Energy Information Administration (2015).

Therefore, there is evidence that disruptive risk has significantly impacted petroleum production capacity in Nigeria. This review has confirmed that every stage of the petroleum value chain have been impacted by disruption risk (See Figure 1.1). However, the taxonomy for explaining the consequential risk events remain implict. Tang (2006a), categorised the dimension of risk as 'operational risk' and 'disruption risk'. Operational risk is an inherent uncertainty, such as uncertain customer demand, uncertain supply and uncertain cost; and disruption risk are consequential damages resulting from natural occurances, such as earthquakes, flood, hurricanes, terrorist attacks or macroeconomic shut-in (currency devaluation or strikes). The consquential impact of these are documented in section 4.11 of this study. This study intends to identify the appropriate disruption risk affecting the petroleum supply chain. The categorisation of supply chain disruption risk taxonomy is exhibited in Table 2.2, Figure 4.2, and explained in Section 4.6. To prevent supply chain disruption risk identified for this research, there is a need to explore a systematic method for validating the criticality of the identified disruption risk and mitigate the adverse consequences of supply chain disruption risk in Nigeria's oil industry.

3.6 Current Approch for Production Capacity Improvement in Nigeria Oil Industry

The crucial challenges confronting the global market competitiveness of the Nigerian oil industry are, the declining trends in the oil production peak of Nigerian onshore oilfields, diminishing levels of new oil fields despite the huge costs invested into geological surveys and exploration of new oilfields, coupled with environmental and geopolitical risks, have influenced the shift of exploration activities to the deep and ultra deep offshore area. The deep water operations is an offshore oil production plan aimed to promote brighter and promising prospects for ensuring positive oil production reserves. However, offshore oil production is technically challenged and capital intensive. In light of these impediments, offshore exploration and production have helped the petroleum industry reduce the onshore risk associated with geopolitical and environmental risks in Nigeria. For example, the unsuccessful discovery of more onshore oilfields coupled with the insurgency of Boko Haram in the Chad Basin have grounded oil exploration and development. However, exploration in the onshore region of the Niger Delta Zone of Nigeria are also decreasing due to the insecure situation of oil infrastructural facilities (i.e oil pipes etc), theft and valdalism, old age of the oil fields, poor maintenance of equipments, skilled employees unwilling to work due to insecurity of the oilfields, which has consequently led to the sharp drop in the oil reserves in Nigeria (Lewis, 2004).

In order to increase production of crude oil output in Nigeria, many oil producing companies are extending their exploration and production (E&P) activities into the deepwater shores of Nigeria. For example, due to the attack on oil industry operating platforms, Shell's company began production of oil at the deep water Bonga field in order to boost production capacity of crude oil (EIA, 2007). The deepwater oilfield of Bonga is estimated to contain recoverable oil reserves of 600million barrels.

The production plans of the offshore initiatives are aimed to balance demand and supply for the petroleum products in Nigeria. Moreover, all customer requirements are translated into schedules for oil product delivery to customers and any emerging future and immediate problems can be identified for urgent response.

Furthermore, the production of oil from these offshore oilfields are stored in the floating production process, storage and offloading (FPSO) unit. The reasons behind the adoption of FPSO, is due to its viability in providing a development solution to the offshore oilfields and flexibility in the operating process. For example, FPSO can be disconnected and removed from a vulnerable oilfield region to a less risky oilfield region. Therefore, FPSO units are the most advantageous choice for the development of oilfields, especially when there are no existing pipelines or infrastructure to transfer crude oil production to shore. In addition, oil spills are not rampant in FPSO units. The only major spillage experienced in an FPSO unit was caused by human error in the late 1990s, where a Texaco Captain in FPSO mistakenly spilled approximately 3,900 barrels of oil. Otherwise, approximately 500 barrels have been spilled in FPSO units. Shell Nigeria store their produced oil from Bonga oilfield in the floating production process, storage and offloading (FPSO) unit, with the capacity of two million barrels.

The diversification of oilfield locations in Nigeria will help to encourage investment into the deepwater oil and gas productions. As a result of production capacity reductions, access to oil resources deposits are diminishing and the high costs of oil exploration and production are affecting performance and profit. These reasons have led those in the Nigerian oil industry, such as Shell and Mobil Exxon etc., to commit their resources to expansion into deep water oilfield production in order to enhance crude oil production and maximise their supply chain potential. Such diversification ventures will involve intensive capital and operation costs. For example, ExxonMobil, invested $11billion in the Nigerian oil sectors in 2011, with the aim of increasing oil production capacity to 1.2million bbl/d (EIA, 2007). Exxon Mobil, however developed its Erha project, which was located offshore of the Western Delta of Nigeria. The production capacity in Erha reached the level of 200,000 bbl/d. Oil from this Erha field is stored in (FPSO) with the capacity of 2.2 million barrels of oil. However, 'Very Large Crude Carrier' (VLCC) have the capacity of holding upto 300,000 deadweight tons used to export the oil from the terminal. In addition, Exxon Mobil operates the Yoho field with an output of 150,000 bbl/d. The Yoho oilfield contains approximately 400 million barrels of oil reserves. Moreover, the Yoho field will be re-injected with liquidified natural gas (LNG) to maintain the field pressure (EIA, 2007). Other companies that are involved in the deep water oil production in Nigeria are Chevron, Total, Agip and ConocoPhillips, Eni., etc. These companies have invested in the petroleum exploration of the offshore oilfields.

Moreover, the oil and gas industry in Nigeria have rolled out production development plans to boost oil production capacity (see Table 3.1). The production development plans will encourage and enhance a joint venture partnership between various Nigerian oil operators and the Federal Government of Nigeria. For example, Mobil Exploration Nigeria Incorporation (MENI), a subsidiary of Mobil Exxon in Nigeria, have set-up a joint venture partnership with Nigeria National Petroleum Corporation (NNPC) who jointly operate over 90 offshore oilfields, comprising about 300 oil wells with a capacity of 550,000 barrels per day of crude oil, condensed and natural gas liquid (NGL). The current production capacity development plans of MENI and NNPC aim to establish stronger joint venture partnerships that will increase oil production to over 1million barrels per day (Folta and O’Brien, 2004).

The cross-boundary collaborative initiative between the NNPC and the Nigerian oil industry will improve forecasting and demand management for the supply of petroleum products in Nigeria. Moreover, oil industry resources will be adequately planned and this will enhance the efficiency of business processes, which will balance the oil demand and supply (Forrester, 1958). Table 3.1, provides the proposed daily production planning figures (1255 bbl per day) for the oil and gas industry in Nigeria. The collective figure for oil and gas are reduced by 50bbl of natural gas per day. Therefore, the production estimation for crude oil production capacity is 1205 bbl/d, which if achieved will boost the production efficiency of the Nigeria oil industry.

Table 3.1: Planned Production Capacity for Nigeria Oil Industry

Project Name	Operator	Type	Plateau Liquids production (000 bbl/d)	Final Investment Decision?	Est. start
Dibi Long-Term Project	Chevron	onshore oil	70	Yes	2016
Sonam Field Development	Chevron	natural gas project	30	Yes	2016
Gbaran-Ubie Phase Two Project	Shell	natural gas project	20	yes	2017
Erha North Phase 2	ExxonMobil	deepwater oil	60	yes	2018+
Egina	Total	deepwater oil	200	yes	2019+
Bonga Southwest and Aparo	Shell	deepwater oil	225	no	2020+
Bonga North	Shell	deepwater oil	100	no	2020+
Zabazaba-Etan	Eni	deepwater oil	120	no	2020+
Bosi	ExxonMobil	deepwater oil	140	no	2020+
Satellite Field Development Phase 2	ExxonMobil	deepwater oil	80	no	2020+
Uge	ExxonMobil	deepwater oil	110	no	2020+
Nsiko	Chevron	deepwater oil	100	no	2020+
Total			**1,255**		

Source: EIA (2015).

**Note: A total of 1,255 (000 bbl/d) production plans are in place but only 380 (000 bbl/d) have obtained investors' decisions, while 875 (000 bbl/d) are still awaiting investors' decisions.*

Further steps to boost oil production capacity through expansion to the offshore deepwater oilfields is the government's attempt to implement the policy of the 'Petroleum Industry Bill' (PIB). The PIB is a governing mechanism that represent a key reform for ensuring certainty on the production of oil and gas in the deepwater oilfields. However, PIB have been confronted with a delay in passing this bill into a working instrument that aims to boost investment into the deepwater oilfield exploration. The delays in passing PIB have capped investment in the oil and gas industry. However, this has stagnated oil production in a flat-terrain over the short term, from November 2013 which remains so, as of the date of this study's commencement in September 2015 (See Figure 3.5).

The oil industry literature has suggested that the Nigerian oil industry has no appropriate risk management framework for handling the impacts of disruption risk on the petroleum supply chain in Nigeria. This research has identified and adopted various strategies in order to stimulate better performance and facilitate the growth of oil production capacity through various initiatives ranging from supply chain management, collaborative partnerships, diversification investment, storage capacity improvement, production development plans and policy implementation for the oil and gas industry in Nigeria. For a clearer understanding of the theoritical constructs explored in this study, a brief contextual definition of supply chain risk management strategy was presented in section 4.5. The effectiveness of these risk management strategies and techniques, from the abstract theoretical constructs, have never been operationalised or precisely measured for the petroleum supply chain in Nigeria. In particular, the assessment of investment in production capacity development plans aimed to improve petroleum production. For example, an overall production plan of 1,255 (000 bbl/d) was set for realisation, but only 380 (000 bbl/d) obtained investors' decisions, while 875 (000 bbl/d) are awaiting investors' decisions. This is as a result of inappropriate risk management processes for identifying the most effective technique that can be used to manage the available resources to minimise oil production output in Nigeria. This study aims is to develop a systematic method for assessing disruption risk in supply chain and examine how the implementation of supply chain risk management can build supply chain resilience in the Nigerian Oil Industry.

3.7 Conclusion

This chapter has discussed the significance of oil industry to the Nigerian economy. The main disruption risk posing challenges to the petroleum resources and production capacity have been presented. The consequences of disruption risks and their improvement strategies were examined and the relevance of the improvement strategies for stimulating supply chain risk management performance and resilience were highlighted. The next chapter develops the research theoritical framework and model to be adopted for defining and elucidating the categorised supply chain risk management strategies for this study.

CHAPTER FOUR

Conceptual Modelling

4.0 Introduction

In order to understand the strategic significance of risk management in supply chain as a process for creating a robust supply chain and attaining competitive advantage (Dani and Deep, 2008), various researchers have explored a series of paradigm to elucidate supply chain risk issues (Kalawsky et al., 2013; Peck, 2006b; Juttner, 2005; Norrman and Jansson, 2004; Johnson, 2001; Lindroth and Norrman, 2001; Zsidisin et al., 2000). The contribution of these researchers have significantly helped to recognise, understand and manipulate the conceptual understanding of global supply chain risk management events. For example, Zsidisin et al. (2000) claim that the development of risk management strategies involves communication, gathering and analysis of relevant information associated with the phenomenon of risk. This process for understanding the conceptualisation of risk management helps acquire human knowledge for intervention and evaluation of propositions or assumptions about the cause of a phenomenon.

4.1 Overview of Supply Chain Management Theory

Supply chain management was introduced as an extension of 'Logistics', which Lamming (1996) considered as existing relationships in the theory of supply chain management. This assertion implies that supply chain management involves participation in the relationship between the supply chain players. Beside, Lambert et al. (1998, p.504) provided a ground breaking definition of supply chain management as, "the integration of business processes from end users through original suppliers, that provide the products, services and information that add value for customers." Tan el al. (2002) identified customer orientation and the synchronised upstream, downstream and internal performance as central to the process of relationship.

Theories are important in order to understand the complexities within business operating environments (Chicksand et al., 2012). In this case, theory can contribute to better understanding the management of the flow of materials and information in an organisation. Manuj and Mentzer, (2008), asserted that "a good research is grounded in theory"; therefore, theory is grounded in empirical observations. Theory is the relationship between independent and dependent variables (Colquitt and Zapata-Phelan, 2007) and thus a theory can consist of variables, constructs, concepts or a collection of assertions that help researchers to explain a phenomenon under investigation (Reynolds, 1971; Bacharach, 1989). Defee et al. (2010) describe theory as a systematised structure and capability for explaining an assumed phenomenon.

Theory is important to advance scientific understanding and create the structural capabilities for supply chain phenomenon (Hunt and Davies, 2008). Frankel et al. (2005) claimed that the use of theory in supply chain management (SCM) encourages the advancement of empirical research in SCM. Scholars, such as Gresov and Drazin (1997) and Oliver (1991), in their dependency theoretical analysis, argued that theory is an opportunity for a company or entity to minimise the occurrence of disruptive risk affecting their business performance. The theory that forms the foundation for supply chain management in this study summarised in Table 4.1.

Table 4.1: Applied Theories in Supply Chain

Theory	Contributions to Supply Chain Management	Authors
Transaction Cost Economics	Central to this theory is balancing costs generated through identified assets and uncertainty, governance / coordination supply chain members.	Defee et al., 2010; Williamson, 2007;1998;1971; Maltz and Ellram 2000.
Resource Based View	This theory asserts that tangible and intangible resources owned and controlled by a firm can position the supply chain and generate superior performance.	Pillai and Min, 2010; Barney, 2001; Gresov and Drazin; 1997; Oliver, 1991.
Dynamics Capability View	Supply chain responsiveness to the dynamic nature of integration and reconfiguring a firm's internal and external resources in order to contribute to competitive advantage.	Foerstl, et al., 2010; Ritchie and Brindley, 2007; Teece, et al., 1997.
Knowledge Based View	Knowledge is a source of competitive advantage. The interchange of knowledge improves supply chain value.	Pillai and Min, 2010; Grant, 1996.
Contingency Theory	Business should develop its supply chain strategy based on the prevailing circumstances	Ainuddin, 2007
Network Theory (NT)	Inter-organisational relationships increase resources and core competencies of supply chain partners. NT aims to develop long-term relationships with supply chain actors.	Squire, 2010; Pillai, 2006; Harland, 1996.
Decision Theory	This is rational process of choice of alternatives. Choice between the alternatives help in the efficiency of organisational supply chain management.	Bruzelious and Skarvad, 2008.
Agency Theory	Delegation of authority leads to conflicts with parties, encourages internalisation. Positive relations are encouraged in the supply chain. It could lead to the abuse of power.	Eisenhardt, 1989.

Source: Researcher, 2017. Modified through literature review.

Table 4.1 summarises the various supply chain management theories that have been used to provide a deeper understanding of the supply chain. In view of the different supply chain theories, this study focuses on agency theory as a perspective for understanding the significance of supply chain risk management. For example, Jean et al. (2002) posits that agency theory aims to advance the goal of organisational supply chain and has proven to be more useful than other theories for explaining the phenomenon of supply chain risk management. Agency theory is imbued with many strategies that can be applied to address supply chain risk management.

Among the large itemised theories in Table 4.1; this study explored agency theory as a priority for explaining the relationships of supply chain players. The supply chain players relate to the business relations that exists between a “principal” and an “agent”. The principal and agent respectively engaged in cooperative behaviour in the upstream and downstream supply chain. An agency theory will structure the incongruences between the principal and agent, who respectively have differing goals and attitudes towards risk in the supply chain.

Indeed, the decision for agency theory choice in this study, is based on the view that agency theory provides the guideline for designing an effective package for achieving efficient relation for the principal and agent in the supply chain. Therefore, agency theory encourages positive relationship between the supply chain players. However, others identified theories in Table 4.1; were thought as not possessing the priority for aligning the goals of the principal and agent in the supply chain of Nigerian oil industry.

4.2 Agency Theory

Agency theory is concerned with the governance and control mechanism structure of firms to mitigate against the chances of opportunism, conflicting interests and information irregularities between the principal (delegating authority) and the agent. Contracts are used as governance and control mechanisms, while behavioural-based, buffer-oriented and incentives approaches are provided for meeting the minimum expected standards for the principal organisation. However, constraints emerge in agency theory through delegation of work to another party (Eisenhardt, 1989; Lassar and Kerr, 1996). Eisenhardt (1989), identified information systems, outcome uncertainty, risk aversion, goal conflict, programmability, and outcome measurement and relationship lengths as factors that influences the delegation of work. Agency theory involves coordination efforts (Celly and Frazier, 1996) and control mechanisms (Anderson and Oliver, 1987), approaches that are concerned with problem resolution in agency relationships.

Agency theory assume that human beings are self-interested individuals, bounded, rational, and risk averse (Bhattacherjee, 2012). Agency theory recommends the combination of buffer or outcome-based contracts and behaviour-based incentives. Williamson (1975) asserted that the attributes of opportunism are in accordance with behavioural uncertainty. Behavioural uncertainty is a self-serving action by business owners or employees, who explicitly or implicitly breach their jointly agreed obligations for self-interest, so as to avert risk (Miller, 1991).

An effective and transparent information flow in the supply chain is an effective means to reduce behavioural uncertainty (opportunism). Forecasting and production errors can be addressed through sharing of information between the upstream and downstream supply chain partners. Inappropriate information exchange may weaken the supply chain and this proportionately results in poor coordination in the supply chain activities. The impact of poor coordination in the supply chain manifests itself in non-transparent demand, which can lead to demand amplification and bull-whips effects (Lee et al., 1997). Risk management in businesses or supply chains require a collaborative approach to exert control in reducing any changes in the governing of existing business strategy. This helps to develop a long-term strategic relationship with the upstream and downstream supply chain partners. The risk management strategies explored in this study are classified as behavioural-based or buffer-based orientations. These dimensions of risk management strategies reduce the occurrence of detrimental events in businesses (Zsindisin and Ellram, 2003). Tang (2006) illustrated how a company can use slack resources to absorb shock to their supply chain. This perspective can emerge in form of companies embarking on flexible sourcing of production materials to minimise inventory stockpiling and reduce firm exposure to risk associated with a single source of supply (Bode et al., 2011).

4.3 Theoretical Links in Supply Chain Risk Management

Supply chain risk management is categorised based on the outcome and behavioural relationship (Elkins, et al., 2005; Christopher and Peck, 2004; Mullai, 2004; Choi and Liker, 1995; Eisenhardt, 1989). Arguably, the outcome-based approach shows the extent or degree to which a business is driven by its results (Zsindsin and Ellram, 2003). Reliance on the outcome-based approach shows an absolute concern with bottom-line results regardless of the achievement of the supplier or supply chain partners (Choi and Liker, 1995). As a result of the insignificance of uncertainty, an agency theory perspective supports the outcome-based supply chain risk management approach (Eisenhardt, 1989). The reliance on this perspective strengthens the management of supply chain risk and the supply chain becomes more effective and coordinated.

Furthermore, desired outcome reduces the impact of disruption risk to supply chain management without obstructing supplier operations in the adoption of buffer-based techniques. In agency theory, buffer-based methods are explored to mitigate the likelihood and the impact of negative effects of disruptive severity (Bode et al., 2011; Zsindisin, et al., 2005). For example, holding inventories often serves as a buffer. Chattopadhyay et al., (2001) observed that a buffering approach safeguards and minimises the business inventory safekeeping units from exposure. Moreover, product design with a long shelf-life is an example of buffer-oriented strategy. Using a multiple source of supply, serves as a buffer strategy (Tullou and Utecht, 1992). The adoption of buffers, enables organisations to have short-term relief to supply chain disruption, and focus on outcomes by eliminating the effects of supply chain uncertainty. Arguably, lean inventory is a prime driver for supply chain risk. (Juttner, 2005). For a disruption in the supply chain to be prevented there is a need for organisations to build slack in the form of buffer stocks and excess capacity to accommodate any eventuality in the supply chain (Squire, 2010; Wilding, 2007; Chopra and Sodhi, 2004). This generic supply chain differentiation and focus will increase the focal organisation's responsiveness to supply chain disruption.

An understanding of buffer depreciation should be considered when deciding stock keeping units (SKU) in the buffering processes. Forecasting methods are frequently used to eliminate uncertainty in future demand. A Pareto or ABC analysis can also be used to build slack for parts that could disrupt the supply chain (Cousins et al., 2008). For example, Toyota and Sears keep inventories of strategic stock at regional locations that can be shared among dealers and outlets in the event of a disruption (Tang, 2006). However, operational slack makes firms more vulnerable as a result of its focus on cost, where the impact on operational decisions-making is as a result of its cost driving strategy. For example, a change in the organisational min-max ordering policy may influence customer ordering patterns and leads to additional cost to the organisation's operations. This may impact the continuity of such an entity or the focal firm. Similarly, a change in the production schedule, which is to improve capacity utilisation may lead to fluctuation in the manufacturing of finished product availability and affect customer service levels (Wallace and Stahl, 2003). Organisational attempts to improve efficiency by reducing buffer inventory, which is aimed at guarding against disruption in the event of supply chain risk. This suggests that buffer stock strategy will reduce protection against emerging disruption from supply chain risk.

4.4 Critiques for Agency Theory

Despite the enormous benefits of a buffer-oriented strategy, the cost of adoption may be prohibitive to organisations in the long-run and stocked inventory may be superseded by changes in technology or fashion, which may impact the consumption of stocked inventory. This consequently result in obsolescence and may prevent businesses from realising quantity discount and economies of scales.

The applications of agency theory is relevant when supply uncertainty becomes a significant factor. Therefore, businesses embrace management efforts that minimise the impact of disruptive events on a firm. At this point, risk management strategies are classified as behavioural-based relationship or buffer-oriented approaches, which prevent organisations from being impacted by detrimental events. Behavioural-based efforts emphasise on process rather than outcome (Anderson and Oliver, 1987). Management focus on tasks and activities to reduce risk in the supply chain (Eisenhardt, 1989; Logan, 2000). For example, frequent contact with suppliers eliminates disruption to the supply chain (Christopher, 2005). The use of a flexible pricing strategy helps organisations to better align supply with customer demand (Christopher and Tomlin 2008). However, organisational efforts in the management of suppliers involves a large amount of capital and human resources, and a frequent follow-up with supplier progress to ensure process improvement. This consequently reduces disruption to the supply chain.

Although, previous literature has comprehensively mirrored supply chain risk management constructs (Squire, 2010; Wilding, 2007; Chopra and Sodhi, 2004), this study examines uncertainty reduction through the assumptions of behavioural relationships (Elkins, et al., 2005; Eisenhardt, 1989). This approach will explain the concepts of supply chain risk as a central issue to unforeseen supply chain events and determine the outcome and behavioural relationships (Elkins, et al., 2005; Christopher and Peck, 2004; Eisenhardt, 1989). The norms for explaining the "behavioural relationship and buffer-oriented" mechanism is to adjust the company incentives hierarchy, in order to align with the interests of the upstream and downstream supply chain objectives (Mile and Snow, 1998). These initiatives may involve a change of company control systems and the ways in which the processes of supply chain performance evaluations are being conducted.

4.5 Contextual Definition of Supply Chain Risk Management Strategy

The improvement strategy in the Nigerian oil industry, has been effective as a production improvement strategy and can be used to analyse and review the supply chain risk management strategy context and develop the baseline for supply chain resilience. This research context is used here to develop the exogenous variable for the research model in Figure 6.5. Table 4.2, provided the brief meaning below:

Table 4.2: Contextual Definition of Supply Chain Risk Management Strategy

Supply Chain Risk Management Strategy	**Descriptions**
Supplier capacity/ production development	Working with suppliers to develop processes with upstream team members to improve their processes and production capabilities.
Legislative compliance/regulations	This involves compliance in conformity with set standards/ thresholds, which an organisation should observe such as, a specification, policy, standard or law. Regulatory compliance enables businesses to attain its fundamental objectives.
Contract strategy/ Collaboration	The process to ensuring a formalised contractual agreement with supply chain members over a given period of time.
Operational Flexibility	This involves the level of flexibility, which emphasises production planning and control, sourcing, workforce sizes and skills, plant and equipment. This builds the capability for adopting demand based on production scheduling.
Postponement/Delay of project	This process involves holding back or delaying a project from implementation, in order to avoid the immediate risk events.
Divestment	*Divestment*/divestiture is the process by which businesses sells parts or some unprofitable process or assets with the aim of boosting productivities.
Licensing/subcontracting arrangements	Prequalifying suppliers to obtain some standard such as ISO 5750, ISO 9001 / 14,000
Geographical diversification	The practice for diversifying an investment portfolio across different geographic regions with the aim of minimising the overall risk and improving returns on investment. This method can be used to build supply chain resilience.
Investment in storage capacity/inventory management	Increase the storage capacity and this can guide against sudden shortfall in availability of petroleum products.
Sourcing policy	Providing responsible code of conducts in line with requirements. This ensures compliance with sourcing policy.
Vertical Integrations	Attempting to control inputs for better results

Inter-firm Personnel Exchange	This involves cross-organisational knowledge exchange. It enables learning on how risk is being managed in other successful organisations.
Joint business planning	Multi-lateral agreement to share business strategic intelligence with the aim to minimise risk.

4.6 Research Models and Hypotheses

The review of agency theory in this study, has explained the interplay of behavioural-based and buffer-oriented mechanisms for managing supply chain risk. These assertions have provided the foundations for the theoretical framework and model as illustrated in Figure 4.1.

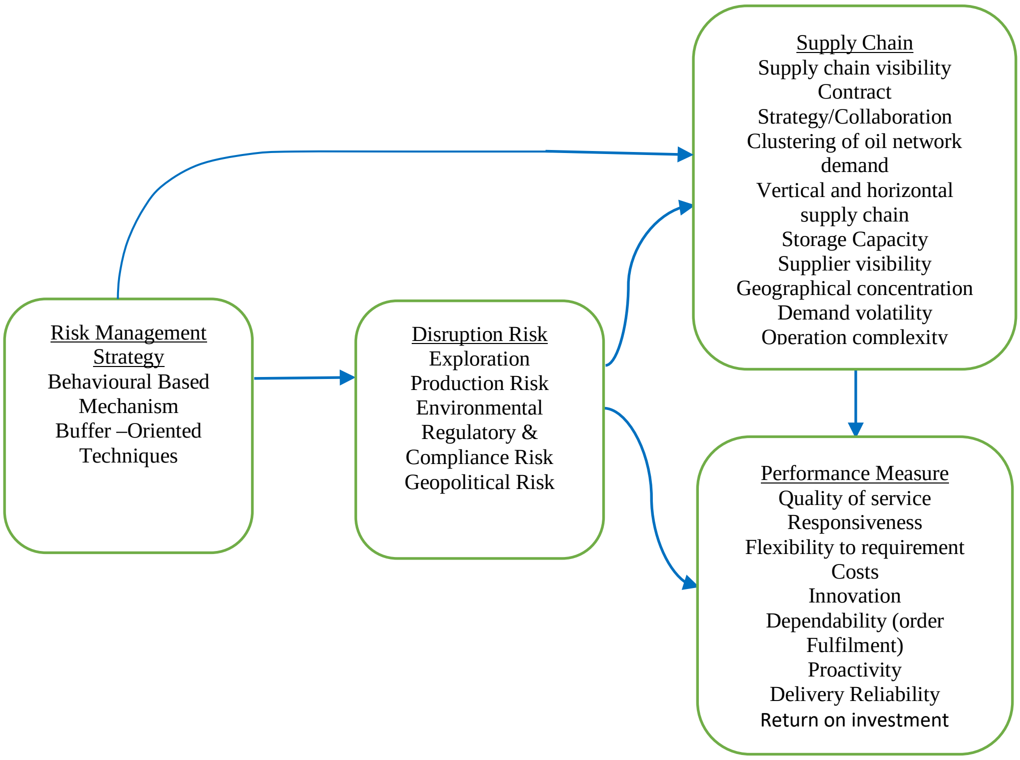


Figure 4.1: Conceptual Model for Supply Chain Risk Management.

With the adoption of behavioural uncertainty for mitigating supply chain risk, it becomes more established that the oil industry will align with the upstream crude oil supply chain and their downstream activities, in order to reduce risk in the oil industry. Eisenhardt (1989), asserted that behavioural uncertainty helps businesses address emerging conflicts between the principal and agent. Conflict in the context of this study is referred to as a stimulating circumstance that hinders the implementation of supply chain management. Alternatively, this is referred to as the supply chain management that developed as a result of incompatibility of response to the emerging supply chain trends. Abbasi and Nilsson (2012), identified emerging trends affecting sustainability of supply chain as; increasing costs, operationalisation of sustainable development, cultural change, uncertainties in management control and complexity of supply chain. Xia and Tang (2011) examined social and ethical issues as emerging trends affecting sustainable supply chain development in the automotive industry. These emerging trends adversely resulted in financial losses, ecological adversity, which consequently affected resources and infrastructural security (Urciuoli et al., 2014; Al-Damkhi et al., 2009). This adversity exposed the supply chain to disruption risks (Abbasi and Nilsson 2012). Behavioural uncertainty has to be adopted to resolve such conflict in the supply chain. For example, a supply chain collaborative relationship, as it relates to sustainable goals, can effectively help to mitigate various cost activities in the supply chain; such as collaborative waste elimination, effective production and services programme improvements and environmentally sound innovation (Pereseina et al., 2013). Ulrich and Barney (1984) illustrated how relationships with supply chain partners can generate vertical integrations. The capability of vertical integration can help a firm control material inputs or demand uncertainties. Relationship management within the context of the supply chain is a behavioural approach for resolving the supply chain members' conflicts. For example, Simpson (2007) claimed that communicating customer requirements to suppliers improves supply chain efficiency.

The source of supply chain risks have been hypothesised and tested from various supply chain dimensions, such as fluctuation in demand is positively related to behavioural-based uncertainty (Elkins et al., 2005; Eisenhardt, 1989). To date research has been slow to explore behavioural-based mechanism to minimise disruptive risk occurrence to supply chain in the oil industry (Madu, 2016).

4.7 Oil Industry Risk Factors Affecting Supply Chain Management

Various macro risk factors have recently been identified as risks factors affecting supply chain management in the petroleum industry. Wan Ahmad et al., (2016), adopted a PESTEL (political, economic, social, technological, environmental and legal) model to identify the external factors affecting the petroleum industry supply chain sustainability goals. Yuksel (2012) suggested that the PESTEL model can be the best approach for evaluating companies' operations and their consequential attributes, on supply chain performance. This backdrop has motivated this study to combine the various and relevant literature to investigate the oil industry risks affecting supply chain management. Therefore, the taxonomy of the oil industry supply chain risk constructs are classified as exploration and production risk, environmental regulatory compliance risk and geopolitical risk (See Figure 4.2). These oil industry risk factors are the focus of this study and will act as the illustrative variables for this study, because they are very relevant to the practice of supply chain management in the petroleum industry.

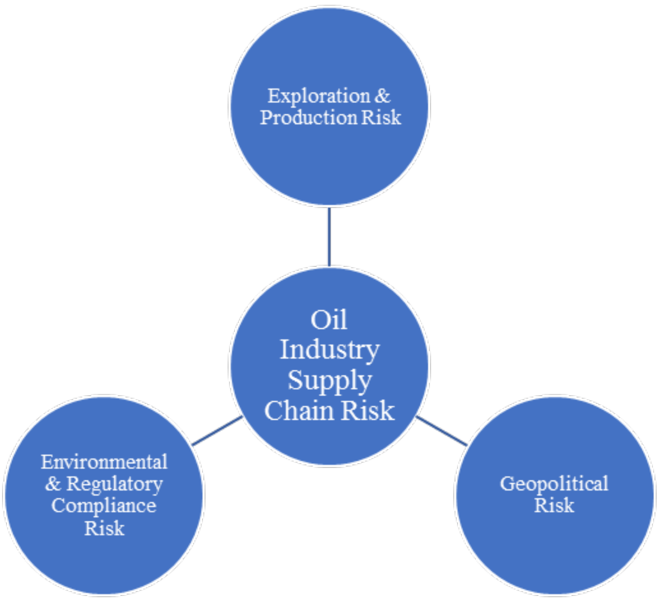


Figure 4.2: Classification of Petroleum Supply Chain Disruption Risk Factors

The value chain activities are affected by the petroleum explorations and production development and this significantly impacts the environment and negatively influences socio-economic activities in the oil producing communities

(Ite et al., 2016). The oil industry in Nigeria is granted unrestricted licensing permits to produce crude oil within the onshore and offshore oil locations. The unrestricted petroleum exploration and production operations in Nigeria, have resulted to environmental risks to the oil producing region of Niger Delta in Nigeria. For example, the geological and seismic survey, ground preparation for road construction, pipeline exploratory drilling, development drilling and production wells, and construction of productions facilities (Ite et al., 2016; Ite and Ibok, 2013). These identified activities constitute environmental issues, which make the socio-economic activities in the Nigeria oil producing region unpalatable.

4.8 Exploration and Production Risk

Exploration and production (E&P) is a specific operational sector within the oil and gas industry. The oil industry is involved in high-risk operations of crude oil production, with the main oil producers obtaining a high-reward from their exploration and production ventures. The focal point is finding, augmenting, producing and merchandising different extracted products of the oil and gas. The exploration and production risk is associated with drilling through seismic data, processing and extraction of crude oil (Omenikolo and Amadi, 2010). Exploration and production of hydrocarbon risk can be attributed to: uncertainty in oil reservoirs, which are due to structure, reservoir seal and hydrocarbon charge; inadequate drilling technology; damage to production facilities; restriction to production time; production capacity; and scheduling and investment/operating costs (Kishik and Oladunjoye, 2009; The Worldbank Group, 2009; Wolf, 2009). These elements are crucial for the effectiveness of supply chains and their economic performance (Cohen and Lee, 1989). Researchers and risk managers have adopted a series of strategies to reduce the impact of exploration and production risks to organisational investment and supply chain management.

Crude oil exploration and production development involves substantial capital investment. To secure these capital needs, oil industry investors are required to secure investment loans to enable the upstream operators to develop their hydrocarbon productions facilities. At times, these capital financing loans, become very difficult to secure, based on the terms and conditions for securing the loans. Similarly, at times, these loans are not widely available, based on the volatility of oil reserves, which may not give the expected capital return over the specified tenure for such capital loans. Another factors militating against crude oil explorations can be attached to the frequent incidence of pipeline sabotage and oil theft. This has hindered the onshore oil upstream production to achieve the expected optimum economic performance.

The prevalence of disruptions to the onshore oil production facilities, have shifted the attentions of the upstream oil investors, to the offshore hydrocarbon production, which is more safe and secure. The huge capital involved in developing the offshore crude oil facilities are ridiculously embarrassing (Wall Street Journals, 2016). The frequent change in government decisions can affect investors' capital and profits could be impacted by incidents of civil disturbance, workers' protest or boycott. For example, the Nigeria economic riots in 1989, was caused as a result of change to the ruling economic policy, which aimed to restructure the economic programme. The consequence of these national riots led to a steep drop in both the upstream and downstream oil production in Nigeria (Noble, 1989). This type of policy change threatens crude oil operating costs and investor profits. For example, Wall Street Journals, (2016) itemised the overhead costs breakdown for producing a barrel of crude oil in Nigeria as: Gross tax, 14.2 percent; Capital expenditure, 45.2 percent, Production cost 30.4 percent; Administration/transport 10.2 percent. Comparing these estimated costs with other oil producing countries that have a stable cost structures. The comparatively high production operating costs affect investment decisions, whether to embark on offshore crude oil exploration and production in Nigeria (Wall Street Journals, 2016). Bhatnagar and Sohal, (2005), illustrate that change in government policies such as fiscal, tax and foreign exchange decisions, encouraging direct foreign investment, administrative control and transparency, all of which may affect business decision to relocate or diversify operations. The variability of crude oil exploration and production are difficult to estimate and this affects the supply chain management. Given the dimensions of exploration and production on supply chain constraints, availability of crude oil becomes difficult to forecast and coordinate. This entrenched supply chain problem is as a result of the macroeconomic policies, which weakens the capability of macroeconomic policy regulation. This creates a wide gap for creating a risk management framework for managing supply chain risk in the petroleum industry in Nigeria. There is a need therefore to address the absence of a supply chain risk management policy framework in the literature and in practice to guide supply chain practitioners.

Further supply chain constraints on exploration and production are the uncertainties of oil resources in the formation rock, where certain areas of the well may have more oil deposits than others. Oil resources and reserve estimates are the amounts of crude oil resources believed to be physically available in the source rock. The oil resource expected may not be available in commercial quantities because of some technical and geological formations failure. Most of the risk affecting the oil resource and reserves are errors in forecasting, technological constraints, experience of rigs workers, and cost of production. This risk of exploration and production operations, results in limited discovery of commercially viable oil quantities for production. This makes it impossible for oil industry investors to accurately estimate the costs of any exploration drilling projects that are due to uncertainties in the oil formation and the associated costs with oil drilling in the over pressure layer (North Sea Energy Inc. (2017). The uncertain oil reservoir tends to prevent the capital financing providers from financing the conventional and unconventional of crude oil productions.

This unpredictability of oil resources and reserves, poses a great challenge to upstream oil investors obtaining capital and this threatens supply chain security. The consequential impact of these challenges on oil resources and reserve leads to inaccurate planning for crude oil production resulting in supply chain volatility. Lee et al. (1997) described this situation as bullwhip effects. Low oil resources and reserves result in oil supply chain risk.

Furthermore, the existence of oil traps are also difficult to predict with any certainty. Most of the located oil traps may not be fertile for immediate drilling/exploration for unknown reasons (Ikoku, 1984). The costs involved in obtaining such a wildcat well, may be significantly huge and the immediate net present returns are unrealistic for the upstream oil investors. For example, offshore drilling of nine (9) out of ten (10) wildcat wells, estimated to cost around

$15million US dollars, failed to produce commercial quantities of hydrocarbons (Watson, 1998; Pike and Neale, 1997; Hyne, 1995). Also, drilling licensing was approved for 150 square miles of UK territorial waters in the North Sea, but this yielded only two (2%) percent of hydrocarbon (Simpson et al., 1999).

The economic factors, which consequently affect the exploitation of oil resources, are subject to unpredictable shifts which defy logical assertions (Ikoku, 1984). This increases the crude oil overhead operating costs, can affect cash flow positions of the oil industry stakeholders including investors, it can also affect joint business planning and collaborative efforts with joint venture partners. This exploration and production uncertainty in the upstream petroleum industry, can militates against the oil supply chain performance. This research explores the application of behavioural-based and buffer-oriented approaches to provide resilience for minimising the impact of oil exploration and production risk to companies' supply chains. This empirical assumption leads to the hypothesis of this study which states that:

H1: Managing supply chain disruption risk using behavioural-based mechanisms, is positively related to the perceived degree of oil industry risk sources.

Therefore

H1a: The involvement of oil industry in managing supply chain risk using behavioural-based mechanisms is positively related to the perceived degree of oil exploration and production risk.

H2: Mitigating supply chain risk using buffer-oriented mechanisms is positively related to the perceived degree of supply chain disruption risk sources.

H2a: The extent to which the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms, is positively related to the perceived degree of exploration and production risk

4.9 Environmental and Regulatory Compliance Risk

The environmental and regulatory compliance risk provides statutory limitations and standards to which the petroleum industry must comply during the process of discharging industry emissions obligations. This compliance standard has imposed a high risk on oil sector operators. Many risks are inherent in oil exploration, drilling and production, which are beyond the control of the petroleum companies.

The upstream petroleum sector is confronted with delays as a result of water conditions, environmental hazards, industrial accident, occupational and health hazards and technical failures (PetrolAfrique, 2015; North Sea Energy Inc., 2017). These global environmental and legislative delays are associated with environmental risk factors affecting the Nigerian petroleum producing communities and involve, oil spillage, pipeline exposure, gas flaring and venting, uncoordinated process for disposing of large volumes of crude oil, hazardous waste streams. Moreover, hazardous waste streams include, drilling mud, oily and toxic sludge, (Ite, 2012); production equipment failure, oil spill due to ageing production infrastructures, sabotage to production facilities, blowout of oil wells and oil blast discharge (Ite and Ibok, 2013; Osuji, 2002). This study has identified natural disaster, regulatory and legislative compliances and cost compliance as associated risks to the Nigerian petroleum industry.

Research studies have indicated that environmental risks are mostly likely cause of disruption to supply chain (Ite, et al., 2016; World Economic Forum, 2013). A survey on 'Global Risk Perception', identified environmental risk, such as meteorological and hydrological catastrophes, as the most likely risk occurrences (World Economic Forum Report, 2011). Swiss Re (2011) observed that the global economic losses from natural disasters in 2010 amounted to US $194billion. Natural disaster occurrence can impact infrastructure and interrupt the smooth flow of production and consequentially impact company performance. Thus the unpredictable nature of the associated consequences of environmental and compliance risk in the Nigerian petroleum industry, has a significant impact on supply chain management performance. It could be argued that improper management of petroleum resources, ineffective formulation of petroleum policies and unsustainable operational practices can result in disequilibrium in the supply chain of the Nigerian oil industry. However, Ite et al. (2016) identified poor management of petroleum resources, ineffective government policies and unsustainable operational policies and practices by the multinational oil companies as a cause of socio-economic, socio-political, militancy and multi-faceted interaction problems within the oil community and economic development in the oil producing community in Nigeria.

The legislative framework, which aims to protect the environmental impact associated with upstream of crude oil operations in Nigeria, has failed to address the various environmental issues. The implementation of regulatory policy by the successive governments in Nigeria, remains ineffective (Ite et al., 2016). The environmental compliance legislation does not set a specific regulatory norm by which Nigeria's oil and gas industry should comply and maintain in order to protect and preserve the environment of upstream operations (Ekpo, 1995). The petroleum industry's failure to embrace given and sustainable guidelines for managing the environmental impact of crude oil exploration and production, can affect the decision-making process and increase the cost of operations. Increasing exploration and production costs can threaten supply chain and business performance. As this study aims to develop a risk management strategy that can provide resilience to the supply chain in the Nigerian petroleum industry, efficient environmental and legislative compliance that can mitigate supply chain risk must be considered. From this review, it is assumed that:

H3: Managing supply chain disruption risk using behavioural-based mechanisms is positively related to the perceived degree of oil industry risk sources.

> **H3a:** The extent to which the oil industry is involved in managing supply chain risk using behavioural-based mechanisms is positively related to the perceived degree of environmental and regulatory compliance risk.

H4: The extent to which the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms is positively related to the perceived degree of critical supply chain risk sources.

H4a: The extent to which the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms is positively related to the perceived degree of environmental and regulatory compliance risk.

4.10 Geopolitical risk

Geopolitical risks pose a great challenge on the oil producing environments (Seegar, 2015). This involves disruption through a range of events, such as social disorder, militant attacks on oil installation, oil rig spillages, theft and vandalism of oil infrastructures. The civil unrest, political instability, theft and terrorist acts have resulted in transversal capabilities on crude oil production and threatened supply chain resilience (Urciuoli et al., 2014). Studies in the Niger Delta region (Nigeria's nucleus for oil and gas distribution) have noted that the geopolitical tension in the Niger Delta region are caused by "lack of transparency of oil revenue, tensions over the allocation of oil revenue, environmental damage resulting from oil spills, communal ethnics and religion affiliation" are source to the oil industry vulnerability in Nigeria (Carbon Tracker Initiatives, 2014).

In addition, the geopolitical events can have adverse effects on company financial reports, ecological disasters, employee morale and oil production infrastructures (Urciuoli et al., 2014). For example, the conflicts in the Niger Delta of Nigeria, have resulted in the oil industry shifting their focus to diversifying into offshore geological exploration. This diversification consequently drags oil investors into contract renegotiation with their collaborative counterparts. These initiatives can push oil industry operating costs up and constrain the oil industry from successfully coordinating their joint venture initiatives. These fragilities prevent oil industry managers from focusing on the management of their supply chain and this ultimately impacts supply chain performance (Abbasi and Nilsson, 2012; Kleindorfor and Saad, 2005). The Central for Global Energy Studies (2014) confirmed that the escalating violence in Libya affected the movement of about sixty-seven percent (67%) of oil production due to supply chain disruptions. Appel (2012) claimed that supply chain disruption resulting from geopolitical events are difficult to manage, with restricted opportunities for industries to influence performance. Empirical research drawn from a large number of enterprises and expert respondents survey carried out in industrial/developed and developing economies, suggests four measures of geopolitical risk as; control of corruptions, political stability, absence of violence/terrorist activities and human right and regulatory excellence (Kaufmann et al., 2013). These parameters are relevant to countries with low risk. Therefore, it is necessary for a behavioural and buffer-based approach for reducing geopolitical risk in the supply chain of the oil industry in Nigeria.

H5: The extent to which the oil industry is involved in managing supply chain risk using behavioural-based mechanisms is positively related to the perceived degree of oil industry risk sources.

> **H5a**: The extent to which the oil industry is involved in managing supply chain risk using behavioural-based mechanisms are positively related to the perceived degree of geopolitical risk.

H6: The extent to which an oil industry is involved in managing supply chain risk using buffer-oriented mechanisms are positively related to the perceived degree of supply chain risk sources.

> **H6a:** The extent to which an oil industry is involved in managing supply chain risk using buffer-oriented mechanisms are positively related to the perceived degree of geopolitical risk

4.11 Consequential Impacts of Oil Industry Risks

Operational risk is defined as failure to internal business processes and events, people and systems. Oil industry operational risk is the probability that it can affect internal operations (Lockamy and McCormack, 2009). Supply chain operational risk breakdown, consists of disruptive events that affect internal activities and the high probability of this occurrence can significantly impact financial performance. Associated risks that can affect financial performance include, process designs, insufficient operational capacity to meet demand, quality problems, delivery delays, labour skills, employee relations, technological vulnerability, logistics complexity and supplier failure (CIPS, 2012; Lockamy and McCormack, 2009). Enyinda et al., (2011) described the oil industry supply chain operational risk as a disruption that impacts firm performance, including geological and production risk, market rate volatility, technological risk, country risk, price cost and government actions. The consequential impacts of operational risk in the oil industry supply chain can affect performance due to failure of internal processes and systems. Transportation risk is the associated risks that relates to the movement of goods and services from one point to another. The movement of goods consists of land, air and sea. The transportation of petroleum products are through pipelines, truck, railways and ocean carriage. Crude oil transportation is challenged with pipeline vandalism and this results in oil spillage due to attacks on oil installations by militant groups. Furthermore, transportation of goods are affected by the activities of piracy, which threaten the security of workers on-board, high costs, poor routeing and scheduling, delays offloading at loading and offloading points. Research studies on maritime piracy estimated the costs of piracy to the global economy to be between US $7 billion and US $12 billion per annum (One Earth Future, 2010). Furthermore, it was reported that piracy attacks have increased by 36% over the last five years (The International Maritime Report, 2011). The increasing dimensions of piracy are posing a growing threat to employee security, the shipping and transport companies. This prolongs delivery lead-times due to rescheduling of routes to avoid piracy attacks. This trend poses severe threats to the oil supply chain. The consequence of transportation risks are severe to the oil industry supply chain. There is a need for a risk management strategy to minimise the impact of transportation risk in the oil supply chain management in Nigeria. (This assumption is relevant to Hypothesis 1 and 2).

The proportional approach to managing these risks is to use the behavioural-based mechanism as a minimising strategy for addressing supply chain risk. A number of risk management strategies can be used to mitigate supply chain risk in the Nigerian oil industry. These appropriate strategies are cooperation, avoidance (Tang, 2006b); control (Manuj and Mentzer, 2008) and flexibility (Thun and Hoeing, 2011). Furthermore, a buffer-based strategy is another risk management approach for mitigating supply chain risk in the Nigerian oil industry. The appropriate contextual definition of the various supply chain risk management strategies for this study are indicated on Table 4.5. Indeed, this research will hypothesise how the Nigerian oil industry can exploit the definitive construct in Table 4.5, as the supply chain risk management mechanism for mitigating petroleum supply chain disruption risk. This can help to address the related themes in RQ3 and RQ4.

The established behavioural and buffer-based techniques formed the basis for developing the research hypotheses for this study. In doing this, analytical hierarchy process is used to explore the risk constructs. The outcome of AHP evaluation will facilitate the processes for selecting or making decisions on the risk factors militating against supply chain performance in the Nigerian oil industry. The risks factors are regarded as "High-Low Risk" (Kleindorfer and Saad, 2005). The high risk will be used to operationalise the constructs in this research. For example, (Sinha el al., 2004) explore Failure Mode and Effect Analysis (FMEA) to identify supply chain risk and this enables effective risk management strategies to supply chain management.

The risk priority vectors (PV) outcome will be reintegrated into partial least squares structural equation modelling (PLS-SEM) to evaluate the existing relationship between the petroleum supply chain risk, supply chain management and performance measures in the Nigerian oil industry (see procedures in Figure 5.1). Besides the use of partial least squares structural equation modelling (PLS-SEM), regression analysis, testing the reliability and validity of the research questionnaire will be conducted. The respective test for reliability and validity will enable the research constructs to measure what it intends to address. Nagurney and Matspura, (2005), developed a mathematical model to analyse risk practices in supply chains. These observed processes involve risk identification and prioritisation on supply chain performance. This enables the selections of critical associated risk factors (Wu et al, 2006). This model created the awareness in supply chain risk factors and this awareness in supply chain risks helps businesses to design and formulate the appropriate mitigating strategies for supply chain.

To address this research gap, this study adopts a thorough research process that includes a literature review, theoretical conceptualisation and methodology that will be used to operationalise all the mentioned constructs that are related to supply chain risk management in this study.

4.12 Conclusion

In order to examine the risk management strategy mitigating the supply chain risk, the theoretical framework for this study has examined the perspectives of global practices and academic views within the in Nigerian context. The empirical links to the theoretical framework provide the strategic insight for explaining and understanding the phenomenon of supply chain risk management. Further, the risk management strategy explicitly broadens the relative practices incorporated in the review of literature. The insight from this review was used to address the research questions of this study (Section 1.6), and provides the background for developing the theme of this study. No similar work of this nature has been conducted on the supply chain in the oil industry in Nigeria. The systematic approach explore in this study integrate PLS-SEM output to identify and prioritise disruption risk in supply chain through AHP model.

CHAPTER FIVE

Research Design and Methodology

5.0 Introduction

Following a review of the literature, conceptualisation of supply chain risk with relevant supply chain management theories used to explain the reality of this study, this chapter will discuss the process through which the aim and objectives of this study (section 1.4 and 1.5) are achieved.

A clear understanding of the underpinning philosophy and research paradigm will help this study to develop a broader knowledge of risk management strategies for managing the supply chain in the Nigerian oil industry. A systematic approach to addressing the identified research questions (section 1.6) or problems posed in this study is used (Kothari, 2004). The various research paradigms and the research methodology used in this study will be presented with the motivation for adopting the respective options.

The identified philosophical and methodological gaps in the practices of supply chain risk management in the Nigerian oil industry will be addressed. The identified effects will effectively help to produce mitigating strategies to ameliorate risk consequences in the supply chain of the Nigerian oil industry. Theories and realities/practices will contribute to the coordination of risk in the Nigerian oil industry. Agency theory, is based on behavioural approach efforts which coordinate and control supply chain activities, has been discussed and is used to underpin this study. The rationale for this study is the lack of a definitive paradigm for supply chain risk management practices in Nigeria, and unreliable risk analytical tools for identifying and prioritising risks for the Nigerian oil sectors and other industrial practices. Although, the focus of this study is on risk management as it relates to the oil industry in Nigeria, the findings through a systematic research approach can contribute to the phenomenon of management of disruptive risk in other industrial settings. For instance, manufacturing, aeronautics, agricultural and biotechnology operations.

Neuman, (2003), grouped the objectives of social research as exploratory, descriptive and explanatory. Exploratory research is employed when none or very little is known about a particular phenomenon. Such a study aims to develop a deeper understanding to allow more precise research questions to be formulated for future research study (Kumar, 2011; Matthew and Ross, 2010). For example, the assessment of risk factors such as petroleum exploration, environmental and legislative compliance and geopolitical risk through the application of using analytic hierarchy process (AHP) for prioritising the oil industry risk factors. The process of risk prioritisation enables firms to identify issues for further research. This is a typical example of an exploratory study.

Descriptive research usually commences with the development of a concept or aspects of a phenomenon (Kumar, 2011). For example, oil pipeline sabotage and theft in the Niger Delta Region of Nigeria, can be used to describe the operational risk experiences of the petroleum industry in Nigeria. This enables a researcher to describe in detail the categorisation for understanding supply chain risk occurrence. Descriptive research is also used in mixed method studies.

Explanatory research aims to test, develop, maintain and link with theory to explain the observed phenomenon. The focus of this study is to use explanatory research through a quantitative approach to understand how behavioural and buffer-oriented mechanisms can act as coordinating factors for managing supply chain risk in the Nigerian oil industry.

In order to answer the research questions, this study explores a quantitative approach to examine risk management strategy in the supply chain of the Nigerian oil industry. A quantitative method is adopted to collect unique and rich empirical data (Collis and Hussey, 2009). A quantitative approach in this study uses administered questionnaires to a sample of participants to collect information on risk management strategies for mitigating supply chain disruption risk in the Nigerian oil industry. Figure 5.1 presents a schematic diagram to depict the research sequence and process of this study.

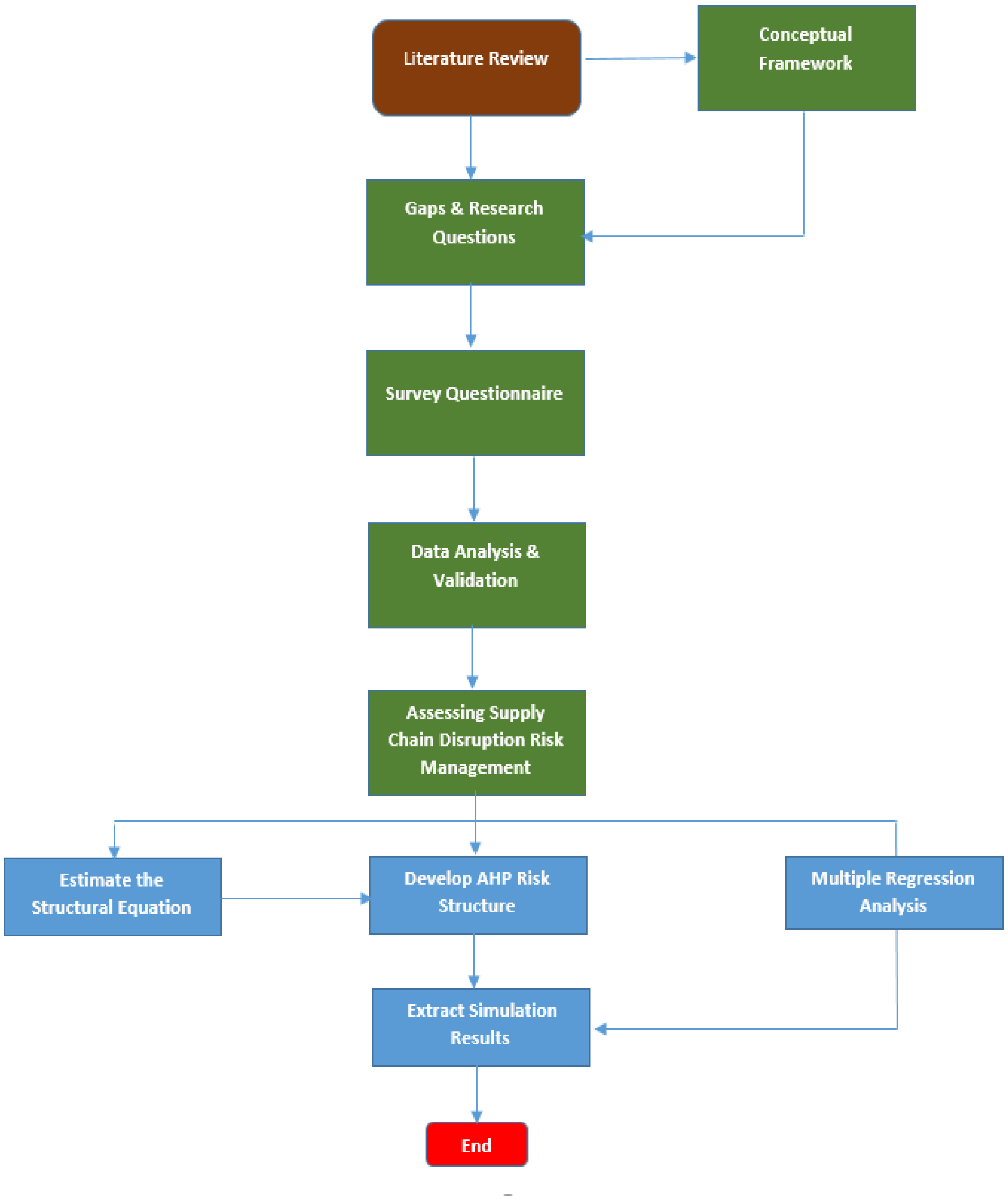


Figure 5.1: Schematic Diagram for Research Methodology

5.1 Research Philosophy for this Study

In order to develop new knowledge from this study, certain assumptions on how the world can be viewed, with the aim of providing a platform upon which the research strategy for this study can be developed. This chosen platform is known as the philosophical stand or position and for this study is positivism. A positivist approach is an epistemology which specifies the philosophical paradigm and sets of beliefs on how a researcher can perceive the world (Kwawu, 2009). The principles behind the adoption of positivism involves a quantifiable observation, which leads to the mathematical application to explain a given phenomenon. A positivist philosophy is viewed by the empiricist as knowledge that is developed from human experience.

Moreover, ontology is an assumption on how we view the world as an observable set of elements and events that interact in order to determine the regular change (Collins, 2010; p.38; Burrell and Morgan, 1979). For example, ontologies are the properties that fundamentally exist for a particular domain of discourse. Relating this instance, which views supply chain management (SCM) dimensions as the buying of raw materials to managing suppliers, warehousing, operation transport fleets, taking orders, collecting payments, repairing products and even answering telephone at calls centres (Markillie, 2006; Karantana, et al., 2006). Ontology is a formal explicit requirement of a shared conceptualisation (Ahmad et al., 2004). This assertion implies that ontologies can be regarded as logic which gives meaning to a specific domain of knowledge. The benefit for this logical thought is to facilitate knowledge sharing and reapply it to future similar research studies. This provides a formal platform for knowledge sharing with stakeholders. The implication of ontology to this study, is that a standard collaborative database for information exchange can be provided for the shareholder in the oil and gas industry on how supply chain risk can be mitigated. A collaborative approach to supply chain risk management can help to design and build resilience in the supply chain.

A positivist approach will enable this study to objectively observe the phenomenon of the event under investigation and it will eliminate any subjective human interest within the study. Crowther and Lancaster (2008) claimed that as a general rule, positivist studies usually adopt a quantitative approach, whereas a qualitative research approach is usually associated with an interpretivist philosophy. Additionally, positivism shares the viewpoint that a researcher needs to focus on facts, while interpretative research concentrates on the meaning and has a subjective influence of human interest. Table 5.1 presents the features that differentiate between positivist and interpretivist philosophy.

Table 5.1: Difference between Positivism and Interpretive Philosophy

Characteristics	**Positivism**	**Interpretivism**
Research Observers	Independent	Researchers are part of the observation
Researcher Interest	Not interested in influencing the research or subjects	Directions of the study are driven by the researcher.
Explanation	Causality of events are observed	Increase the understanding of the study.
Progression of Research	Deductive hypothesis are used	Nuance data are collected and the original idea is influence by the researcher
Concepts	Variables are operationalised and measured at empirical (observational) level.	Research thoughts are enhanced
Units of Analysis	Social problems are broken down into smaller components and every individual element of components are addressed in details.	All components are studied at the same time and a subjective meaning is used to address the complex activities.
Generalisation of Study	Statistical probability is used	Abstractions of theory or inductions
Sampling	The population is randomised	Small groups are chosen from a specific case

Sources: Ramanathan (2008) and Amended by Author (2018).

Adopting a positivist approach in this study, will allow the author to collect data through a numerical pattern and exhibit the existing relationship among the constructs in this study (Bryman and Bell, 2007; Berger, 2003). Arguably, positivist research helps a researcher to objectively capture the experiences, opinions and beliefs of research participants (Saunders and Tosey, 2013;

Bhattacherjee, 2012; Burns and Grove, 2009). Bhattacherjee, (2012), claimed that positivism holds a systematic and organised body of knowledge on observed phenomenon of measure which is exclusively dependent on tested theories. Hence, positivism is more formal and systematic based on its ability to integrate numerical data (Burns and Grove, 2009).

Positivist paradigms suggest that the collection of data for the study of a phenomenon should be conducted in an interactive social environment with research participants (May, 1997). This will help this study to explain and predict the supply chain risk in terms of 'cause and effect' of the existing relationship.

Collected data through a questionnaire method are scaled symmetrically in a five-point Likert scale (Murphy and Likert, 1938). The Likert scale is characterised by a balance of positive (+) and negative (-) answers to the statements. Using a 'Likert' scale encourages the test for validity and reliability (Loewenthal, 2001: p.119). This approach will help to eliminate the problem of acquiescence prejudice. Acquiescence is a tendency to agree with scaled items regardless of their content. The problem of acquiescence can be reduced by ensuring that an equal number of items is scored in each direction. This will help the researcher to ensure that reverse items on the questionnaire have the same meaning as the original item. This will help the researcher to avoid double negative statement that may cause confusion to the process of this study.

5.2 Motivation for Positivist Research Philosophy

To logically assess the risk in the supply chain management of the Nigerian oil industry, a positivist paradigm has been chosen to direct the course of this research study. The reason for choosing this research paradigm is that positivism relies on scientific perspectives, which allows complex research problems to be broken down into smaller components of activity and every component is handled systematically. This will help develop the conceptual frameworks that specify the relevant supply chain risk variables in this research (Seuring and Mullier, 2008). Positivism is mechanistic in nature in the sense that it allows the researcher to test and develop a reliable and validated research instrument, which is associated with a deductive research method

(Yusuf, et al., 2013). Creswell, (2009) asserted that deductive method is objective in nature and data collected through this process are consistent. This approach will also test and explain the research constructs through the appropriate theory, which are fundamental to supply chain risk behaviour.

In addition, positivism as a scientific method, allows the researcher to sample selections of the research population, measure the risk constructs of this study, analyse and report this study's research finding as it relates to the Nigerian oil industry.

This study has identified the potential categories of supply chain disruption risk in the Nigerian oil industry as production and exploration; oil resource availability, transportation, regulatory compliance; geopolitical events; operational risks. Agency theory has identified a behaviour-based approach that can be used to explain these sources of risk and test for their respective hypotheses. Some researchers (Kern et al., 2010; Bode and Wagner 2009; Nagurney and Matsypura, 2005; Nagurney et al., 2005), have developed and operationalised the supply chain risk management construct through a mathematical model which helps test for construct relationships.

In contrast, quantitative research methods are more reliable than qualitative data such as making use of documentary analysis (Cullen, 2004). Scepticism in positivist research can be eliminated through randomisation - a process that enables a random selection of samples from a population (Bhattacherjee, 2012). Qualitative methods have been criticised for their subjective nature and scepticism, which could jeopardise the research process and are difficult to eliminate. Qualitative research (i.e., face-to-face) methods are more flexible in terms of the process, where interviewer has control over the interview process and questions asked, the respondents are also able to give their opinions that could sharpen the directions of the study. However, qualitative research, such as the use of personal interviews, are expensive to conduct, include some bias, lack the appropriate anonymity (Cullen, 2004) and the follow-up process with research subjects can be difficult and labour intensive (Cooper and Schindler, 2003).

Consistent with the stated argument to support a positivist research paradigm and considering the nature of this study, 'Assessment of Disruption Risk in Supply Chain, the Case of Nigerian Oil Industry', a positivist research philosophy will facilitate objective data collection through a survey questionnaire. A positivist paradigm will help me to conceptualise and use the mechanical nature of a scientific approach to explain and translate the exploration risk in the supply chain management of the Nigerian oil industry.

Applying a positivist research philosophy in this study, will enable the researcher to give a deeper meaning to issues relating to the contextualisation of supply chain risk management in the Nigerian oil industry. Applying this meaning to the context of risk management in Nigeria, the existing gap will be addressed based on the discovery of a definitive meaning to supply chain risk management. However, a reliable risk management framework for risk identification and prioritisation will be in place for the management of supply chain and oil industry professionals to use for their decisions making on petroleum matters.

5.3 Research Approach

It is necessary to determine the various approaches and methods that warrant the selection of a particular research approach for data collection methods. The philosophical position for this study are germane to the decisions for the choice of the appropriate research approach that will be used to answer the research questions and shape the direction of this study. This approach is regarded as the block of skills, assumptions and practices which researchers espouse in the collection and analysis of observable data (Denzin and Lincoln, 2005). However, several research approaches are available and a researcher can adopt any of these research approaches. These include survey, experimental research, ethnography, documentary analysis, case study and action research (Matthews and Ross, 2010; Saunders et al., 2009). Any of these research approaches can be explored based on the appropriate research philosophy. For the sake of sound understanding the individual research approach is briefly explained below (see Table 5.2).

Table 5.2: Research Approaches

Research Approach	Definition
Survey Research	This is non-experimental research that does not control for or manipulate the independent variable. It measures these variables and tests the cause-effect relationships (Bhattacherjee, 2012).
Experimental Research	This involves research studies that are intended to test the cause-effect relationships (hypotheses) in a strictly controlled setting by excluding cause from the effect during the administering of the cause (treatment group) but not to another group (control group) (Bhattacherjee, 2012).
Phenomenological Research	This is a descriptive research strategy that take its root from interpretive philosophy. The research strategy aims to elucidate a subject's experience (Bhattacherjee, 2012; Saunders and Tosey, 2013)
Ethnography Research	An interpretive research strategy motivated by anthropology, which emphasis that a phenomenon should be studied within the context of culture. Data collection is through observation (Saunders and Tosey, 2013; Burns and Grove, 2009)
Case Research	This is an in-depth research study about a real-life situation over a given period of time. The data collection process for this type of study may be either quantitative, qualitative or a mixture of both approaches (Saunders and Tosey, 2013).
Action Research	This type of research strategy is called participatory and it involves the use of insight, reflection and personal involvement. This study is conducted in a real-life situation (Bhattacherjee, 2012).

The choice of research process depends on the research questions and objectives, a priori experience of the researcher, existing resources, time limitation and underpinning research paradigm (Saunders et al., 2009). Due to the shared characteristics which underpins the positivist philosophy (Table 5.1) and the various theories proposed for developing hypotheses in this study, deductive methods will be used to build up the theme of this study. Deductive research methods use a survey approach through structured questions with fixed responses, which encourages the sampled population of research respondents to convey their experience on a given research problem. In this study, the experiences of the upstream petroleum industry subjects on the risk management strategy for managing supply chain disruption risk in the Nigerian oil industry will be sought.

5.4 Survey for Determining Crude Oil Supply Chain Risk Management

To determine the experience of respondents in line with the aim and objectives of this study (section 1.4 and 1.5), is to expand knowledge on supply chain risk management practices in Nigeria's oil industry. Namely, to identify and operationalise the current oil industry risk constructs (exploration and production, environmental and legislative compliance and geopolitical), critical oil industry risk associated with supply chain performance and developing resilience in the petroleum supply chain management in Nigeria. Research of this nature relies on surveys, experiments and mathematical modelling (Boyer and Swink, 2008; and Malhotra and Grover, 1998). Exploring any of these three mentioned research approaches means drawing on the experience of supply chain practitioners, and testing the appropriate theory which was adopted in this study. In this case, the appropriate agency theory, such as behavioural and buffer-oriented based mechanisms, is presented as the governance and control mechanisms that can provide the minimum expected standards for mitigating supply chain risk in the focal organisations.

To address this study, quantitative data was collected from a selected sample of upstream petroleum industry employee, contractors and stakeholder in Nigeria. The research subjects are believed to have industry experience and professional competencies and are able to add new insights to the various supply chain risk management practices in the Nigerian oil sector.

A survey method was explored to collect the structured data from the selected petroleum industry respondents. Using a survey questionnaire enable a scientific approach to be use to conduct supply chain research; validate and ensure reliability in addressing the research questions posed in section 1.6 of this study. Wagner and Bode, (2006), used a survey based approach to investigate supply chain disruption risk including several supply chain features. Kern el al., (2010) operationalised the risk mitigation constructs through an extensive literature review and linked them to risk performance.

Burgess et al, (2005) asserted that field survey research is cost effective and accommodates the use of survey questionnaires as an instrument that can be used to seek the a priori opinion of research subjects. This study seeks to evaluate the attributes of risk management strategy on supply chains. Seeking the appropriate experience of the various oil industry employees from the various oil rigs in Nigeria, makes survey research ideal. The use of questionnaires will allow a concomitant measurement of both the independent and dependent variables through a single survey instrument (Keats and Hitt, 1998). However, a survey research approach will discourage the manipulation of the predicting (independent) variable that may defeat the temporal precedence and result in the probability of the expected. This may have a strong impact on the expected cause and effect relationship. In order to eliminate this ambiguity in this research study, research evidence, which are consistent with theory testing of hypotheses and statistical testing of extraneous variables which are explored in this study. Furthermore, a research survey allows the researcher to explore statistical analysis to determine the existing relationship between the dependent and independent variables. It provides snapshots of research outcomes and respondents' opinions on the existing inferential relationships. This builds trust in the testing of hypotheses and the research outcomes.

5.5 Survey Questionnaire Design

A survey questionnaire design will be based on the identified categorised risk in section 2.5 (Table 2.2). The potential Nigerian oil industry supply chain risk constructs identified for this study are production and exploration; environmental and legislative compliance and geopolitical events. The attributive consequences of the oil industry risk on supply chain are used to address the research questions for study (section 1.6). These constructs have been explained in the literature review of this study (Sheu, 2006; Sheu, 2005; Tari and Sabater, 2004). Moreover, a series of discussions with academic experts and practising professionals in supply chain management in the Nigerian oil industry have been incorporated into the design of the survey questionnaire (Appendix 1).

The survey questionnaire for this study was divided into two parts and each part is categorised into sections. Prior to section A of the survey questionnaire, a covering letter was written to the targeted research respondents to solicit their participation in this study. This letter was incorporated in this questionnaire. (See Appendix 1).

Section A of this study is concerned with demographic features of the oil industry in Nigeria. These demographic elements consisted of the research subject positions, business units/departments and their respective years of work experience in the oil industry.

Section B was divided into nine (9) parts B1 - B9. The questions in this section are linked to issues such as petroleum exploration risk, application of risk management techniques, effectiveness and efficiency of risk analysis techniques, supply chain elements, performance measures, current supply chain risk management strategy and risk management strategy that can create resilience in the oil industry in Nigeria.

Section B1 relates to the research questionnaire consisting of the oil industry risk constructs identified as petroleum industry variables mitigating against operational performance of the supply chain in Nigeria. The oil industry risk constructs are identified as exploration and production risk (EPR - EPR12), environmental and legislative compliance (ERC1 - ERC11) and geopolitical risk (GEO1 - GEO7). These constructs consist of thirty (30) questions and research subjects are expected to give their a priori thoughts on the severity of petroleum exploration risk affecting supply chain performance measures in Nigeria. The scale was ranked on a 1 to 5 scale for the reflective scale 1 = low risk and 5 high low risk.

In section B2 - 5 is concerned with supply chain risk techniques used for understanding the application of risk analysis techniques. This section contains eleven (11) most commonly used risk analysis techniques for evaluating global supply chain risk events. Respondents are expected to provide information on how these global risk management techniques have been appropriately explored to managing supply chain risk in the Nigerian petroleum industry. In addition, in the second parts of this section B further respondents provide information on the effectiveness and efficiency of the risk analysis techniques in the Nigerian oil industry. The response of the research subjects provides added information on the management of supply chain risk (RQ 1 and 4) in the Nigerian oil industry.

Section B6 and 7 contained the upstream petroleum exploration supply chain and performance measures with nine (9) respective formatives scale constructs, which obtained information from respondents on the effective management of petroleum supply chain in Nigeria. The second consists of the overall organisation performance measure, quality of service /customer satisfaction, customer responsiveness, flexibility to requirement, costs, innovation, dependability (Order Fulfilment)/inventory level, throughput efficiency, productivity and return on investment (Yusuf et al., 2013; Wagner and Bode, 2008). The highest value (5) and lowest value (1) on the Likert scale were correspondingly allocated.

Section B8 is related to the risk mitigation approaches, which are currently used for managing supply chain risk in the Nigerian oil industry. This section contains thirteen (13) items most commonly used risk management strategies for managing global supply chain events. Respondents are expected to provide information on how these global risk management strategies can appropriately be explored to mitigate supply chain risk in the Nigerian petroleum industry.

However, sections B9 consists (13) of questions, which asked respondents to provide information on how the risk management strategies can create resilience in the petroleum supply chain over the next five years in the Nigeria oil industry. Every aspect of this survey questionnaire was scored on a five point Likert rating in order to enable the subjects in the study to response accordingly

(Murphy and Likert, 1938). The Likert scale scores on these instruments will range from extremely unimportant to extremely important (scores 1 to 5).

5.6 Pre-testing and Piloting of the Survey Questionnaire

Based on the development of this survey instrument, a pilot test was carried out with the aim of preventing the research from using and an inappropriate instrument or too complicated wording. De Vaus (1993: p54) warned that researchers "do not take the risk, pilot testing first". Pilot testing eliminates risk in instrument measurement, enhances the development and testing the adequacy of the research questionnaire. Furthermore, pilot testing helps to identify and reveal issues that with questionnaire wording and eliminate the likelihood of type 1 or 2 errors and test how respective variables in the study are measured, and test of methodological change to the implementation of the research instrument (van Teijlingen and Hundley, 2001).

A pilot test is carried out with the aim of testing the survey questionnaire on a selected small group. This approach is employed before the commencement of the research study with the target research respondents. The pilot test for this study was carried with the selected group of experts through the following procedures.

Phase 1

An independent survey was pretested with 3 doctoral researchers, 3 operations management lecturers and 4 chemical engineering students at the University of Bradford. The selected people have requisite knowledge and experience in supply chain risk management research. Each respondent in the pre-testing phase was asked to assess the items of oil industry risk factors, supply chain risk management analytical techniques, effectiveness and efficiency of risk analysis techniques, supply chain elements, significant impacts of performance measures and approaches for managing supply chain risk. The respondents gave their feedback on the wording and design of the survey instrument and respective items. Suggestions given by the respondents were used to correct the survey questionnaire. This phase was used to establish the research instrument and test the reliability and adequacy of the research questionnaire. This phase identified inadequacies related to possibilities, inaccurate assumptions, redundancies and ambiguous items in the questionnaire, which were then reworded, reprioritised and modified were appropriates. For example, Wah Ahmed et al. (2016), pretested earlier survey questionnaires with three (3) oil industry experts and academics in their survey. Questionnaire items were revised after a pre-testing twenty-nine (29) measurement items of external factors, six (6) questions, ten (10) supply chain sustainable goal measurement items and one (1) question item were retained. This provided assurance of the research constructs, which were corrected and this consequently improved the content validity.

Phase 2

The second phase is the pilot study, which involves administering the research instrument with the research respondents. The intention is to conduct exploratory data analysis which evaluates the features of the questionnaire and capability of the sampled research subjects. Q-sort analysis was used to pre-evaluate convergent and discriminant validity of the questionnaire dimensions. The supply chain directors, managers and explorations and productions engineers in the identified oil industry, were requested to judge the research constructs based on the similarity and differences of scales. These selected respondents were given the scale within the definition of the research constructs with the aim for each to judge the validity of the construct indicator. The indicator of the construct validity is the convergence and divergence of items within the categories of items. The consistency of the item's category is considered as 'convergent validity' with similar constructs, and 'discriminant validity' with other dissimilar categorical items. However, the judges (individual reader or interpreter of the questionnaire items) were asked to independently assess each item and give their observation of the items' clarity, readability, and semantic implications of the items and sort them with the construct based on which seems to make more sense, according to the definitions given to the constructs in this study.

Inter-rater reliability of items were assessed to determine the extent to which the individual reader have agreed with their items' categorisations. Ambiguous items that were missed were reworded and those with low value were discarded.

Reliability involves the estimation of the accuracy of the questionnaire. This will help this study to confirm that the survey questionnaire measures what the instruments are intended to measure so as to generate expected outcome in the process of questionnaire administration to the same sampled respondents (Flynn et al., 1990; Forza, 2002; and Bryman, 2008). Cronbach Alpha was used for evaluating the reliability of the internal consistency of the survey instrument (Flynn et al., 1990).

5.7 Procedures for Assessing Supply Chain Risk Management in the Nigerian Oil Industry

This study is based on the collection of quantitative data from research subjects in the oil industry in Nigeria. The rationale for doing this are based on the significance of the research constructs and the approach for analysing quantitative data. However, the oil and gas industry in Nigeria, has a long history of inconsistencies in their supply chain.

The literature review, partial least squares structural equation modelling (PLS SEM) and analytical hierarchy process (AHP) are used for the evaluation of supply chain risk management in this study. The AHP is adopted to compliment the prioritisation of risk factors in partial least squares structural equation modelling (PLS-SEM). PLS-SEM allows for the modelling of the latent variables, reflective and formative constructs and effects on the relationship of this variables. The application of the AHP is to rank and facilitate a decision process on the risk with higher weight scores. The combined risk criteria weights and scores obtained is simulated for mitigating supply chain risk in the Nigeria oil industry. However, Kurn (2008) claimed that the adoption of risk assessment will structure research tasks and these attributes will greatly influence business procedures, which this study is going to adopt through the application of AHP stages for evaluating risk priority and PLS-SEM for assessing the relative supply chain risk management. This is represented in Figure 5.1.

These procedures will help supply chain practitioners provide a step-by-step assessment of risk management for the petroleum supply chain in the Nigerian oil industry. This framework will provide the process through which supply chain risk can be documented and managed.

The use of PLS-SEM will establish the effectiveness of the constructs which this research has adopted to explain and direct the paths this study. However, the adoption of PLS-SEM is subject to some difficulties that may arise in satisfying all the assumptions of the structural model. This perhaps is the significant limitations of structural modelling techniques. Although, some difficulties may arise in satisfying all the assumptions of structural model, the issue of assumptions is significant when a researcher is working with covariance-based structural equation modelling (CB-SEM). Therefore, normality assumptions are desirable when working with CB-SEM. In contrast, PLS-SEM generally do not required any assumptions about data distributions. For the sake of considering the distribution of normality a statistical test such as the Kolmogorov-Smirnov test and Shapiro-Wilk test are appropriates (Sarstedt and Mooi, 2014; Shapiro and Wilk, 1968; Shapiro and Wilk, 1965). However, two measures of distributions skewness and kurtosis are used to assess the normality in this study. Indeed, two assumptions deserves strong attentions in this study. Normality is assumed to be the distribution of skewedness. Multicollinearity is assumed to be more than two independent variables that are highly correlated. In order to detect the problems of multicollinearity in this study, an Eigen value (Lewis-Beck, 1980) or adopting the rule of thumb, by examining the data for any correlation coefficient > 0.8 or 80%, as suggested by Hauser (1975), is used. In order to overcome 'Normality' problems, data transformation by logarithm or square root will be undertaken. For multicollinearity, factor analysis or principal component analysis will be conducted.

5.8 Sampling Procedures

This involves a statistical process for selecting a subset of a population of interest with the aim of making observable and statistical inferences about a population (Bhattacherjee, 2012). The sampling procedures may involve probability and non-probability sampling (Kumar, 2011).

A probabilistic sampling allows for the selection of respondents and every member of the population has an equal opportunity for selection in a study. The probabilistic sampling techniques are grouped as simple random sampling, systematic sampling, stratified sampling, cluster sampling and multi-stage sampling. The parameters for this sampling are accurately determined and estimates are unbiased.

Furthermore, non-probability sampling allows for a researcher to select the research subjects based on the composition of the target population and the objective of the study (Fink, 2003). The selection of a sample in non-probability sampling is not statistically based, which at times could be prone to bias on the side of the researcher in selecting their subjects. Non-probability sampling is referred to as purposive and convenience sampling.

The sampling selection for this study is a convenience sampling type of sampling process. Convenience sampling allows the researcher to obtain a represented characteristic of the issues that relate to supply chain risk management from the respondents in the Nigerian oil industry. It is most appropriate in this study as using other sampling methods may provide inappropriate information for this study. For example, other sampling methods may require the researcher to conduct a representative statistical sample, and this may consequently lead to the choice of research subjects that are not experienced in the upstream oil production programme. Research subjects may be reluctant to give their a priori views on the theme of the study. This leads to variability in the phenomenon of study. Glaser and Strauss (1967) used theoretical sampling, which resulted in wide variability among the variables being observed. In contrast to randomised sampling, where variability emerged from random selection in a larger population (Maykut and Morehouse, 1994). Convenience sampling will motivate the research subject to respond to the survey questionnaire, because the subject's knowledge and technical skills are relevant to the study. The responses from the research subject through the use of convenience sampling will be relevant to this study's research questions. A convenience sampling technique is employed based on the research objectives of this study (Section 1.5), with the upstream oil industry functions - the exploration/production and supply chain activities - as the unit of analysis (Creswell, 2007). The scores obtained through the functional units will be used to conclusions of this study.

5.9 Unit of Analysis

The planned interactive approach through which research data are collected and analysed are referred to as units of analysis (Trochim, 2006). The intended focus of this study is to investigate the risk management strategy for supply chain management in the Nigerian oil industry. The planned focus for this study is to: (1) investigate current practices for supply chain risk management in the Nigerian oil industry (2) identify the critical disruptive risk to supply chains in the Nigerian oil industry (3) examine the impact of the associated oil industry risk on supply chain management and performance measures in the Nigerian Oil Industry (4) develop a methodology to evaluate disruption risks in the petroleum supply chain (5) define a research methodology for developing risk management options that could provide resilience in the supply chain of Nigerian oil industry (6) analyse the results of the implementation for disruption risk management in the context of supply chain in the Nigerian oil industry.

Here, the unit of analysis is the Nigerian oil industry. Supply chain management is the process of integration along the supply chain, which involves the upstream, midstream and the downstream. The integration approach consists of the value chain, which includes the functional activities in crude oil exploration, such as geological survey, production, procurement, transportation, refining, marketing and distribution. This study needed to narrow its scope of investigating the oil industry supply chain risk management in Nigeria and thus the focus of this study is the upstream of oil supply chain risk management in Nigeria's oil industry. This will help to spot research respondents with whom research data and questionnaires on the issue of supply chain risk in the Nigerian oil industry can be administered. The unit of analysis of this study will help to minimise errors in the process of illustrating the findings of this study for conclusions. The unit of analysis for this study will limit the conclusion of this study to the identified subjects. For example, if data is collected to compare two classes of social work students on their achievement on child protection assignment scores, the unit is the individual student because they have the scores for individual student. In another dimension, if I compare two classes within a given child protection atmosphere, the unit of analysis is the group in the case of child protection, because I have the child protection atmosphere scores. This analysis relates to the objectives of this study, on how the unit of analysis for this study can be derived. The scores for the (1) investigate current practices for supply chain risk management in the Nigerian oil industry (2) critical disruptive risk to supply chains in the Nigerian oil industry (3) the impact of the associated oil industry risk on supply chain management and performance measures in the Nigerian Oil Industry (4) evaluated disruption risks in the petroleum supply chain (5) developed risk management options that could provide resilience in the supply chain of Nigeria's oil industry (6) results of the implementation for disruption risk management in the context of supply chain in the Nigerian oil industry. The obtained scores from this unit of analysis, helps to confine the conclusions of this study.

5.10 Sample Size

The sample size consisted of fifteen (15) selected oil firms in Nigeria. Many operations management researchers have used a similar approach to select their sample size to represent the appropriate sample size of participating firms (Coughlan and Coghlan, 2002; Juttner et al., 2003; Juttner, 2005; Kern et al., 2010). The sample of the participating firm was drawn from the database of the "Nigerian Petroleum Resources Ministry" so as to provide cross-industry comparison or strength. A multiple industry sample will not be used because it poses some challenges and is beyond the scope of this study. Using a limited industry sample will help this research obtain reliable and focused information on risk management practices from the supply chain experts in the Nigerian Oil Industry.

While maintaining convenience sampling of the participating firms in this study, the research participants in this study were drawn from the team across the functional units in the Nigerian oil industry. These participants were purposively selected to represent the entire aggregated population of the oil and gas firms. Due to financial constraints and time, only two hundred and seventy-one (271) questionnaires were distributed to these participant practitioners in supply chain management in the Nigerian oil industry.

5.11 Ethical Issues and Confidentiality

The research ethics adopted for this study are in line with the ethics guiding principles for the University of Bradford incorporated into an ethics checklist and application form (EC 2377/Ethics Application E568) approved by the Chair of the Humanities, Social and Health Sciences Research Ethics Panel at the University of Bradford. The research ethics are based on the themes of consent, doing no harm to the subjects, privacy, social status, protection against any adverse effects for revealing information thus anonymity and confidentiality, place and time when research will take carried out with the subjects. All these principles were what guided and established the relationship between the researcher and the research. These principles motivated research participants to understand the legitimacy of this study and thus to cooperate and partake in this study (Dillman, 1983).

This survey questionnaire was conducted with the consent of respondents and the selected firms in the oil industry in Nigeria. The conveniently sampled research subjects were employees in the supply chain, logistics transport, service providers/contractors and suppliers, transporter, exploration and production, engineering and construction of the participated oil industry in Nigeria. Throughout the data collection for this study the research ethics principles were complied with in confidence and the terms of anonymity were maintained with the selected oil industry research subjects.

5.12 Data Collection Methods

Following the approval of the research ethics panel on the 22nd December 2016, the data collection began in January 2017. Based on the pilot test and sampling choice for this study, the oil companies and their subjects were selected (Section 5.10) and were contacted by email, which outlined the requirements of the oil company and their subjects. An assurance of confidentiality and anonymity on any information provided by the research subjects was highlighted.

This message was sent out in February 2017 and I began to receive positive responses in March. There were significant responses from the proposed research subjects on their willingness to part take in this study. Fifteen of the twenty companies approached agreed to participate in the study. A response rate of 75 percent. This response rate was determined by the schedule for the respondents to confirm their readiness to partake in this study.

Two hundred and seven-one (271) questionnaires were mailed to research respondents in the identified and selected oil industry for this study in Nigeria. The research subjects that participated in this study are the employees in the supply chain, logistics transport, service providers/contractors and suppliers, transporter, exploration and production, engineering and construction in the Nigeria Oil Industry. Out of the 271 survey questionnaires distributed to these respondents, one hundred and eighty-seven (187) questionnaires were completed and returned by the research subjects. This represents a response rate of sixty-nine (69) percent, however, eighty-four questionnaires were excluded from the analysis of this study. A summary of research respondents is outlined in Table 5.3.

Table 5.3: Analysis of Sampled Respondent Rate in the Oil Industry

Business Units Responses	Sample Respondents	% Rate of Respondent	Response Rate	% Rate	Rejected	Rejected %
Exploration and Production	70	25.83	53	28.34	17	20.23
Service Providers / Contractors	28	10.33	16	8.57	12	14.29
Business Development	26	9.6	14	7.49	12	14.29
Engineering and Construction	57	21.03	45	24.06	12	14.29
Marketing and Distribution	25	9.23	13	6.95	12	14.29
Logistics and Transport/Supply Chain	30	11.07	22	11.76	8	9.52
Others	35	12.91	24	12.83	11	13.09
Total	271	100	187	100	84	100

The analysis of the distribution of questionnaires to research respondents in the oil industry and allied partners, formed the basis for the statistical analysis of the data components or factors as they relate to the context of supply chain risk management strategy in the oil industry. This process ensures a deeper scrutiny of the sampled data set and enables the testing of research hypotheses and validation of research questions (section 1.6) of this study.

5.13 Non - Response Error Bias

The sampled population size of three hundred (271) represents the entire population of the study. The error bias for the sampled mean was determined by the proportion of employees that were conveniently selected from the firms in this study. Error bias is the confidence interval used for estimating the proportion of a population. Thus, 95% is the statistically accepted confidence interval in this study. The research participants in this study are the employees and stakeholders of the upstream of the oil industry in Nigeria.

5.14 Data Analysis

Data analysis involves the process through which data collected from the field of study are organised in order to give a meaningful interpretation to the information obtained from the research respondents. Creswell and Clark (2011) emphasise that data analysis is concerned with the presentation of data in a logical format with the aim of facilitating the interpretation of research results in a broader context.

To obtain research results for this study, computerised analytical data processing tools such as SmartPLS3, Statistical Packages for Social Sciences (SPSS) 22 and Microsoft Excel software, were used to obtain the research results. The usefulness of these three proposed software in this this research are; "SmartPLS3" will be us to analyse the partial least square structural equation model (PLS-SEM); the "Statistical Packages for Social Sciences" (SPSS) is use for regressions / correlation analysis; and "Microsoft Excel" is use for analysing the analytical hierarchy process (AHP) model to identify and prioritise disruption risk in supply.

Both multivariate and multi-criteria decision-making (MCDM) models were used to analyse the data. Multivariate analysis involves the application of statistical methods that simultaneously analyse multiple variables (Hair et al., 2017). Multi-criteria decision-making (MCDM) models help to determine the importance of criteria, such as analytical hierarchy process (AHP). In addition, descriptive data analysis was used to estimate the mean, apportion scores of variables and plot distributions where required. Analysis of the research questions based on the unit of analysis of items discussed in the literature review are appropriately exhibited in chapter 6 of this study.

5.15 Reliability and Validity of the Instrument

Reliability and validity of the research scale (psychometric properties) is the yardstick against which the adequacy and accuracy for measuring procedures are evaluated in this study. The reliability assessment for the supply chain risk management construct was carried out in order to ensure the degree of consistency of the supply chain risk constructs. This assessment of the individual construct (Internal Consistency reliability) is to ensure the rate at which the same construct will repeatedly generate the same outcome if it is administered to the same sample of respondents (Berg 2009; Bryman, 2008). However different accuracy methods are used for reliability measurement, such as inter-item correlation, average item-to-total correlation and Cronbach alpha.

Cronbach's Alpha are used to measure the consistency between the individual supply chain risk construct in this study. Cronbach Alpha is a widely used reliability of items scale, which ensures the conformity of items in a study (Cronbach, 1951). Cronbach's Alpha are used to evaluate the conformity of supply chain risk constructs of the Nigerian Oil Industry. In this study, Cronbach's Alpha (a) are used to evaluate the reliability of item by item on the supply chain risk constructs. Cronbach's Alpha (a) are used to test inter-item consistency (Field, 2009). The reason to adopting techniques for reliability testing in this study is that it is a commonly used approach for reliability test (Flynn et al., 1990). Cronbach's Alpha (a) can be express:

$$\text{Cronbach's Alpha (a standard)} = K^2\bar{e} \,/\, (1 + (K - 1)\bar{e})$$

where K is the item number being measured, ē is the mean of inter-item correlation, for example, the mean of (K - 1) /2 coefficients in the upper or lower quadrant of the correlation matrix. This strategy will improve the reliability of the research instruments.

Besides the measurement of the individual supply chain risk item’s consistency, an extended measure of the underlying constructs will be carried out for this study through a validity process. A construct validity is an assessment process which ensures that research constructs measure what it is expected to evaluate through a transformation of a set of research constructs into a set of correlated coefficients, with a new factors explaining the variable in the original set of data. The factor analysis is used to transform these variables into new sets of data (Kanelliaindis and Abacoumkin, 1983; Rummel, 1967). The variance of each of these components is measured by Eigen-values, which are equal to the sum of the squared loadings for factor of the supply chain risk.

5.16 Demographic Description of Research Subjects

This section illustrates the profile of the oil industry respondents. Three criteria are used to discuss the demography of the respective research subject (Hoff, 2003). These criteria include the functional designation, business units and experience of respondents and are discussed under the captions of Table 5.4, 5.5 and 5.6.

Table 5.4: Respondents Designated Position

Criteria	Frequency	Percent	Valid Percent	Cumulative Percent
Directors/Heads of Unit	41	21.9	21.9	21.9
Supply Chain Professionals	50	26.8	26.8	48.6
Technical/Engineering Managers	29	15.5	15.5	64.1
Project Teams	28	15.0	15.0	79.1
Business Developers	27	14.4	14.4	93.6
Others	12	6.4	6.4	100.0
Total	187	100.0	100.0	

Table 5.4 relates to the functional designation of the research respondents. The heads of unit/directors (26.7%) overwhelmingly responded to the survey. The supply chain professionals accounted for 21.9% of the subjects. However, the technical/engineering managers accounted for 15.5%, the project team 15%, business developers 14.4% and others 6.4% respectively.

Table 5.5: Business Units

Criteria	Frequency	Percent	Valid Percent	Cumulative Percent
Exploration & Production	53	28.3	28.3	28.3
Service Providers/Contractors	16	8.6	8.6	36.9
Business Development	14	7.5	7.5	44.4
Engineering & Construction	45	24.1	24.1	68.4
Marketing & Distribution	13	7.0	7.0	75.4
Logistics & Transport/Supply Chain	22	11.8	11.8	87.2
Others	24	12.8	12.8	100.0
Total	187	100.0	100.0	

Table 5.5 defines the responses of business units to the study. It is most interesting to see that the highest response rate of 28.3% is from exploration and production. The service providers/contractors response rate was 8.6%, while business development, engineering/construction, marketing/distribution, Logistics Transport/Supply Chain and others accounted for 7.5%, 24.1%, 7%, 11.8% and 12.8% respectively.

Table 5.6: Experience of Respondents (Yrs.)

Criteria	Frequency	Percent	Valid Percent	Cumulative Percent
0 - 5yrs	31	16.6	16.6	16.6
6- 10yrs	51	27.3	27.3	43.9
11 - 15yrs	64	34.2	34.2	78.1
16 - 20yrs	34	18.2	18.2	96.3
21yrs and Over	7	3.7	3.7	100.0
	187	100.0	100.0	

Table 5.6 established the experience of the research respondents, which shows 16.5% of the respondents have work experience of 0-5 years. While 27.3% of respondents have 6-10 years' experience. Respondents with 11-15 years, 16 - 20 and 21 years and over accounted for 34.2%, 18.2% and 3.7% respectively. The experience of the respondents in the oil industry were significant for explaining the current supply chain risk management practice in the Nigeria oil industry.

5.17 Conclusion

The method applied to operationalise the research questions and identify the research subjects in this study were presented in this chapter. The chapter described the abstract process of designing a precise measure for the theoretical framework. The precise measurement approach using survey methods, involves pretesting and pilot testing of the questionnaire survey, ethical issues and confidentiality and data collection methods with the research subjects in the Nigerian oil industry.

CHAPTER SIX

Implementation of Systematic Methodology for Disruption Risk in Supply Chain

6.0 Introduction

This chapter focuses on the implementation of the proposed systematic method for evaluating disruption risk in the supply chain of the upstream petroleum industry. The implementation of this process is based on the data collected from the sampled research participants in the Nigerian oil industry. These data relate to the assessment of disruption risk in supply chain of Nigeria's Oil Industry. The study involves respondent demographics, upstream oil industry risk constructs, risk analysis techniques and appropriate supply chain risk management strategies, which were adopted from the theoretical research framework (Figure 4.1). Items from the research framework were translated to form the questionnaire survey instrument in Appendix 1. However, this survey instrument was analysed from the diverse theoretical and empirical perspectives using SmartPLS software v.3.2.6 (Hair et al., 2017) to evaluate the structural model for this research. SmartPLS will be the central tool used in analysing and testing the research model. Any other modelling and testing tools, such as Microsoft Excel and Statistical Package for the Social Sciences (SPSS) were purposely used for this research, to complement and confirm the consistency of any emerging intended assumption. This research aimed to develop a model for evaluating the attributes of behavioural-based and buffer-oriented mechanisms on supply chain risk in the oil industry. To achieve this, a reflective measure of Partial Least Squares of Structural Equation Model (PLS-SEM) was used to facilitate the evaluation of the research constructs. Partial least squares' is a regression driven structural equation model (SEM) approach, which is appropriate for testing latent (unknown) variables. This regression driven modelling technique automatically displays the paths and relationships between the risk management strategy, the oil industry risk, supply chain and organisational performance measures constructs. The displayed construct results were used to examine the coefficient of determination (R^2), F and Q square effects and structural model of collinearity. Furthermore, tested hypotheses are central to the consequential attributes of risk management strategy on oil industry supply chain risk and performance measure. All these features of PLS techniques are designed to explain variance, predict and logically build theory (Chin, 1998). However, analytic hierarchy process (AHP) will aid decision-making for prioritising associated risk items in the oil industry risk constructs. The descriptive analysis, which this research adopted for implementing PLS-SEM, are strictly in line with accepted guidelines (Hulland, 1999; Chin, 1998). These guidelines will help to address the research questions (Section 1.6), which are linked with the research hypotheses for this study. The research hypotheses to be tested are:

H1: The extent to which the oil industry is involved in managing supply chain risk using behavioural-based mechanisms is positively related to the perceived degree of oil industry risk sources.

H2: Managing supply chain disruption risk using buffer-oriented mechanisms is positively related to the perceived degree of supply chain risk sources in the oil industry

H3: Associated oil industry risk significantly impacts supply chain management and performance measures in the Nigerian oil industry.

Besides, the hypotheses which this study has proposed to examine, issues around research question (RQ4) will be discussed.

6.1 Examination of Data

The survey questionnaire data collected from the field study were downloaded into the coding sheet, scrutinised and checked in order to ensure the data were correctly filled out by the research respondents. A significant number of 68 questionnaire responses were found to be inappropriately completed and were removed from the dataset. Missing values were replaced with -99. However, 16 items were totally missing from the overall dataset, due to respondent inconsistencies in answering questions asked and multiple responses to similar questionnaire items. A total of one hundred and eighty-seven (187) questionnaires were used to analysing the field survey results in this study.

6.2 Measurement Development Procedures for Research Analysis

Following the cleaning up of the collected data, all missing items were replaced based on individual missing corresponding items. The inconsistent items were removed from the total number of obtained items used for the analysis of this research data. The measurement of the results in this study are reflectively evaluated on a five-point Likert scale of 1-5 indicated scales. The risk management strategy involves the logical adoption of agency theory, which involves the approaches for addressing conflicts and eliminating risk in the supply chain of the Nigerian oil industry. These approaches for eliminating risks were categorised in agency theory as behavioural-based and buffer-oriented mechanisms (Elkins, et al., 2005; Eisenhardt, 1989). The risks minimisation strategies were grouped as proactive or reactive risk management approaches (Dani and Deep, 2010; Knemeyer et al., 2009). Proactive risk management is the behavioural pattern used to eliminate a risk source, such as collaboration with supply chain partners. The re-active risk management strategies are buffering, which do not prevent risk from occurring but are used to absorb the negative effects of risk (Hoffmann, et al., 2013). To assess the oil industry risk, various literature relating to the practice of management of risk in the petroleum and related industry were used to develop three constructs for this study: upstream petroleum risk exploration and production; environmental and regulatory compliance; and geopolitical risk (Wan Ahmad et al., 2016; Ite et al., 2016; Omenikolo and Amadi, 2010; Ite and Ibok, 2013; Pereseina et al., 2013; Hoffmann, et al., 2011; Abbasi and Nilson, 2012; Xia and Tang, 2011; Kishik and Oladunjoye, 2009; Worldbank Group, 2009; Wolf, 2009). These studies have substantially contributed to the development of risk items used for the research instrument. For supply chain management, a literature review of supply chain improvement strategies in the Nigerian oil industry was conducted. The performance measurement construct was moderated (Yusuf et al., 2013). The respective research items' scale designed for this study were incorporated in the research instrument (Appendix 1).

6.3 Model Measurement

In order to ensure that the item scale measured the latent variable, which forms the model for this study. This process helps to establish the existing relationships between the latent constructs and corresponding indicators. However, the goal of the conceptual model (Figure 4.1) is to explain the relationships between risk management strategy, supply chain risk and their ultimate impact on supply chain performance measures.

The assessment of the model in this study involves composite reliability (See Fig. 6.1), which evaluates the internal consistency of the model. Individual indicator reliability and average variance extracted (AVE) were used to assess convergent validity of this research. Furthermore, the evaluation of the research measurement model consists of discriminant validity. Hence, the Fornell-Larcker criterion for cross loading, which emphasises the adoptions of heterotrait-monotrait (HTMT) ratio of correlations, was used to examine the assessment of discriminant validity (Table 6.2). Each of these quality criterion was used to evaluate the related psychometric perspective for this study.

6.3.1 Internal Consistency Reliability

This study established a significance level of 0.60-0.75 of reliability range and this shows good statistical properties for Cronbach's Alpha. However, the accepted threshold is 0.70 (Henseler et al., 2009; Chin, 1998). The Cronbach's Alpha assumed that all items in the scale have equal outer loadings on variables. The outcome of PLS-SEM prioritised these indicators in accordance with the reliability of the construct. This divergent outcome of Cronbach's Alpha negatively underestimates the internal constituent reliability. The limitation of Cronbach's Alpha is technically relevant to explore composite reliability, which is more appropriate for taking all outer loadings into account. Due to matter of principle, Bagozzi and Yi (1988) asserted that composite reliability can be used to replace Cronbach's Alpha, especially in exploratory research as in this study. Exploratory research in the sense that risk management strategy for managing supply chain risk in Nigeria, is still under explored due to the sluggish response of researchers to exploring this risk management context. The process for exploring the phases of this research involves selecting research questions for this study, examining relevant published literature addressing supply chain management strategies within the global petroleum sectors, manufacturing, commercial aviation, defence, agriculture and biotechnology and other business that share similar features with the oil industry. In addition, agency theory is explored to address the research questions (Section 1.6). These form the basis of the research model (Figure 4.1 and Figure 6.5) for this exploratory research.

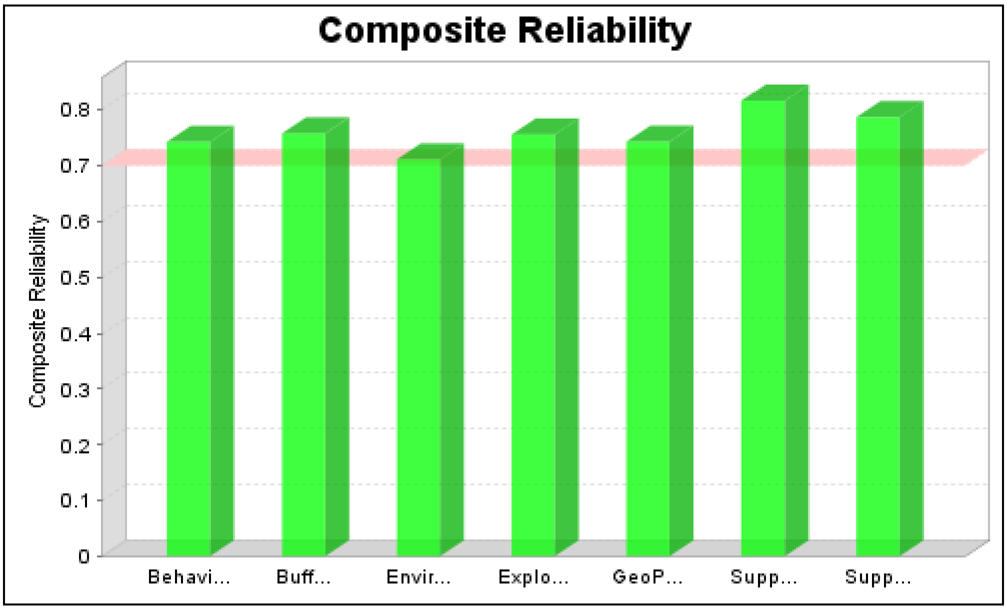


Figure 6.1: Composite Reliability

The composite reliability for items in this study have taken all the relevant outer loads of the model measurement details into consideration. Hair et al. (2017) suggested that 0.60 to 0.70 is an appropriate significant threshold for an exploratory study. The derived composite reliability significance level for this research model's measurement constructs were significant at 0.71-0.82. This value suggests that each scale was very reliable. Hair et al. (2017) described this composite reliability as an appropriate figure for advanced exploratory study. The internal consistency reliability of items in this research shows that there are no semantically redundant "items that may cause error terms in the correlations process for this study" (Hayduk and Littvay, 2012; Drolet and Morrison, 2001). The significant level of composite reliability of 0.71-0.82, indicates a sound level of internal consistency reliability. Fornell and Larcker (1981), illustrated a mathematical equation for this as:

$$CR = \frac{(\sum \lambda_i)^2}{(\sum \lambda_i)^2 + (\sum \epsilon_i)}$$

Hence, λ (lambda) is the standardised factor loading and *i* and ε is the respective error variance for item *i*. The error variance (ε) is estimated based on the value of the standardised loading (λ)
as:

$$\epsilon_i = 1 - \lambda_i^2$$

6.3.2 Convergent Validity

Convergent validity is the degree at which a measure correlates positively with an alternative measure of a similar construct. The convergent validity for each item in this study is summarised in Table 6.1, obtained using SmartPLS software (v.3.2.6).

Table 6.1: Reliability and Validity Assessment for Constructs

Items	Cronbach Alpha	Composite Reliability	AVE
Behavioural Based Mechanism	0.603	0.743	0.554
Buffer-Based Mechanism	0. 603	0.758	0.672
Environmental Compliance Risk	0.562	0.711	0.509
ExploProd Risk	0.665	0.756	0.516
Geo-Political Risk	0.625	0.743	0.549
Performance Measure	0.703	0.787	0.543
Supply Chain	0.752	0.817	0.577

Item indicators for this research measure the converge constructs in Table 6.1. The evaluation of the convergent validity in this study was based on the outer loadings of indicators and the average variance extracted (AVE). The convergent validity for each item presented in Table 6.1, was strongly correlated with related constructs because all items loadings were positively correlated.

The AVE is greater than 0.50 because the latent constructs in this study accounted for significant proportions of variance on the average scores (Hair et al., 2010; Fornell and Larcker, 1981).

6.3.3 Discriminant Validity

This is a circumstance through which a construct is distinctive from other constructs by empirical norms. To empirically distinguish a construct from other sets of variables, this study explored the Fornell-Larcker criterion. Fornell, (1981) who prescribed the average variance extracted (AVE) (Table 6.1) as the grand mean of square loading of the indicators associated with the research construct. Hair et al. (2017) conclude that AVE is equivalent to the communality of the research constructs. The square root between the latent variable were presented in Table 6.2.

Table 6.2: Fornell-Larcker Criteria

Discriminant validity	Beh Mgt	Buffer Mgt	EnvironPro Risk	ExploProd Risk	GeoPol Risk	Perf Measure	SCMgt
Behavioural-Based Management	**0.744**						
Buffer-Oriented Management	0.389	**0.819**					
Environmental & Compliance Risk	0.274	0.18	**0.713**				
Exploration & Production Risk	0.397	0.279	0.310	**0.719**			
Geopolitical Risk	0.319	0.318	0.326	0.313	**0.741**		
Performance Measure	0.510	0.400	0.326	0.221	0.231	**0.737**	
Supply Chain Management	0.394	0.238	0.295	0.337	0.260	0.463	**0.759**

Fornell-Larcker is another method for assessing discriminant validity. This approach compares the square root of the average variant extract (AVE) value with latent variable correlations. The attained values listed in Table 6.2, are significantly different from 1 (Anderson and Gerbing, 1988). The estimated constructs square for this study is less than 1 or < 1. Therefore, the statistical norms is satisfied for the constructs used in this study (Hulland, 1999). This implies that each variable and each of the constructs are significantly distinct from one other. The discriminant validity conformed to the set rule of thumb for square value of correlations, that it must be smaller than the average variance extracted (AVE) for the respective construct (Fornell and Larckner, 1981) - see Table 6.2.

6.4 Exploratory Factor Analysis

In order to uncover the underlying structure of the relative dimension of scales of sets of variable, 'Exploratory Factor Analysis' (EFA) was conducted on the individual measuring constructs. The output of the SPSS software (Version 22) showed that twenty-three factors were clearly identified with significant loadings. However, the Eigen values of these twenty-three values were above 1, (See Appendix 4). The eigen values are relatively associated to the represented explained variance in a given linear component. The standardised factor loading is 0.68. This loading is above the minimum threshold of 0.60 (Hair et al., 2009). However, the value of Cronbach’s Alpha was significant at 0.60-0.75 and composite value 0.711-0.817.

For the overall model constructs, a Kaiser-Meyer-Olkim (KMO) coefficient of 0.60, which complied with the rule of thumb and the parametric value of the Chi-Square of Bartlett’s test corresponded to 3669.804 with a significance level of 0.000. This shows the good fit of the Exploratory Factor Analysis as shown in Table 6.3.

Table 6.3: Kaiser-Meyer-Olkin (KMO) Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.600
Bartlett's Test of Sphericity	Approx. Chi-Square	3669.804
	df	1830
	Sig.	.000

In relation to the commonalities, that is, the common variance ratio for each item explained by the factor (See Appendix 5), the explained factor items had an average of 0.68 for the twenty-three (23) items. However, item 23 (Appendix 4) is relatively small for weighing against factors 1-22. The large eigenvalues which produces a meaningful factor, which is judged through graph plots of each eigen value (Y-Axis) against the (X-Axis). This representation is by scree plot as shown in figure 6.1a.

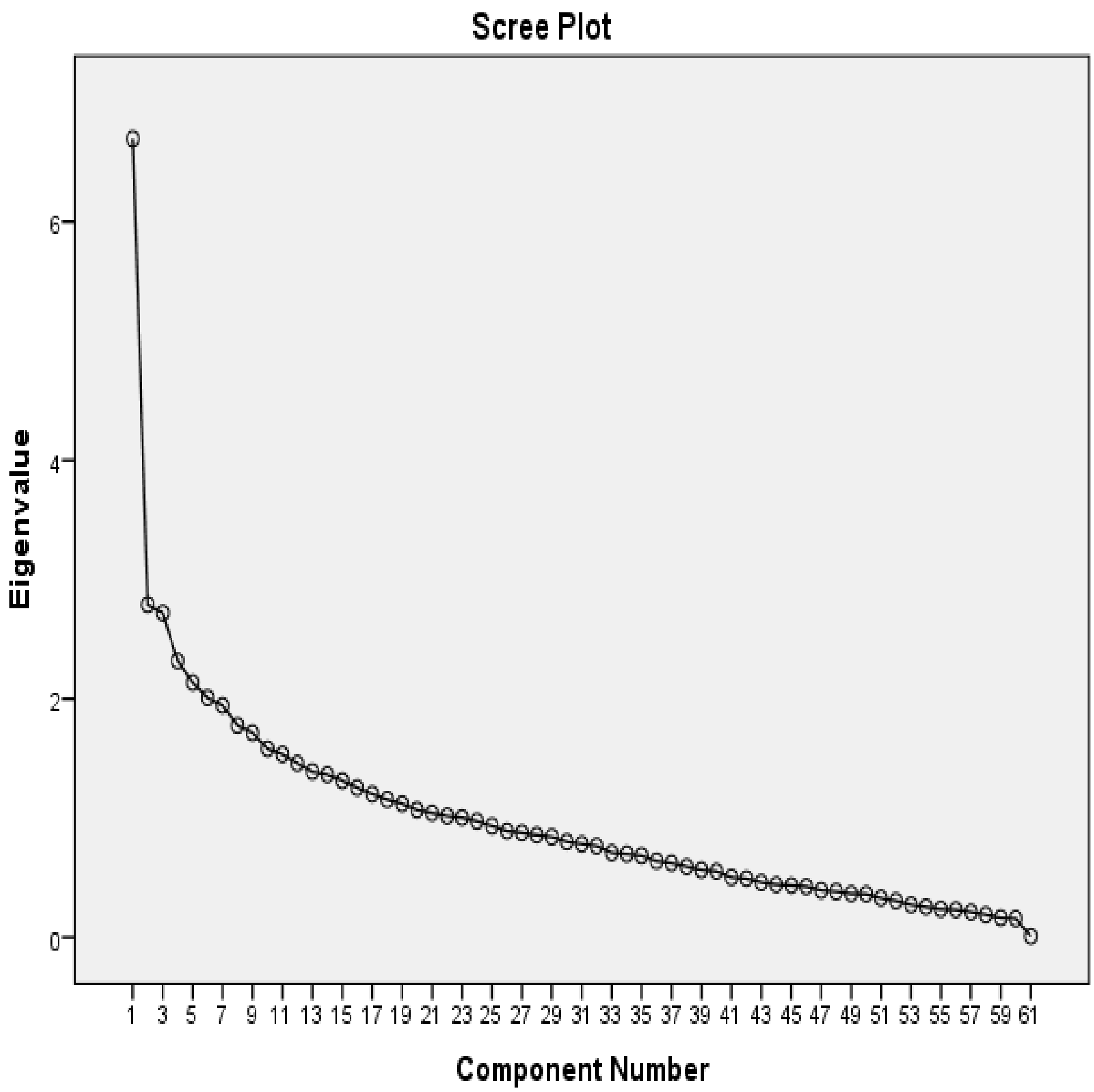


Figure 6.1a: Extracted Components for Scree Plot

The scree plot displays the associated eigen values with components or factors. The representation (see figure 6.1a) visually displays the factor associated to the research sample explored in the study. However, the points of inflexion for component 23 is greater than 1. This criterion complied with recommendation for retaining eigen values greater than 1 (Kaiser, 1960; and Lilliefors, 1967). The scree plot was visually used to evaluate the components which explains the variability in this research.

6.5 Evaluating Model Fit

To maximise the explained variance within the structural model for this study. The maximisation of explained variance helped to ascertain the predictive influence on the model on endogenous latent constructs. The process of assessing the model fit enabled the research to determine how well the hypothesised model structure fitted the empirical data and enhanced the identification of a mis-specified research model.

The root square residual covariance (SRMR), 'RMS-Theta' value of 0.10 was obtained for this study. This value is below the indicated threshold of 0.12 or 12%. This indicates a well-fitting model, whereas a high value above the thresholds of 0.12, shows a lack of fit (Henseler et al., 2009). The explained variance of this research is maximised as an accepted model fit for this study. Hence, the summary for the estimated model for this research are; SRMR 0.085; d_ULS 9.86; d_G 2.428; Chi-Square 2,010.91 and NFI 0.309.

6.6 Developing Risk Structure with Analytical Hierarchical Process (AHP)

The oil industry risk factors which consist of exploration production, environmental and regulatory compliance risk and geopolitical risk were discussed in the conceptualisation section (4.6). These studies were assessed with the derived output oil industry risk factors or components of Partial Least Squares Structural Equation Modelling (PLS-SEM). The oil industry risk exploration and production, environmental and regulatory compliance, geopolitical risks factors were derived from PLS-SEM. The pairwise comparison matrix of the respective oil industry risks was evaluated with Microsoft Excel. The estimation aimed at obtaining the normalised matrix and geometric means for the Priority Vector (PV). The reason for using these multiplicative preference rationing techniques is to utilise the feature of mutual exchange privileges of systems and methods for determining preference and identifying critical oil industry risk affecting the upstream oil industry supply chain management that can be rationed. The rationale for geometric mean and normalised matrix approaches is to satisfy the mutual exchange principle of pairwise comparison (Kim et al., 2007).

6.6.1 Pairwise Comparison of Exploration and Production Risk Factors

The risk pairwise comparison factors (See Appendix 6) and the normalised matrix of exploration and production risk is exhibited on Table 6.4.

Table 6.4: Normalised Priorities for Exploration and Production Risk.

Variables	Risk Criteria	Geometric Mean (PV)	Rank
EPR3	Lack of sufficient recovery quantities of hydrocarbon	0.123	3
EPR4	Low permeability of oil reservoir	0.104	6
EPR5	Error in reserve oil forecast	0.088	9
EPR6	Delivery inappropriate production equipments /lead time	0.109	5
EPR7	Formation damages / unexpected drilling conditions	0.102	8
EPR8	Regulatory time limits for exploration	0.103	7
EPR9	Experience of rigs workers / Inadequate production capacity	0.112	4
EPR10	Ageing of oilfields /infrastructure	0.126	2
EPR12	Availability of capital investment fund	0.134	1

The output of the priority vector (eigenvectors) were presented on a risk priority score graph, which depicted the criticality, medium and low level risk factors affecting the management of the petroleum supply chain in Nigeria. Figure 6.2 exhibits the priority vectors for the prioritised components of exploration and production risk in the Nigerian oil industry. The relative weight and indicated coefficient with other exploration and production risk factors are shown on Table 6.4.

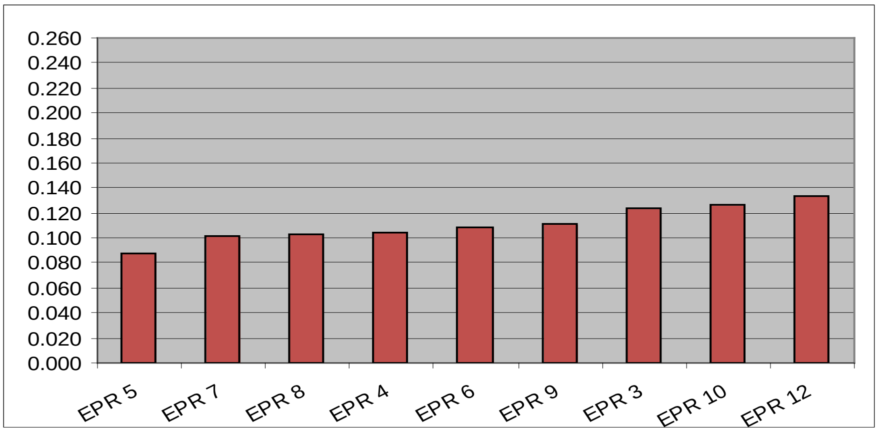


Figure 6.2: Comparing Priorities of Exploration and Production Risk

Figure 6.2 identified the critical priority scores associated with the exploration and production risk. The identified critical important associated exploration and production risk involves availability of capital investment funding (EPR 12), ageing of oilfields /infrastructure use for oil exploration (EPR 10), lack of sufficient or short falls oil recovery quantities of hydrocarbon (EPR 3), experience of rigs workers / inadequate production capacity (EPR 9), delivery inappropriate production equipment /lead time (EPR 6), regulatory time limits for exploration (EPR 8), formation damages / unexpected drilling conditions (EPR 7) and low permeability of oil reservoirs (EPR 4). The exploration and production risks are excessively high for the oil industry to operate. Furthermore, the observed trends risk priority for the error in the oil reserve forecast is within the thresholds of 0.06 or six (6) percent.

This study revealed that availability of capital investment fund 13.4% and ageing of oilfield infrastructures 12.6%, are the most critical risks affecting supply chain performance in the Nigerian oil industry. The excessively high risk trend of availability of capital investment fund and ageing of oilfield infrastructures pose a greater threat to the exploration and production risk of crude oil in the Nigeria oil industry. These findings can concomitantly have a negative influence on the oil industry's ability to accurately forecast the oil resources needs. This can affect the oil resource reserves and the national revenue and gross domestic product (GDP) in Nigeria. Moreover, Figure 6.3 shows the priority of the associated risk to environmental and regulatory compliance risk.

6.6.2 Pairwise Comparison of Environmental and Regulatory Compliance Risk

The risk pairwise comparison matrix and normalised vector for environmental and regulatory compliance risk respectively, are exhibited in Appendix 8 and 9.

Table 6.5: Priorities for Environmental and Regulatory Compliance Risk

Variables	Risk Criteria	Priority	Rank
ERC2	Oil spillage as a result of ageing infrastructure	0.095	7
ERC 5	Management of petroleum resources	0.156	3
ECR 6	Inadequate government policies on petroleum	0.160	2
ERC 7	Change to government economic policy	0.151	4
ERC8	Cargo routeings and scheduling	0.177	1
ERC10	Adverse weather conditions	0.141	5
ERC11	Environmental impacts & legislative policy compliance	0.120	6

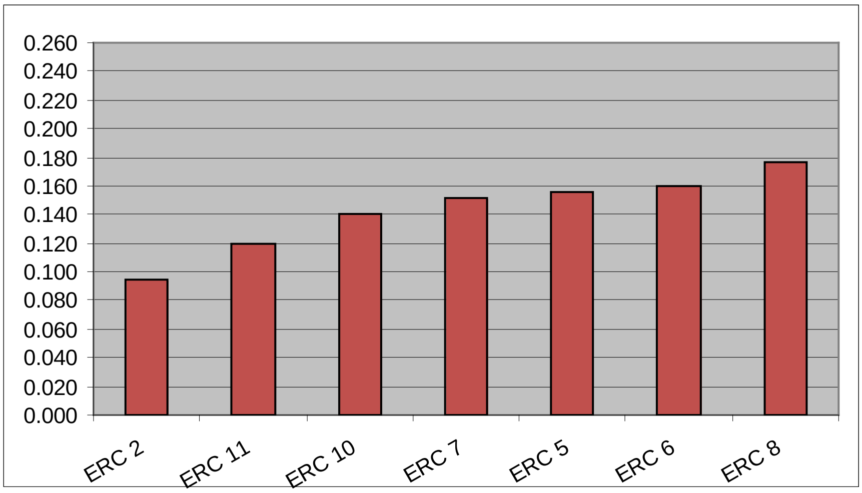


Figure 6.3: Comparing Priorities of Environmental & Regulatory Compliance Risk

The most important identified critical risks are presented in the following order of priority: cargo routeings and scheduling (ERC 8), inadequate government policies on petroleum (ERC 6), management of petroleum resources (ERC 5), change to government economic policy (ERC 7), adverse weather conditions (ERC 10) and oil spillage as a result of ageing infrastructure (ERC 2). These findings show that Cargo routeings and scheduling and inadequate government policies are critical risk factors affecting the petroleum supply chain performance in Nigeria's oil industry. Furthermore, Figure 6.4 shows the priority value for the geopolitical risk associated with the oil industry in Nigeria.

6.6.3 Pairwise Comparison of Geopolitical Risk

The risk pairwise comparison matrix and normalised vector for geopolitical risk criteria are exhibited in Appendix 9.

Table 6.6: Priorities for Geopolitical Risk Criteria.

	Criteria	Priority	Rank
GPR1	Theft of oil infrastructures	0.114	6
GPR2	Armed conflicts / militant attacks on oil rigs	0.099	7
GPR3	Unsustainable operational practices	0.131	4
GPR4	Complexities of interactions with oil communities	0.167	3
GPR5	Demand volatility	0.193	1
GPR6	Supply variability	0.181	2
GPR7	Piracy threats to the security of oil carrying vessels employee	0.114	5

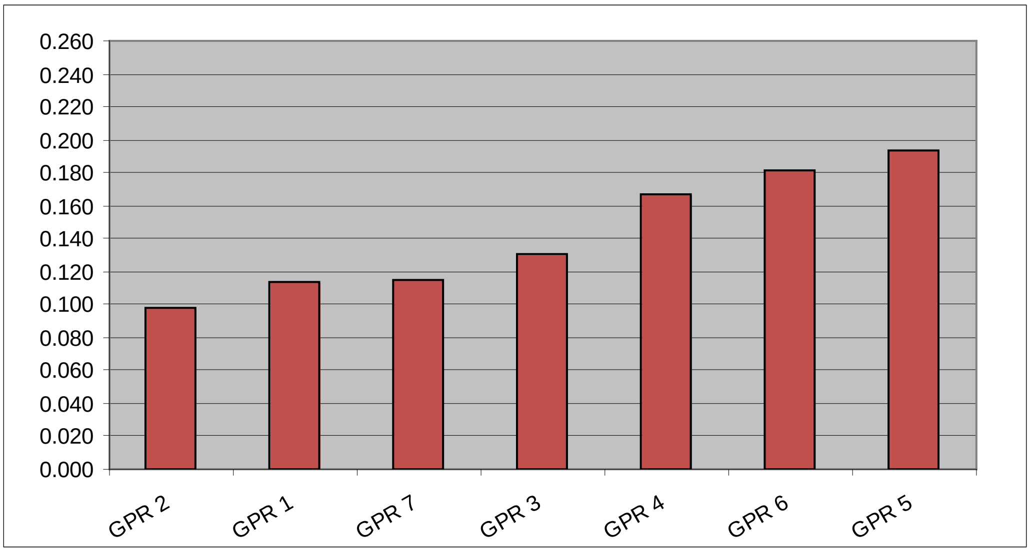


Figure 6.4: Comparing Priorities of Geopolitical Risk

Figure 6.4 presents the prioritisation of geopolitical risk in the Nigeria oil industry. Demand volatility (GPR 5), supply variability (GPR 6) and complexities of interactions with the oil communities (GPR 4) have been identified as the most critical important risk components in geopolitical risk. Furthermore, piracy and military attack are identified as medium risk associated to the geopolitical risk. This finding shows that demand volatility and supply variability are the critical risks affecting supply chain performance in Nigeria.

In summary, a pairwise comparison matrix evaluation is highly relevant in addressing research question (RQ2) which investigate the critical oil industry risks that affects supply chain management in Nigeria's oil industry. The estimation of the normalised matrix and geometric means for the priority vectors (PV), provide relative weights among all the compared elements of the oil industry risk. However, the overall summary of these findings shows that availability of capital investment funding (EPR 12), ageing of oilfields /infrastructure use (EPR 10), cargo routeings and scheduling (ERC 8), inadequate government policies on petroleum (ERC 6) and demand volatility (GPR 5) and supply variability (GPR 6) are the risk factors affecting supply chain and performance measures in Nigeria's oil industry. This finding will further be addressed through partial least squares structural equation modelling (PLS-SEM). The relationships of the supply chain risk and risk management strategy on the research model will be simulated on figure 6.5. This reiterative process is based on the procedures which have been designed for assessing the supply chain risk management for this study (See Figure 5.1).

6.7 Structural Model Estimation

6.7.1 Assessing PLS-SEM Structural Model

The results of the structural model are shown in Figure 6.5. The model of observed variance in supply chain performance measure is 26%. However, the supply chain management observed variance is 22%; environmental and regulatory compliance is 0.08 or 8%, geopolitical risk 15% and exploration and production risk exhibited the variance of 0.21 or 21%. The structural model path coefficients which influence the supply chain risk management in the oil industry are presented in Figure 6.5.

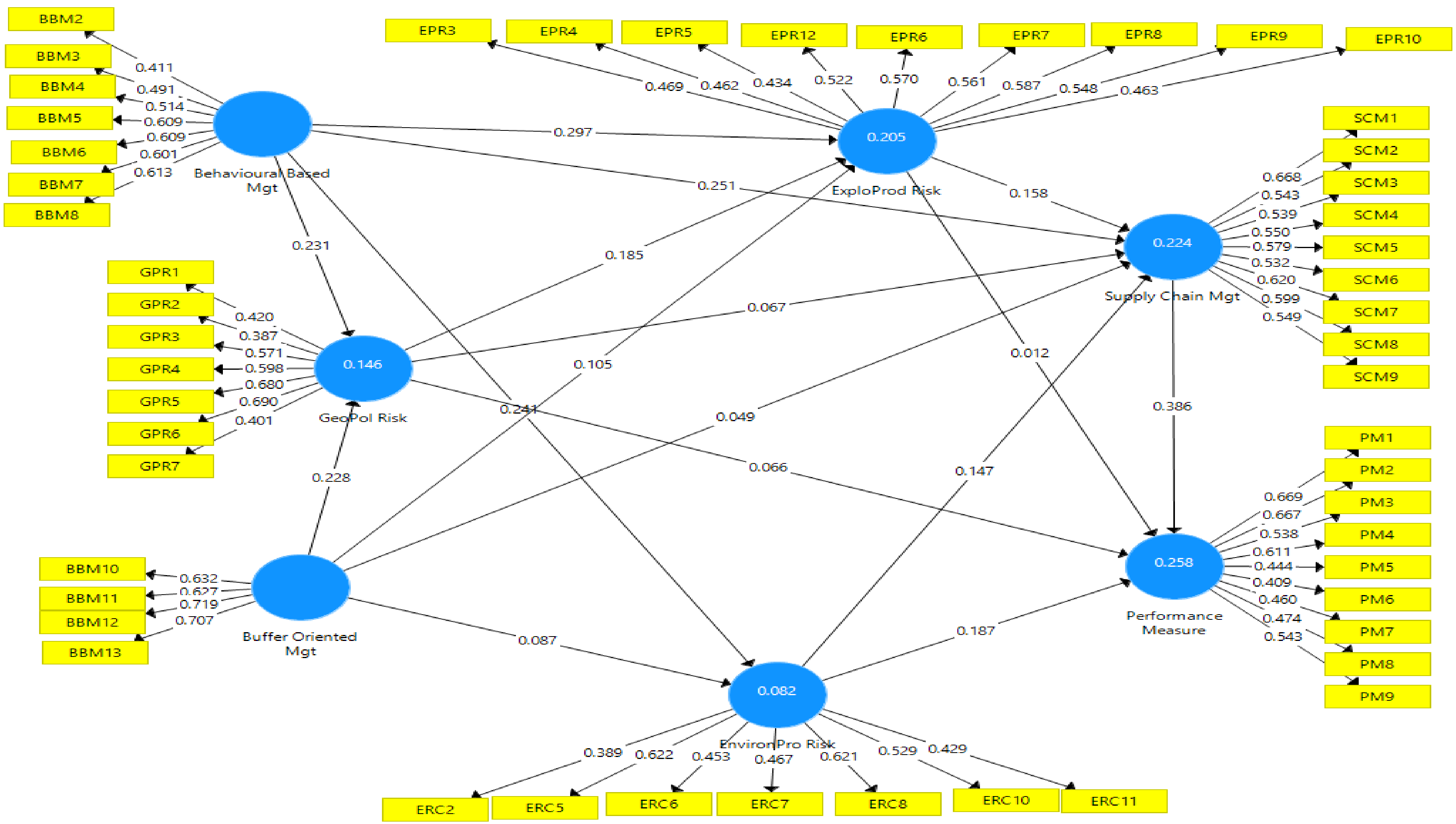


Figure 6.5: Research Structural Model

These paths coefficients show the influence of the independent latent variables on the dependent variables. The path model evaluation in Figure 6.5, pictorially displayed the respective hypothesis and the consequential relationship, which characterises this research framework. These examined output were obtained from the PLS structural equation model.

Table 6.7 provides the path coefficients and the statistical test of significance, tValue and pValue, for this study.

Table: 6.7: Results of Path Coefficients and Significance Testing

Indirect Results	Path Coefficients	*t* Values	*p* Values
Behavioural-Based Management → Environmental Regulatory Risk	0.241	2.410	0.016
Behavioural-Based Management → Exploration & Production Risk	0.297	3.497	0.001
Behavioural-Based Management → Geopolitical Risk	0.231	2.773	0.006
Behavioural-Based Management → Supply Chain Management	0.251	2.906	0.004
Buffer-Oriented Management → Environmental Regulatory Risk	0.087	0.777	0.437
Buffer-Oriented Management → Exploration & Production Risk	0.105	1.080	0.281
Buffer-Oriented Management → Geopolitical Risk	0.228	2.658	0.008
Buffer-Oriented Management →Supply Chain Management	0.049	0.588	0.556
Environmental Regulatory Risk → Performance Measure	0.187	2.481	0.013
Environmental Regulatory Risk → Supply Chain Management	0.147	1.926	0.055
Exploration & Production Risk → Performance Measure	0.012	0.141	0.888
Exploration & Production Risk → Supply Chain Management	0.158	1.916	0.056
Geopolitical Risk → Exploration & Production Risk	0.185	2.326	0.020
Geopolitical Risk → Performance Measure	0.066	0.725	0.469
Geopolitical Risk → Supply Chain Management	0.067	0.861	0.390
Supply Chain Management → Performance Measure	0.386	5.490	0.000

6.7.2 Collinearity Statistic

The examination of the collinearity statistic, variance inflation factor (VIF) in this study, involves the assessment of VIF value for all the exogenous (independent) constructs. The behavioural and buffer-based mechanisms constructs in the structural model were assessed for collinearity. The assessment of each of the corresponding latent constructs of the rows are the exogenous variables of exploration and production risk, environmental and regulatory compliance risk and geopolitical risk, which are the predictors of supply chain and performance measurement. The analysis of the independent variable is relatively moderate, which implies that collinearity among these exogenous latent variables are low and, does not pose any problems to the structural model (Ringle, et al., 2015; Manson and Perreault, 1991). The estimated multi-collinearity in the research was calculated from the VIF scores ranging from 1.0-1.46. Therefore, the examined values of collinearity are below the threshold of 5. This relative value is significant for developing subsequent relationship among the latent constructs for this study (Hair et al., 2010).

6.7.3 Structural Model Path Coefficients

The estimated structural model in Figure 6.5 was used to determine the relational path coefficients which established the hypothesised relationships among the constructs. These constructs involve risk management strategy (behavioural-based management and buffer-oriental mechanisms), oil industry risk (exploration and production, environmental/regulatory compliance risk and geopolitical risk), supply chain and performance measures. Figure 6.5, displays these constructs as endogenous latent variables. The PLS-SEM was used to obtain the path coefficient results. The path coefficients are useful means by which researchers differentiate between the statistical levels of significance within arrays of sampled data of a study. The coefficient significance of these structural paths were determined with a bootstrapping procedure (187 cases, 500 samples).

6.8 Risk Management Strategy and Supply Chain Risk in Nigeria's Oil Industry

In order to answer the research questions (RQ1 and RQ2) which address the issue of how the oil industry is involved in managing supply chain risk by adopting the logic of risk management strategies as being positively related to degree of oil industry risk. The supply chain risk management strategies classified for this study include behavioural-based and buffer-oriented mechanisms. Partial Least Squares Structural Equation Modelling (PLS-SEM) path coefficient techniques were explored to evaluate the impact of the independent variables of behavioural-based and buffer-oriented mechanisms on the dependent variables, exploration and production, environmental regulatory compliance and geopolitical risks. This aimed to point out the probabilities of the efficiencies of risk management strategies on supply chain risk in the Nigerian oil industry (Figure 6.5). However, a path coefficient assessment for behavioural-based and buffer-oriented mechanisms was significantly related 0.504; pValue<0.05 level. This relational observation is realistic and evidenced, although the author of this study has deliberately excluded it from the model paths (Figure 6.5) in order to reduce congestion on the paths of the structural model. In addition, most of the excluded path coefficients were insignificant to predict accept relationship. Figure 6.5a and 6.5b have respectively displayed the full structural estimated model and the model bootstrapping for research model.

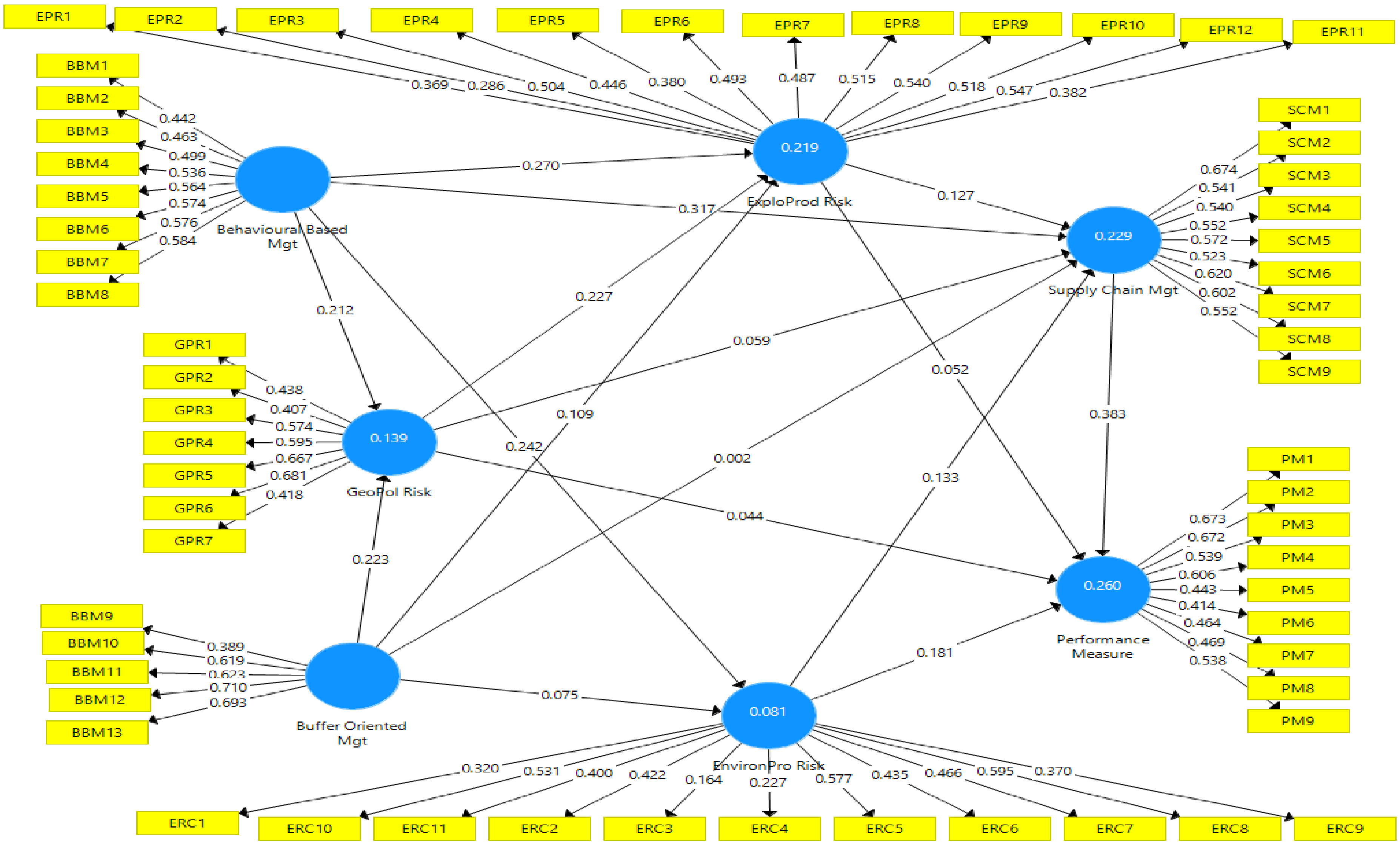


Figure 6.5a: Structural Estimated Model

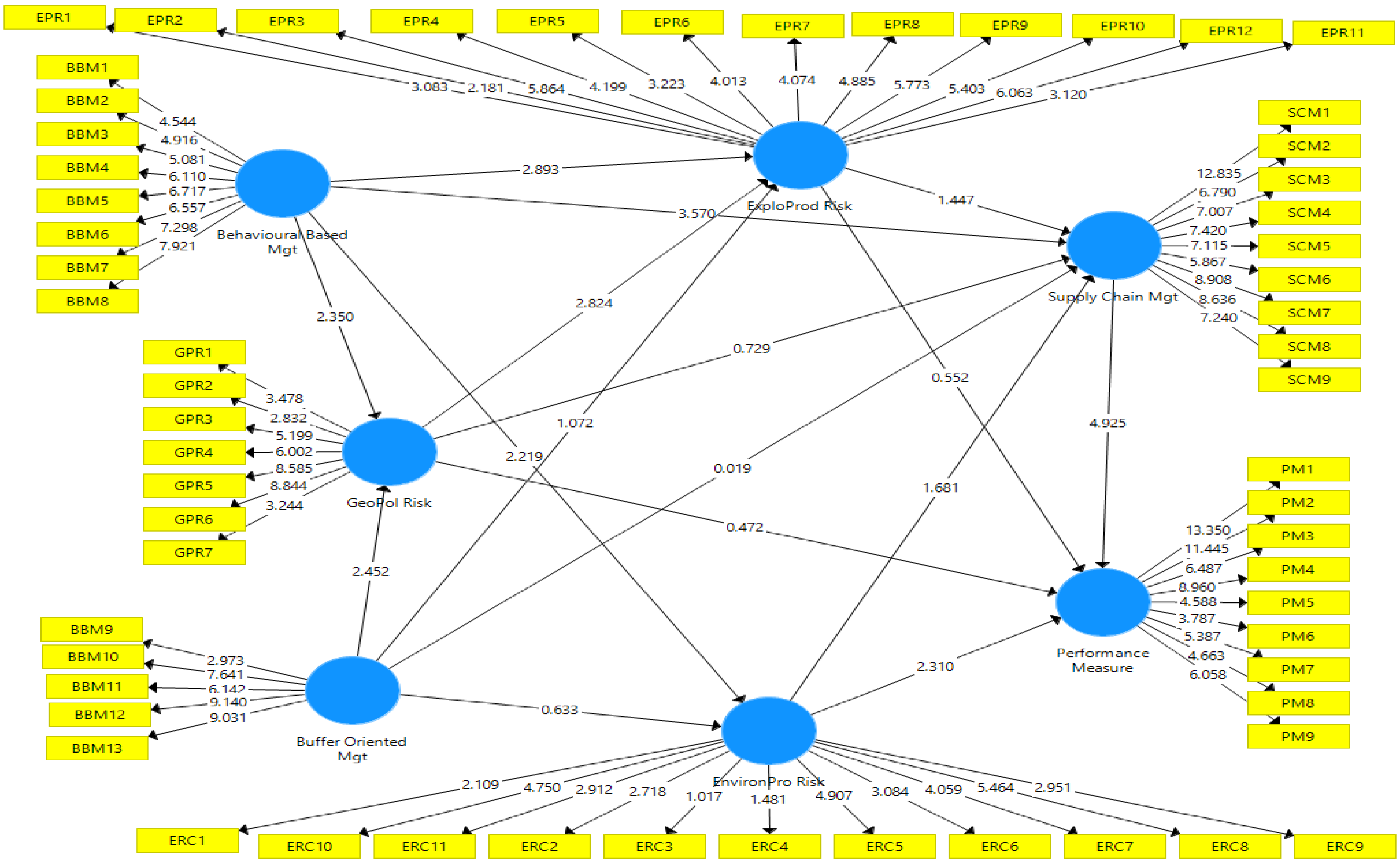


Figure 6.5b: Model Bootstrapping - Complete Research Model

Behavioural-based mechanisms significantly predict the relationship between exploration and production risk. The path coefficient of behavioural-based mechanisms on exploration and production was significantly positive (0.297; t-statistic 3.497 and $P < 0.05$ level). There is a significant positive relationship between behavioural-based mechanisms on exploration/production risk. However, there is a strong indication that the influence of the exploration and production risk moderately impacted the management of supply chain. The statistical results (0.158; t-statistics 1.916; pValue ≥ 0.05) have supported this assumption. This premise is addressed through the first hypothesis (H1), which is divided into three sub-categories (H1a-c).

Hypothesis H1a is concerned with the relationship between behavioural-based mechanisms and exploration and production risk. This hypothesis states "the extent to which the oil industry is involved in managing supply chain risk using Behavioural-Based mechanisms is positively related to the perceived degree of oil exploration and production risk". This proposition is strongly supported that behavioural-based mechanisms is related to the effective management of petroleum exploration and production risk. Table 2.2 (Section 2.3), has classified organisational risk as associated with production disruption. The classifications of organisational disruptive risks include, machinery failures, change to production schedules, overcapacity (Manuj and Mentzer, 2008). This study identified the availability of investment fund (EPR 12) and ageing of oilfield infrastructures (EPR 10) as critical risk factors affecting the efficiency of supply chain in Nigeria’s oil industry. The influence of the availability of investment fund and ageing of oilfield infrastructures are the reasons for the low positive relationship on supply chain (0.147; t-statistics 1.916; Pvalue >0.05) in the model. This analysis further shows that the increase in the exploration and production risk factors can negatively affect supply chain management, if no mitigating factors are in place to address the impacts of supply chain disruption risk.

Hypothesis H1b, involves the extent to which the oil industry is involved in using behavioural-based mechanisms to manage environmental regulatory compliance risk as a perceived degree of petroleum supply chain risk. The path coefficient for behavioural-based mechanisms and environmental and regulatory compliance risk are positively significant 0.241; pValue<0.05 level (See Figure 6.5). The significance of this path coefficient shows that behavioural-based mechanisms positively impacted on environmental and regulatory compliance risk. However, the path coefficient for environmental regulatory compliance risk revealed that cargo routeing and scheduling (ERC 8) and inadequate regulatory policies on petroleum (ERC 6) are critical risk factors affecting supply chain performance in Nigeria's oil industry.

The attribute of cargo routeing and scheduling (ERC 8) and inadequate regulatory policies on petroleum (ERC 6) have significantly influenced the supply chain 0.147, tValue 1.926; P≥0.05. (Table 6.7). The significant attributes of cargo routeing and scheduling (ERC 8) and inadequate regulatory policies on petroleum (ERC 6) supply chain, can improve the performance measure in the Nigerian oil industry. Furthermore, Hoffmann et al. (2013) concludes that high environmental uncertainty consequentially resulted in moderate change in supply chain performance. This assumption shows that the path coefficient for environmental and regulatory compliance risk have led to moderate change in the management of supply chain performance in the Nigerian oil industry, despite the influence of behavioural-based mechanisms on environmental regulatory compliance risk. This coefficient indicates that behavioural-based mechanisms impacted on supply chain management (Figure 6.5).

In summary, these findings suggest that management of the oil industry should pay more attention to cargo routeing and scheduling (ERC 8) and ensure adequate regulatory policies on petroleum (ERC 6) in order to improve the management of petroleum supply chain performance.

Hypothesis H1c, is concerned with the management of supply chain disruptions using behavioural-based mechanisms' relationship with geopolitical risk affecting supply chain. The path coefficient for the behavioural-based mechanisms shows a significant relationship between geopolitical risk, which is 0.231; t-statistics 2.773 and p-value≥0.05. Managing supply chain risk using behavioural-based mechanisms is positively related to the perceived degree of geopolitical risk. This positive indicator of the path coefficient shows that behavioural-based mechanisms has a positive impact on geopolitical risk. However, the model shows that demand volatility (GPR 6), supply variability

(GPR 5) and complexity of interactions with the oil community (GPR 4) have insignificantly impacted supply chain performance. The proportional coefficient of demand volatility (GPR 6), supply variability (GPR 5) and complexity of interactions with the oil community (GPR 4) have negatively contributed to supply chain and performance measures in Nigeria's oil industry. This research finding suggests the need to provide a response for managing these negative geopolitical criteria of demand volatility (GPR 6), supply variability (GPR 5) and complexity of interactions with the oil community (GPR 4) and ensure resilience is created in the supply chain risk management in Nigeria's oil industry.

The second hypothesis (H2) focused on the assessment of the extent to which the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms as a perceived related degree of oil industry risk affecting the petroleum supply chain in Nigeria. This hypothesis (H2) is subdivided into three dimensions classified as H2a, H2b and H2c.

Hypothesis (H2a) is concerned with how the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms is positively related to the perceived degree of exploration and production risk. The path coefficient for buffer-oriented mechanisms and exploration and production risk were relatively significant with 0.105; T-statistics=1.080; and P>0.10. However, the estimated probability shows an insignificant P-value=0.28, between buffer-oriented mechanisms and exploration and production risk. This finding established that the buffer-based mechanisms are not able to absorb the negative influence of inadequate availability of investment fund and ageing of oilfield infrastructures. The combination of buffer-oriented mechanisms and exploration and production risk, resulted in a proportionate downward trend in the coefficient buffer-oriented mechanisms' direct influence on supply chain management (0.049; T-statistics 0.588 and P>10). This relationship is a confirmation that the geopolitical criteria of demand volatility (GPR 6), supply variability (GPR 5) and complexity of interactions with the oil community (GPR 4), coupled with other factors, such as theft of infrastructures, armed conflicts, non-compliance with environment legislatures and unsustainable operational practices, have grossly affected the management of petroleum supply chain and performance measure in Nigeria's oil industry. The buffer-based mechanisms have failed to create resilience in the supply chain in the Nigerian oil industry. Therefore, the path coefficient for buffer-oriented mechanisms and exploration and production risk indicates the perceived influence of buffer-oriented mechanisms for managing supply chain disruption risk in the oil industry in Nigeria, are grossly insignificant. This finding does not support hypothesis (H2a) and this calls for management to intensify its capabilities to effectively coordinate its buffer management approach on the management of the production risk components, in order to improve the oil industry, supply chain performance.

Hypothesis (H2b) is concerned with the extent to which the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms as positively related to perceived degree of environmental and regulatory compliance risk. The path coefficient of buffer-oriented mechanisms and environmental and regulatory compliance risk is 0.087, T-statistics 0.777; $P>0.10$. This result shows an insignificant coefficient value due to the negative influence of cargo routeing and scheduling and inadequate government policies, coupled with the frequent change in government policies in Nigeria. These environmental and regulatory compliance risk criteria have prevented the ability of the buffer-based techniques to create resilience in supply chain performance in Nigeria's oil industry. In addition, the corresponding environmental and regulatory compliance risk criteria of management of petroleum resources (ERC 5), complexities of transportation network due to the oilfield cluster (ERC 9) and environmental impacts of legislative policies have negatively impacted a buffer-oriented approach and creating the rigidity to supply chain resilience in Nigeria's oil industry. This corresponding findings are supported with the coefficient 0.049; T-statistics 0.588; $P > 0.10$.

Hypothesis (H2c) explores the extent to which the oil industry is involved in managing supply chain risk using buffer-oriented mechanisms is positively related to the perceived degree of geopolitical risk. The path coefficient for buffer-oriented mechanisms was significant with a value of 0.228; t-statistics 2.658; $P \geq 0.05$. This significant indicator positively influenced the geopolitical risk factor affecting the management of petroleum supply chain in Nigeria. Despite the strong path coefficient between buffer-oriented and geopolitical risk, the consequential relationship for geopolitical risk and supply chain remain statistically insignificant (0.062; T-statistics 0.861; P>10. This insignificant relationship is due to the impact of geopolitical risk criteria of demand volatility, supply variability, and complexities interacting with the oil communities, which have hindered the effectiveness of buffer-oriented risk management strategy. These geopolitical risk criteria of demand volatility, supply variability, complexities in interacting with the oil communities render the supply chain vulnerable to risk in the Nigerian oil industry. Therefore, there is no existing direct relationship between geopolitical risk and supply chain and performance measure. This finding is due to geopolitical events, such as demand volatility, supply variability, complexities in interacting with the oil communities, unsustainable operational practices, armed conflicts and piracy threats affecting the production of crude oil in Nigeria.

In summary, this hypothesis recommends the need for a coherent review of the current risk management mechanism to effectively manage supply chain disruption risk. This study will help to improve the supply chain performance and organisational performance measures in Nigeria’s oil industry.

6.9 Effects of Supply Chain Risk Management and Performance Measures

Following the underpinning research question (RQ3) for this study, which seeks to address the components of the research hypothesis that state the associated relationship of oil industry risk and its significant impacts on supply chain management and organisational performance measure. The impact of associated oil industry risks on the petroleum supply chain management and organisational performance measure were hypothesised based on the research structural model (See Figure 6.5). The components of the hypothesised constructs in the research model include, exploration and production, environmental regulatory compliance and geopolitical risks. These conceptual dimensions were individually tested on the supply chain and organisational performance measure constructs. The supply chain management variables consist of supply chain visibility/information access (SCM1), contract strategy/collaboration (SCM2), clustering of oil network demand (SCM3), vertical and horizontal supply chain (SCM4), storage capacity (SCM5), supplier visibility (SCM6), geographical concentration (SCM7), demand volatility (SCM8) and operational complexity (SCM9). In addition, the organisational performance measure constructs consist of quality of service/customer satisfaction (PM1), responsiveness (PM2), flexibility to requirement (PM3), costs (PM4), innovation (PM5), dependability/order fulfilment (PM6), pro-activity (PM7), delivery reliability (PM8) and return on investment (PM9). The conjectural research statements which glue the associated oil industry risks with the petroleum supply chain management and organisational performance measure were subdivided in three sections (H3a, H3b, H3c) detailed below.

The analysis of hypothesis (H3a) involves the assessment of the direct effects that resulted from the contribution of exogenous constructs thus, behavioural and buffer-oriented techniques impact on the oil industry risks variables. The analysis of hypothesis (H3a) tested the effects of exploration and production, environmental and regulatory compliance and geopolitical risks on supply chain management and performance measure. The three oil industry risks were individually tested on supply chain management and performance measure as a direct effect. However, there is an indirect effect mediated by supply chain constructs on the performance measure (Table 6.8).

Table 6.8: Significant Testing of Indirect Effects

Indirect Results	Indirect Effects	t Values	p Values
Behavioural-Based Management → Exploration & Production Risk	0.043	1.518	0.130
Behavioural-Based Management → Performance Measure	0.201	3.831	0.000
Behavioural-Based Management → Supply Chain Management	0.104	2.423	0.016
Buffer-Oriented Management → Exploration & Production Risk	0.042	1.646	0.100
Buffer-Oriented Management → Performance Measure	0.072	1.346	0.179
Buffer-Oriented Management → Supply Chain Management	0.051	1.671	0.095
Environmental Regulatory Risk →Performance Measure	0.057	1.756	0.080
Exploration & Production Risk → Performance Measure	0.061	1.825	0.069
Geopolitical Pol Risk → Performance Measure	0.040	1.086	0.278
Geopolitical Risk → Supply Chain Management	0.029	1.249	0.212

The indirect effect is the relationship between two latent variables via third (the mediating) constructs. The summation of both the direct and indirect effects were used as an evaluating techniques for the total effects. The significance testing of the "Total Effects" are presented in Table 6.9. The model as shown in Figure 6.5 was used as a representative process for imitating the effects of the applied logic on exploration and production, environmental and regulatory compliance, geopolitical risks on supply chain management and organisational performance measure. This linked the research question (RQ3) to this hypothesis, which intended to address how the oil industry risk impacts supply chain management and performance measure.

Testing the established hypotheses H3a, H3b, H3c, the standard path coefficients established mediating effects of direct and indirect relationship for the oil industry risks constructs on supply chain management and performance measure.

Table 6.9: Significance Testing of the Total Effects

Total Effect	**Total Effect**	**tValue**	***p*Values**
Behavioural-Based Management → Environmental Regulatory Risk	0.241	2.45	0.015
Behavioural-Based Management → Exploration & Production Risk	0.339	4.185	0.000
Behavioural-Based Management → Geopolitical Risk	0.231	2.581	0.010
Behavioural-Based Management → Performance Measure	0.201	3.831	0.000
Behavioural-Based Management → Supply Chain Management	0.355	5.399	0.000
Buffer-Oriented Management → Environmental Regulatory Risk	0.087	0.851	0.395
Buffer-Oriented Management → Exploration & Production Risk	0.147	1.567	0.118
Buffer-Oriented Management → Geopolitical Risk	0.228	2.537	0.011
Buffer-Oriented Mgt → Performance Measure	0.072	1.346	0.179
Buffer-Oriented Management → Supply Chain Management	0.100	1.350	0.178
Environmental Regulatory Risk → Performance Measure	0.244	3.400	0.001
Environmental Regulatory Risk → Supply Chain Management	0.147	2.024	0.044
Exploration & Production Risk → Performance Measure	0.073	0.945	0.345
Exploration & Production Risk → Supply Chain Management	0.158	1.934	0.054
Geopolitical Risk → Exploration & Production Risk	0.185	2.230	0.026
Geopolitical Risk → Performance Measure	0.106	1.087	0.277
Geopolitical Risk → Supply Chain Management	0.097	1.179	0.239
Supply Chain Mgt → Performance Measure	0.386	4.799	0.000

Research Question 3

Table 6.9.1: Results of Hypothesis Testing (H3a) Supply Chain Risk and Supply Chain Management

Hypothesis	**H3ai**	**H3aii**	**H3aiii**
	EPR → SCM	**ERC → SCM**	**GPR→ SCM**
Paths Coefficient	0.158	0.147	0.097
T-Statistics	1.934	2.024	1.179
Significance	0.054	0.044	0.239

Hypothesis 3a is concerned with the total effects of the supply chain risk on the management of supply chain in Nigeria. The path coefficient for exploratory and production risk on supply chain management are significantly positive P>1, and environmental & regulatory compliance risk p>1. However, the path coefficients for geopolitical risk on supply chain management is significant negative at P-Value of 0.239 or 24%. Although, the central aim of the hypothesis is to assess the supply chain risk which does significantly impact the management of supply chain. This result shows that geopolitical risk negatively impacts supply chain management in Nigeria. This analysis shows that there is a direct partial mediation and full indirect mediated relationship. This finding corresponds to other studies (Zhao et al., 2010; Baron and Kenny, 1986) whose findings were based on the concept of partial and full mediation.

Table 6.9.2: Results of Hypothesis Testing (H3b)

Supply Chain Risk and Supply Chain Performance Measure

Hypothesis	**H3bi**	**H3bii**	**H3biii**
	EPR → PM	**ERC → PM**	**GPR→ PM**
Path Coefficients	0.O73	0.244	0.106
T-Statistics	0.945	3.400	1.087
Significance	0.345	0.001	0.277

Hypothesis H3b examined the total impact of the associated oil industry risk on performance measure. The total coefficient of environmental & regulatory compliance risk on performance is significantly positive at 0.001. However, exploration & production and geopolitical risk have negatively impacted performance measure at a significance p-value level of 0.345 and 0.277. This finding shows that exploration & production risk and geopolitical risk are the associated oil industry risks that impact the supply chain and performance measure. Hendricks and Singhal (2013) found that production disruption is associated with a statistically significant increase. The high statistical significant of 0.345 is associated with exploration and production risk on performance measure, which strongly revealed that exploration and production disruption risk does adversely impact performance measure in Nigeria's oil industry. Supporting this finding, Hendricks and Singhal (2013) affirmed that production disruption impacts long-term shareholder value in a firm.

This analysis shows a complementary mediation among the environmental and regulatory compliance, supply chain management and performance measure. Therefore, complementary in this study implies that, the direct and indirect effect of environmental regulatory compliance risk and supply chain management are respectively significant, as they point to the same directions (Hair et al., 2017: p. 232).

In summary, this finding provides empirical support for mediating the absolute value of the standard path coefficient role of the associated oil industry risk in the model of this study. More so, exploration and production risk, environmental regulatory compliance and geopolitical risk represent the mechanisms that trigger the relationship between supply chain management and performance measure. However, geopolitical risk have negatively impacted on supply chain and performance measure. Therefore, exploration and production risk and geopolitical risk respectively, have provided the empirical evidence indicating the associated oil industry risk which significantly impacts supply chain and performance measure (RQ3) in the Nigerian oil industry. In addition, maximum efforts are need to focus on the environmental and regulatory compliance risk in order to create supply chain resilience to absorb the associated oil industry risk in Nigeria's oil industry. This result calls for the appropriate risk management strategy to address these internal and external oil industry risks that have affected the management of supply chain in the Nigerian oil industry.

6.10 Appropriate Supply Chain Risk Management Techniques

Managing supply chain risk in the oil industry is crucial and there are a series of techniques that can be explored to manage risk in the petroleum industry. This study has identified an array of risk management techniques which have been used in various industrial setting. To understand the appropriate risk management techniques that the Nigerian oil industry can use to manage their supply chain risk, this study sought the opinions of the research respondents on the risk analysis techniques included to the survey questionnaire. The various risk management techniques which were adopted in this research include linear programming (RMT1), game theory (RMT2), Monte-Carlo Simulation ((RMT3), decision tree ((RMT4), statistical analysis ((RMT 5), analytical hierarchy process (RMT6), failure mode effective analysis (FMEA) (RMT7) structural equation modelling (SEM) (RMT8), multiple regression analysis (RMT9), real option theory (ROT) (RMT10) and portfolio analysis model (PAM) (RMT11). These relative risk management techniques and their usefulness to petroleum exploration and supply chain risk management were discussed in section 2.9 in this study.

Table 6.10: Model Summary and Stepwise for Risk Management Techniques

Independent Variable	Coefficient	Std Error	T-value	Sig-Level	Collinearity Statistics VIF
(Constant)	1.106	0.351	3.154	0.002	-
RMT 2	0.273	0.068	4.021	.000	1.155
RMT 4	0.165	0.071	2.341	.020	1.061
RMT 5	0.148	0.071	2.077	.039	1.175

R^2 (Adj) = 0.175 SE= 0.951 Durbin-Watson = 1.611

The perceived results of risk management techniques were translated into a regression model. The mean experience of the research subjects was compared with risk management techniques based on the surveyed data. Table 6.10, showed the predicting sum for the respondents' experience by the individual mean of the risk management techniques (RMT1-RMT11). The stepwise model identified three important risk management techniques which are the most commonly used for managing supply chain risk in the oil industry in Nigeria. These important risk analysis techniques were game theory (RMT2), statistical analysis (RMT5) and decision tree (RMT 4). However, linear programming (RMT1) was identified as a dependent variable for risk management techniques for predicting the significance of supply chain risk management. Indeed, structural equation modelling, multiple equation analysis, real-options, Monte-Carlo Simulation (RMT3), failure mode effective analysis (FMEA) (RMT7), analytical hierarchy process (RMT6), and portfolio analysis model (PAM) (RMT11) were not selected as an important predictor for managing supply chain risk in Nigeria oil industry. This does not imply that these risk management analytic techniques are not relevant to risk management in the oil industry in Nigeria. This reason for deselecting risk analytic techniques are due to the fact that these risk analytic methods are mostly use for petroleum exploration in Nigeria. For example, (Enyinche and

Nwosu, 2011) recently applied Failure Mode Effective Analysis (FMEA) as risk analysis methods for managing pipeline risk in the Niger Delta in Nigeria.

The identified three important risk management techniques' 't-value' provide more explanation as shown in Table 6.10. When all the variables in the model were assessed in the regression model, yielded an F ratio of 3.711 which is highly significant at 0.00 (Table 6.11).

Table 6.11: Analysis of Variance for Risk Management Techniques

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	40.777	10	4.548	3.711	.000
Error	162.903	176	.939		
Total	204.679	186			

R^2 (Adj) = 0.149   Durbin-Watson=1.636

The significant deductions which can be derived from the above analysis, is that the relationships displayed the coefficient value of the independent variables. The significant three factors in Table 6.10, show a positive coefficient, while structural equation modelling, multiple equation analysis, real-options, linear programming (RMT1), Monte-Carlo Simulation ((RMT3), failure mode effective analysis (FMEA) (RMT7), analytical hierarchy process (RMT 6) and portfolio analysis model (PAM) (RMT11) had negative coefficients. The level of risk management techniques increases the trends of the positive significant constructs in a positive direction. This explanation is responsible for the overall significant level of risk management techniques summarised in Table 6.11.

In addition, this study explored the opinion of the research respondent to confirm if there are other risk analytical techniques used to manage risk in their oil supply chain in Nigeria. The respondents were asked to respond on a Likert three (3) point scale of "yes", "No" and "Does not know". The responses of the research subjects are presented in Figure 6.6.

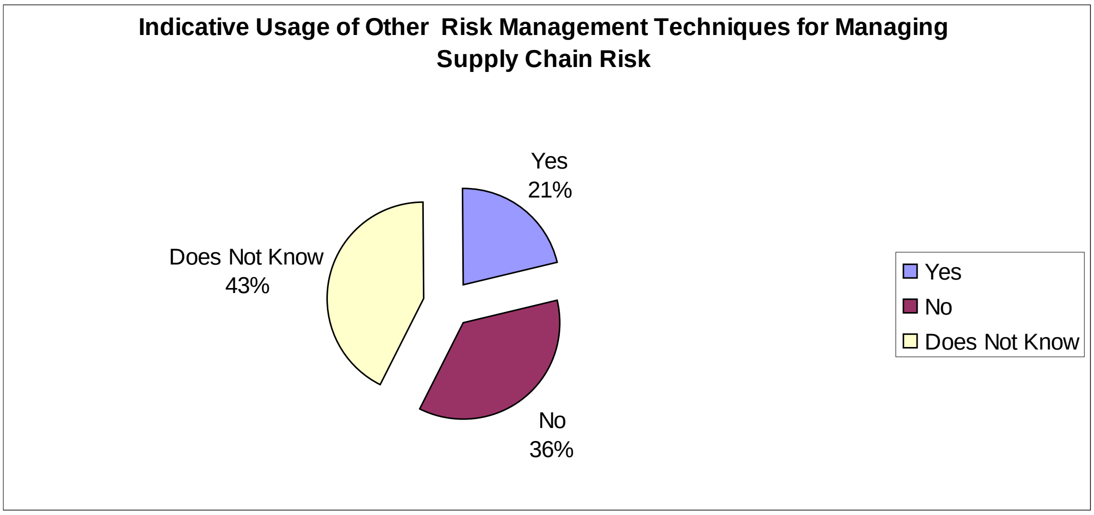


Figure 6.6: Indicative of Alternative Risk Management Techniques.

Figure 6.6 shows the opinion of the respondents on the indicative use of alternative risk management techniques for supply chain. About (21%) twenty-one percent of respondents indicated that their organisation uses other risk management techniques for managing supply chain risk. Furthermore, thirty-six (36%) percent of the respondents, indicated that they are unable to confirm if other risk management techniques are used to manage supply chain risk. Indeed, forty-three (43%) percent of the respondents, indicated that they "do not know" if their industry uses other risk management techniques for managing their supply chain risk. This diverse view of the research respondents call for a sensitivity approach for modelling disruption risk in the supply chain of the Nigerian oil industry. This will impose a coherent understanding of the application of risk management techniques in Nigerian oil industry.

6.10.1 Specified Risk Management Techniques for Supply Chain Risk

The respondents were asked to name other risk management techniques used for managing supply chain risk in Nigeria's oil industry. The various risk analytic techniques were grouped into similar to currently used techniques, interpretative techniques and no clue of any other techniques. Figure 6.7 presents the responses of the research respondents on other specified risk management methods used for assessing and managing supply chain risk in the Nigerian oil industry.

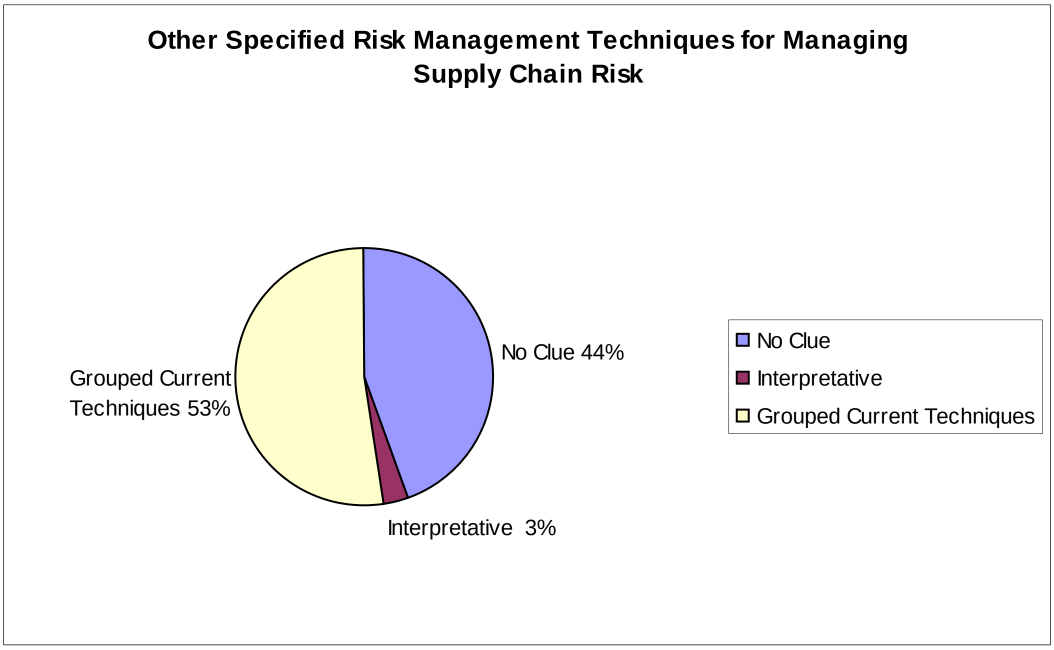


Figure 6.7: Specified Risk Management Techniques for Supply Chain Risk

Forty-four (44%) percent of the respondents said that they do not have any clue of other risk management techniques. Three (3%) percent of respondents indicated that they use interpretative analytical risk management techniques, while 53% identify linear programming (RMT1), game theory (RMT 2), monte-carlo simulation ((RMT3), decision tree ((RMT4), statistical analysis ((RMT5), analytical hierarchy process (RMT6), failure mode effective analysis (FMEA) (RMT7), structural equation modelling (RMT8) multiple regression analysis (RMT9), real option theory (RMT10) and portfolio analysis model (RMT11), as the most common current risk management techniques for managing supply chain risk. While, forty-four (44) percent of the respondents categorically indicated that they have no idea of a specified risk management techniques for supply chain risk. Therefore, 53% of respondents in Figure 6.7, can be the reason for explaining the regression model as shown in Table 6.11. All the variables in the regression model yielded a significant F ratio of 4.842 which is highly significant at 0.00.

6.11 Effectiveness and Efficiency of Supply Chain Risk Analysis Techniques

Having established the indicative and specified appropriate risk management techniques for managing supply chain risk in the Nigerian oil industry, this analysis examined the effectiveness and efficiency of supply chain risk analytic techniques in the Nigerian oil industry. The predicting sum of the effectiveness and efficiency of risk analytic techniques factors are explained in Table 6.12.

Table 6.12: Predicting Sum of Effectiveness and Efficiency of Risk Analysis Techniques

Model	Unstandardised Coefficients		Standardised Coefficients	T-Value	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	1.759	.254		6.930	.000		
ERT2	.442	.072	.411	6.124	.000	1.000	1.000

The result in Table 6.12, identify game theory as the most significant factor explaining the prediction of the effectiveness and efficiency of risk analytic techniques. The identified factors are Monte-Carlo Simulation ((RMT3), failure mode effective analysis (FMEA) (RMT7) and multiple regression analysis (RMT9), decision tree ((RMT4), statistical analysis ((RMT5), analytical hierarchy process (RMT6), real option theory (RMT10) and portfolio analysis model (RMT11), were not considered as factors for explaining the effectiveness and efficiency of supply chain risk analytic techniques in the oil industry in Nigeria. This does not mean that these risk management techniques are not an effective and efficient tools for managing supply chain risk in the oil industry. This could depend on the nature and composition of the relevant operations; which the individual risk management techniques are required to perform. Specifically, some of these tools, such as linear programming, are used for decision-making for risk management processes within the oil drilling operations and production events. Furthermore, the literature considered linear programming as a risk management technique for managing supply chain risk in the petroleum industry. This reason can be supported with the objective that linear modelling helps businesses to improve decision-making processes in supply chain management (Bogataj and Bogataj, 2007).

In addition, Lee et al. (1997) built a dynamic programming model to minimise the expected cost of production, inventory cost and lead time based on production capacity constraints. Furthermore, respondents have considered structural equation modelling as the third technique for managing supply chain risk. Kern et al. (2010), considered structural equation modelling as a super risk identification tool that helped businesses to better manage risk in their supply chain. The application in this study can be relevant to other businesses such as manufacturing, agriculture, etc. This aspect of the analysis identified the existing methodological gap which this study aimed to address due to the scarce nature of risk management techniques in the supply chain management in Nigeria.

The significance of game theory as an important risk analytic technique is categorically expressed as t-value 0.000. This significance level of important factors increases the trends of the other factor to predict a significant overall model summary for the effectiveness and efficiency of risk analytic techniques in Table 6.13. This model is based on the assumption that risk analytic techniques is effective and efficient for managing supply chain risk in Nigeria's oil industry.

Table 6.13: Model Summary for Effectiveness and Efficiency of Game Theory

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.411[a]	.169	.164	1.048	.169	37.499	1	185	.000	1.778

Table 6.13 shows the description of the predicting model as follows; R^2 = 0.164 and F change is significant at 0.000. This implies that risk management techniques accounted for 16.4% of the level of effectiveness and efficiency in the management of supply chain risk in the Nigerian oil industry. This research finding suggests the need for using game theory to coordinate supply chain events in the petroleum exploration in Nigeria. Sheu (2011) used an

asymmetrical bargaining game theoretical model to resolve issues between producers and reverse logistics vendors to manage government subsidies on financial interventions to improve environmental supply chain among players. Esmaelli et al., (2009) claim that the exploration of game theory improves the coordination and eliminates risks that hinders the governing of the supply chain process.

6.12 Determinant of Supply Chain Resilience

Following the predictive effects of supply chain risk analytic techniques in the Nigerian oil industry, this study addressed research question (RQ4) in order to examine the determining factors that can provide resilience to the petroleum supply chain in Nigeria. The nature of relationship strength within the explanatory variables for categorical risk management strategy are considered as determining factors. Bivariate correlation analysis was used to examine and identify the significant relationship among the determinants of supply chain resilience in the Nigeria oil industry. The measure of mutual association with the risk management strategy will help this research to draw some assumptions in the model. Table 6.14 exhibits the bivariate correlation matrix for determining the factors that can provide resilience to the supply chain in the Nigeria oil industry.

Table 6.14: Correlation Matrix for Determining Supply Chain Resilience

	RES1	RES 2	RES3	RES4	RES5	RES6	RES7	RMA8	RES9	RES10	RES11	RES12	RES13
RES1	1												
RES2	.388**	1											
RES3	.329**	0.315**	1										
RES4	0.131	0.248**	0.297**	1									
RES5	0.125	0.127	0.195**	0.297**	1								
RES6	0.072	0.154	0.099	0.166*	0.229**	1							
RES7	.160*	0.081	0.312**	0.101	0.342**	0.208**	1						
RES8	.181*	0.132	0.136	0.001	0.058	0.068	0.254**	1					
RES9	0.142	0.141	0.09	0.047	-0.035	0.117	0.209**	0.186*	1				
RES10	.263**	0.149*	0.170*	0.155*	0.145*	0.182*	0.250**	0.161*	0.306**	1			
RES11	0.006	0.074	0.08	0.151*	0.079	0.018	0.068	-0.035	0.085	0.091	1		
RES12	.274**	0.143	0.299**	0.247**	0.037	0.175*	0.119	0.001	0.047	0.192**	0.021	1	
RES13	0.113	0.220**	0.249**	0.267**	0.163*	0.224**	0.154*	0.001	0.021	0.114	0.097	0.404**	1

Table 6.14 shows the positive (+) and negative (-) relationship on the supply chain resilience variables. This implies that an increase in one variable decreases the other variable, or one variable increases the other. The converging variable for determining supply chain resilience in this study are: supplier capacity/production development (RES1); legislative compliance/regulations (RES2); contract strategy/collaboration (RES3); operational flexibility (RES4); postponement/delay of project (RES5); divestment (RES6); licensing/subcontracting arrangement (RES7); geographical diversification (RES8); investment on storage capacity/inventory management (RES9); sourcing policy (RES10); inter-firm personnel exchange (RES11); vertical integrations (RES12); and joint business planning (RES13). The convergence of the supply chain risk management variables exhibits positive and negative bivariate relationships which decrease and increase with one or more variables (Table 6.14).

Studies in supply chain risk management in a developing economy, explore the influence of supplier appraisal on supply chain risk management (Chemoiwo, 2016). There is a strong relationship of 0.763<0.05 level, between supplier and supply chain risk management practices. The positive bivariate relationship suggested an increase in the supply chain risk management process. However, this research concludes that adoption of supplier improves supply chain risk management.

The bivariate correlation for the determinant of supply chain resilience as posited in research question (RQ4) is relatively significant between most of the components used for explaining the risk management strategies that can provide resilience to supply chain management in Nigeria's oil industry. A significant proportion of the variables set for verifying the determinant of supply chain resilience, were positively correlated and this concomitantly increased and decreased other variables. The positively correlated coefficients were significant at the 0.01 level (1-tailed **) and 0.05 level (1-tailed *). The bivariate correlation matrix in Table 6.14 shows that the correlation coefficients are relatively low to indicate the actual risk management strategy that can determine supply chain resilience in Nigeria's oil industry.

Fixing the determining supply chain resilience factors into a regression model with the aim of obtaining the predicting components among the bivariate coefficients in Table 6.14 can identify the appropriate risk management strategy for building supply chain resilience in the Nigerian oil industry. Table 6.15 shows the regression coefficient and the relative significant of the predicting sum for explaining the determinants for supply chain resilience in Nigeria’s oil industry.

Table 6.15: Predicting Sum for Determinants of Supply Chain Resilience

Independent Variables	Unstandardised Coefficients		Standardised Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	T-Value	Sig.	Tolerance	VIF
Constant	.409	.515		.794	.428		
RES2	.315	.073	.307	4.294	.000	.814	1.228
RES3	.180	.085	.160	2.117	.036	.732	1.366
RES4	-.059	.082	-.053	-.727	.468	.778	1.285
RES5	.072	.077	.070	.937	.350	.740	1.352
RES6	-.057	.072	-.056	-.794	.428	.848	1.179
RES7	.004	.080	.004	.052	.959	.720	1.388
RES8	.089	.071	.086	1.254	.212	.887	1.128
RES9	.035	.072	.034	.478	.633	.803	1.245
RES10	.161	.076	.156	2.129	.035	.780	1.282
RES11	-.042	.074	-.044	-.571	.569	.692	1.444
RES12	.234	.083	.212	2.813	.005	.732	1.367
RES13	-.073	.078	-.071	-.944	.346	.741	1.350

However, supplier capacity development provided a positive explanation for the determinant of supply chain resilience. Table 6.15 exhibited a strong predicting sum for the supply chain risk management strategy variables. The predicted risk management constructs were prioritised as legislative compliance/regulations (RES2), vertical integrations (RES12), sourcing policy (RES10) and contract strategy/collaboration (RES3). The significance to individual predicting sums for the determinant of supply chain resilience variable provided the explanation shown in Table 6.15.

Table 6.16: Model Summary and ANOVA for Determining SC Resilience

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	58.560	4	14.640	15.297	.000
Residual	174.188	182	.957		
Total	232.749	186			

R^2 (ADJ) = 0.235, SE = 0.978, Durbin - Watson = 1.694

The four significant variables fitted to the equation and regression model yielded an F ratio of 15.3 with a high significance level of .000 as shown in Table 6.16. The model results indicate that 15.3% of the significant factors explained the proportional contribution of legislative compliance/regulations (RES2), vertical integrations (RES12), sourcing policy (RES10) and contract strategy/collaboration (RES3) in the overall model in Table 6.15.

The significant deductions which can be derived from these results of determinant of supply chain resilience in Table 6.15, are the high positive coefficients among the variables in Table 6.14 and 6.15. This indicates that multi-collinearity does not pose any problem in this analysis of the determining factors for supply chain resilience in this study.

Inferring from the research model (Figure 6.5), suggested that geographical diversification (RSE8), investment on storage capacity/inventory management (RSE9), sourcing policy (RSE10), inter-firm personnel exchange (RSE11), have both contributed to the explanation of buffer-based mechanisms and how this component of agency theory can help businesses embrace management efforts to minimise the impact of disruptive events on a firm. Indeed, buffer-based methods are explored to mitigate the likelihood and the impact of negative effects of disruptive severity (Zsidisin et al., 2005). In view of the significant influence of buffer-based management techniques, it can be confirmed that legislative compliance/regulations (RES2), vertical integrations (RES12), sourcing policy (RES10) and contract strategy/collaboration (RES3) can positively impact the management of supply chain risk in Nigeria's oil industry.

Turning to the research question's (RQ4) hypothesis for legislative compliance/regulations (RES2), vertical integrations (RES12), sourcing policy (RES10) and contract strategy/collaboration (RES3) revealed the significant relationship between the predicting supply chain resilience variables as indicated on Table 6.15. This study suggests that these listed variables would build resilience in the supply chain in Nigeria's oil industry. Building resilience in the petroleum supply chain in Nigeria, would allow the operating oil sectors to develop the capability for managing supply chain disruption and ensuring the continuous flow of petroleum products (Blackhurst et al, 2011; Sheffi and Rice, 2005; Vorst, et al., 1998).

Although, postponement/delay of project (RSE4), divestment (RSE5), licensing/subcontracting arrangement (RSE6), investment on storage capacity/inventory management (RSE7), geographical diversification (RSE8) and joint business planning (RSE13) are insignificant in the regression model. They are insignificant to effect the capability to build resilience for the supply chain of Nigeria's oil industry.

6.13 Conclusion

The research respondents' a priori view on the theme of risk management strategy for mitigating supply chain disruption risk in Nigeria's oil industry was collected and empirically measured. The empirical results show that availability of capital investment fund, ageing of oilfield infrastructures, shortfall in crude oil recovery, inadequate government policy, petroleum resource management, routeing scheduling, demand volatility, variability in supply and unsustainable practices have militated against supply chain performance in the Nigeria oil industry. Furthermore, this study supports the need for specific policy standards, development of a contract management strategy/collaboration, a sourcing policy and knowledge management for mitigating supply chain risk. However, the study suggests the need for a game theory simulation for coordinating and managing supply chain disruption risk. This study will help to improve the supply chain performance and organisational performance measure in the Nigerian oil industry. The theoretical contribution of this study, its practical implications and methodology, limitations and future areas for research development are detailed in the next chapter of this thesis.

CHAPTER SEVEN

Discussion of Findings

7.0 Introduction

In this chapter the research findings are summarised and discussed.

This study has examined the risk management strategy for managing supply chain disruption risk in Nigeria's oil industry. The unit of analysis relates to the current practices for supply chain risk management, disruption risk to supply chain, impacts of the associated oil industry risk on supply chain management and organisational performance measure and risk management strategy that can provide resilience to the supply chain of Nigeria's oil industry. This study explained the use of behavioural and buffer based mechanisms that link exploration and production risk, environmental regulatory compliance risk, geopolitical risk, supply chain management and organisational performance measure. These entities formed the foundation of the research model which was tested empirically with data collected from the Nigerian oil industry. A combined multi-criteria decision-making (AHP), multivariate analysis (SEM PLS), regression modelling and other applications of statistical analyses were used for explaining the research constructs. A triangulation of quantitative methods was used to enhance the validity of the empirical data and cross-verify the research results.

7.1 Supply Chain Risk Factors in the Oil Industry

This study identified the risk factors affecting the supply chain in the Nigerian oil industry. The supply chain risk classifications involve exploration and production risk, environmental regulatory compliance risk and geopolitical risk. This study suggests that these oil industry risks were at the maximum level, which revealed the severity of supply chain risk occurrence in the Nigerian oil industry. The normalised priorities of exploration and production risk, environmental regulatory risk, geopolitical risk in Figures 6.2, 6.3 and 6.4 respectively, demonstrated the maximum risk value of the contributing factors. The severity of the supply chain risk has affected the operational activities by causing disruption to oil industry activities in Nigeria. Tang (2006) categorised supply chain risk as operational and disruptive risks. Operational risk involves uncertainty of customer demand, uncertain supply and uncertain costs. Risk categorised as disruption includes flood, hurricanes, terrorist attack, economic crises, and workers' strikes. Tang, (2006) affirmed that disruptive risks impact businesses more strongly than operational risk. The three types of oil industry risk explored in this research are extremely high and impacted the oil industry supply chain in Nigeria. The supply chain risk in this study are categorised as operational and disruptive to the Nigerian oil industry.

7.1.1 Exploration and Production Risk

The effect of the exploration and production risk, environmental regulatory risk and geopolitical risk have resulted in an observed variance of 22% on the supply chain. For example, the environmental regulatory risk had a negligible value on the coefficient of determination at 8% in the research model. This suggests there is negative influence of risk on supply chain management in the Nigerian oil industry.

In view of this, the exploration and production risk in hypothesis (H1a) negatively affected the management of supply chain in the Nigerian oil industry. The behavioural-based management approach had low influence on supply chain management due to a lack of funding (EPR12), the aging of the oil field/infrastructure (EPR10) and uncertainty in the recovery of sufficient quantity (EPR3). The failures of the pipeline infrastructures are due to corrosion and disruption by the militants in the oil producing regions of Nigeria. This leads to loss of human life, environmental degradation in petroleum exploitation within the Nigerian environment. Consequently, this leads to errors in the forecasting of crude oil and supply chain visibility issues in the Nigerian oil industry. However, investors view the parameter of oilfield age and realistic forecasting factors as a requisite for obtaining investment funding for developing oil rigs. The need therefore arises for the petroleum industry to seek ways to minimise the occurrence of these risks in their operating environment in the Nigerian oil industry.

7.1.2 Environmental and Regulatory Compliance Risk

In a similar dimension with the environmental and regulatory compliance risk, the behavioural-based mechanisms have indirectly influenced the management of supply chain with a marginal relative proportion of 0.147. However, the marginal relationship is trivially low to generate the sustainable earned value for supply chain performance in the Nigeria oil industry. Hoffmann et al., (2013) asserted that the influence of high environmental risk can moderately change supply chain performance, which suggests that the trivial value obtained for environmental regulatory compliance has negligible attributes on supply chain management in the Nigerian oil industry. The research model (Figure 6.5) shows that environmental and regulatory compliance risk can vary the supply chain management in the Nigerian oil industry. However, this study revealed that environmental regulatory compliance risk has a negative influence on supply chain performance, which arise from the inadequate government policies on the regulation of petroleum exploration in Nigeria. For example, Nigeria's oil industry has been exposed to macro-economic indices, such as high interest rates, erratic foreign exchange and political instability which have had a negative influence on supply chain operations. This impacts the scheduling delivery and the management of petroleum resources. Furthermore, the change in the economic policies, adverse weather conditions and oil spillage due to aging infrastructure have negatively affected the coefficient of the environmental and regulatory compliance and supply chain management. The inadequate government policies on petroleum explorations, negatively impacted the sustainable practices of supply chain resulting in supply chain risk in the Nigerian oil industry. This finding however is outside the main aim of this study, but can be the subject of future work.

7.1.3 Geopolitical Risk

In view of the research hypothesis H1c, the result suggests that a behavioural-approach positively influences the management of geopolitical risk in the Nigerian oil industry. This related perceived degree of managing supply chain with behavioural risk management strategy as significantly positive with geopolitical risk. This finding revealed that geopolitical risk has a negative direct relationship with supply chain management. In a similar dimension geopolitical risk negatively impacted the supply chain performance measure in the Nigerian oil industry. The militant attack against 'Bourbon Company' in the Addax oil field off Nigeria's coast significantly impacted maritime operations (Bouejla et al., 2014). This affected logistics operations, including the hindering of production. planning and scheduling of crude oil delivery. This variability affected the supply chain performance in the Nigerian oil industry. These findings suggest the need for investment in geographic diversification and storage/inventory management with the aim of stabilising supply chain strategy and improving visibility into the supply chain.

7.2 Managing Supply Chain Risk in Nigeria oil Industry

The management of geopolitical risk revealed that a buffer-based approach has a positive influence on geopolitical risk. This strong relationship suggests the ability of vertical integration, training and joint business planning as a propelling influence to suppress the militant influence in the Nigerian oil industry. Appel (2012) claimed that geopolitical risk to supply chain is difficult to manage as it restricts performance. However, the current war against corruption is being waged through amnesty and regulatory control such as the petroleum industry bill (PIB - Draft 2012) and National Oil Spill Detection and Response Agency (NOSDRA) Amendment Bill (2012), which have been introduced to deal with all matters related to security and risk in the Nigerian oil industry. The positive effects of these regulations have made a substantive improvement in geopolitical risk in Nigeria. For example, research with large enterprises and expert survey respondents in developed and developing economies, suggested measures for improving geopolitical risk as controlling corruption, political stability, absence of violence/terrorists activities, respecting humans' rights, and regulatory excellence (Kaufmann et al., 2013).

There are divergent views on the strength of current supply chain risk management using a buffer-based approach to influence the management of exploration and production risk and environmental regulatory risk. A buffer-based approach revealed an insignificant effect on environmental compliance regulatory risk as an influence on supply chain management. Moreover, the buffer-based strategy was a negligible contributing factor to the management of supply chain risk in Nigeria's oil industry. The negative influence of production and exploration risk are polarised by capital investment fund which oil investors find difficult to obtain because capital fund providers are not pleasant with the low permeability of oil reservoir. The meagre oil deposits are unattractive to foreign investors and this hinders access to modern oil drilling technology in many oil deposit zones. The backdrop for managing supply chain risk (Hypothesis H2b), suggests that the influence of adverse weather conditions prove unsafe for oilfield workers to drill for oil products. This affects the morale of workers and productivity is severely reduced and this process affects petroleum supply chain. In addition, disposal of oil waste is uncoordinated and this causes hazards in the movement of goods and product delivery is also affected. Thus, the management of oil resources and complexities of transportation systems are uncertainties which call for close working relationships with supply chain partners so as to manage the consequences of the supply chain risk. The research findings for Hypothesis H2a, 2b, 2c, confirm the concept in resource dependence theory, that a firm should coordinate and form alliances, joint ventures, and mergers and acquisitions to reduce risks and uncertainties that might hinder their organisational operational performance (Sharif and Yeoh, 2014; Drees and Heugens, 2013). The resource dependence theory for hypothesis (H2c) would reduce the complexities in the interaction and communication between the oil industry and stakeholders in the oil producing communities in Nigeria.

Furthermore, this study have given insights into the unique application of game theory for identifying the appropriate coping strategies for mitigating supply chain risk in the petroleum exploration industry in Nigeria. The uniqueness of game theory enables the inclusion of cooperation or defensive attitudes for obtaining collective benefits which enhance supply chain performance, coordination and economic stability (Zhang and Huang, 2010). The inclusion of these capabilities expose businesses to forming alliances and joint ventures in executing various petroleum exploration projects. Cousins et al. (2008) described the inclusion of cooperation or defensive attitudes for obtaining: capacity sharing, savings through economies of scale, dynamic capabilities, and improvements in business performance. The significance of game theory competences will stabilise the supply chain, thus balancing demand and supply variability, eliminating unsustainable practices, and entrenching compliance to established regulatory policies in the implementation of supply chain management in the Nigerian oil industry.

7.3 The Effects of Supply Chain Risk Management on Performance Measure

The Hypothesis (H3a) findings, partially supported the influence of exploration and production risk on supply chain management and performance. The exploration and production risk have insignificantly affected the organisational performance measure. This effect is as a result of the aging of the oilfield/infrastructure (EPR10) and errors in oil reserves forecast (EPR5), which have both significantly affected the supply chain management and organisational performance measure. The oilfield/infrastructure used for the exploration and production in the oil production zones in Nigeria are outdated and damaged by the militants. It requires the oil sector to invest a lot of funds for the repair and maintenance of the oilfield infrastructure. Capital projects financing organisations are reluctant to provide loan financing for the pipeline exploration projects. The scarcity of funds to finance the aging oilfield infrastructure projects have contributed to the inability of the oil sector to accurately forecast the correct quantities that can be delivered to meet customer demand. These factors cause uncertainty in the supply chain as products and orders are not fulfilled or fail to arrive as scheduled.

The Hypothesis (H3b) suggests that environmental regulatory compliance is a complementary mediation. This implies that environmental regulatory compliance is directly and indirectly significant to the supply chain management and performance measure. The relationship between the supply chain and performance measure was mediated by exploration and production, environmental regulatory compliance and geopolitical risk. The intervening constructs reveal that supply chain visibility, supplier variability and geographical concentration are the core supply chain elements that have absorbed the disruptive influence of the supply chain risk in the Nigeria oil industry. The lack of visibility is due to the resultant effects of inadequate government policies on petroleum (ECR6) and the uncoordinated oil waste disposal process. The non-compliance to petroleum regulatory law by the operating oil companies in Nigeria, have challenged the cost structure, capital projects and the safe operation of the oil industry. This exerts pressure on the management of oil resources and supply chain visibility.

Anejionu et al., (2015), suggested that oil companies in Nigeria exploited the inadequacy of government policies and improper petroleum waste disposal for their economic benefits. This practice affects the management of resource and the supply chain partners. This puts pressure on the sustainability of supply chain management, thus hindering visibility in the supply chain in the Nigerian oil industry. Wei and Wang (2010) claimed that supply chain visibility provides firms with the capability to reconfigure their supply chains and attain a superior performance. The capability of visibility can help the oil industry to manage and integrate the geographic location of the oil cluster region. For example, resource management helped companies in all phases of supply chain management, from vendors' vetting to delivering supply chain documentation to the end-users. These initiatives help to review the supply risk management process and confirm sustainable supply chain practices (https://www.rmagreen.com/sustainable-supply-chain-management); (Accessed 26th June 2017). This provides the capability for managing supplier variability and adjusting oil production and logistics scheduling. This supply chain configuration strategy has limited the influence of the exploration and production and environmental regulatory compliance risk in the Nigerian oil industry. For example, Walmart managed their supplier variability by working with a supplier to reduce the environmental impact. Walmart exploited the environment regulatory law for the sustainable development of the supply chain partners Walmart and other major companies in their business and global community saved suppliers a combined $12.4bn in 2016 for supply-chain emissions reduction initiatives (Lyons, 2017).

Furthermore, the dimensions of geopolitical risk suggest that both supply chain management and organisational performance measure are negatively affected. The direct effects of geopolitical risk have an overall total effect of 0.032. A negligible effect of 3% shows how geopolitical risk has influenced the supply chain management and performance measure as a confirmation of how the militant attacks in the Niger-Delta region of Nigeria, have affected the management of supply chain in Nigeria. Geopolitical supply chain disruption is caused by the instability of the crude oil market forces caused by the political instability in Nigeria (Habib and Wenzel, 2016). The results of the research revealed that the oil industry in Nigeria are challenged with uncertainties ranging from theft of oil infrastructure, militant attacks on oil rigs, unsustainable operational practices, complexities of interactions with oil communities and piracy threats to the security of oil carrying vessels. This individual factors have directly or indirectly disrupted the supply chain management and consequentially affected the performance measures in the Nigerian oil industry. Indeed, these findings can confirm that current breakdown in supply chain management in Nigeria, is mostly due to the geopolitical risk factors of militant attacks, communal interactive difficulties, volatility in demand and supplier variability. These factors have imposed a negative influence on the petroleum supply chain in Nigeria. Furthermore, the attack by militants in the Niger-Delta region of Nigeria have brought insanity to the supply chain, causing ecological disaster to oil exploration and production efficiency. Urciuoli et al., (2014) asserted that political instability threatened the oil and gas suppy chain and adversely affected employee and infrastructural safety, caused financial losses and ecological disaster.

7.4 Effects of Behavioural Approach on Supply Chain Risks

The behavioural-risk management strategy revealed that there is a positive relationship between the oil industry risks: exploration and production risk, environmental compliance risk and geopolitical risk. The mediating analysis results demonstrated the strong total effects of behavioural-based mechanisms on exploration and production risk 0.377; environmental compliance risk 0.103 and geopolitical risk 0.354, all these total effects are in conjunction with supply chain management. However, a significant emerging observation from this revelation is that the behavioural-based mechanisms revealed little effect on environmental regulatory risk. The impact of supply chain management affected the overall effects on the related model linking the behavioural-based mechanisms, environmental compliance risk and supply chain management in the Nigerian oil industry.

Contrary to the buffer-based mechanisms, the exploration and production risk, environmental compliance risk and geopolitical risk suggest insignificant total effects on supply chain management.

7.5 Building Resilience in the Supply Chain of Nigeria's Oil Industry

The risk management strategy was identified as a supply chain capability for building supply chain resilience in the Nigerian oil industry. The performance attributes of the supply chain capability can mitigate against the severity of disruption risk and develop new competencies for dealing with hazards. Handling supply chain risks through supply chain capability and competencies imposes strong confidence in the supply chain (Christopher and Lee, 2004). Reflecting on the assumption of risk, how are supply chains effectively managed in Nigeria's oil industry? The research model (Figure 6.5) suggests the significance of visibility/information access to managing disruption risk in the supply chain. This increases the flow of materials and information, and determines the ability to which supply chains are ready to prevent any unexpected risk occurrences to the supply chain. The unexpected occurrences can be flagged through early warnings and real-time monitoring in order to prevent instability in the supply chain (Blackhurst et al., 2011; Craighead et al., 2007). Furthermore, monitoring measures increase the visibility of demand details across the supply chain so that the oil industry can assess the performance of their supply chain members and protect themselves against potential opportunistic behaviours that could derail the efficiency of their supply chain. This will establish an expectation in contractual arrangements, regulatory compliance policies and procedures in the Nigerian oil industry. Ponomarov and Holcomb (2009), assumed in their study of the concept of supply chain resilience that flexibility (Christopher, 2005), agility (Christopher, 2004), visibility (Chopra and Sodhi, 2004), structure and knowledge (Hong and Choi, 2002 and Choi and Liker, 1995), collaboration (Sinha et al., 2004; Lee, 2004), operational capability (Smith, 2004) were practices that would enforce resilience and breed competencies in the supply chain. Thus, Ponomarov and Holcomb (2009) work's has much relevance to this study.

However, the analysis of this study focuses on the upstream supply chain of the petroleum industry; exploring supplier capacity development in order to make supply chains engage in leaner processes, ensure timely decisions are taken and manage risk more effectively. This helps key players in the supply chain to better manage their resources, predict demand, effectively schedule oil production in accordance with planned capacity. For example, UK Continental Shelf (UKCS) invested into its oil production capacity with the aim to create resilience in its supply chain. The production capacity development improvement strategy improve efficiency, streamlined costs and boosted productivity for UKCS. The UK Continental Shelf (UKCS) capacity development strategy created resilience and enhanced global competitiveness (Business Outlook Report, 2017).

Indeed, this study suggests that legislative compliance/regulations (RES2), enforces governance mechanisms which entrust operational transparency in the supply chain management. This enhances market transparency, visibility and creates efficiency, integration, optimisation and identifies real-time intelligence. This provides the ability to collect both internal and external data that can aid decision-making on compliance data of supply chain partners. This potential can create real-time intelligence for supply chain monitoring to provide feedback on environmental supply chain risk performance in the Nigerian oil industry. For example, Clark (2017) asserts that oil industries have adopted real-time intelligence to identify suppliers with financial difficulties, in order to ensure the regulatory and legal practices adhered to. This assumption supports the views of (Ratnersingam, 2005; Marcella et al., 1998; Jamieson, 1996), in their studies of security and control of e-commerce technology, which suggested that best business practices enforce governance mechanisms in the form of contracts, regular audit practices, top management commitment, high quality standards, adequate and complete training, risk management procedures and control of quality transactions.

Further, these practices have suggested the need for the Nigeria's oil industry to effectively work with supply chain partners to reap the benefits of contract strategy/collaboration (RES3). However, collaboration (RES3) and sourcing policy (RES10) can be proactive by forming strategic alliances for managing supply chain risks in the Nigerian oil industry. For example, Voluntary Inter-Industry Commerce Standard (VICS) developed the initiatives of collaborative planning. For example, the cross-boundary collaborative initiative between the NNPC and the Nigeria oil industry improved forecasting and demand management for the supply of petroleum products in Nigeria. This initiative facilitated collaborative forecasting and developed mutual contracts with the supply chain partners while also promoting a culture of risk management in the management style of employees of the Nigerian oil industry.

Inter-firm personnel exchange/training (RES12) develops employee skills in the various ways for managing supply chain disruption risk. For example, Chinta (2017a) proposed that supply chain operators should group their skills and resources in order to enable them to adapt and manage prevailing change affecting their organisations. Grouping skills and resources enables employees to act proactively on their approach to preventing risk, building resilience into the supply chain and taking into account the commitment of resources for minimising disruptions (Makheria et al., 2012). This creates the capability to improve the supply chain and investors' return on capital invested in the Nigerian oil industry. Furthermore, this behaviour of inter-firm personnel flow/training (RES12) encourages change to supply chain performance and entrenches resilience in the Nigerian oil industry. For example, Shell and Mobil Exxon and others, committed resources to the expansion into the deepwater oilfields production, with the aim to manage disruption to their crude oil production and maximise their supply chain potential. This initiative was achieved through the use of inter-firm personnel exchange/training (RES12). This increased oil production capacity to 1.2million bbl/d (EIA, 2007). Shell and Mobil Exxon were able to create resilience in their supply chain and this introduced a culture of disruption risk management to the Nigerian oil industry.

The Nigerian oil industry is one of the largest industrial settings in Nigeria. However, the importance of postponement/delay of project (RSE4), divestment (RES5), licensing/subcontracting arrangement (RES 6), investment on storage capacity/inventory management (RES7), geographical diversification (RES8), auditing (RES9), vertical integration (RES11) and joint business planning (RES13) have failed to demonstrate an ability to build supply chain resilience in the Nigerian oil industry. This implies that the resilience of the contingency processes for managing supply chain disruption in Nigeria's oil industry are hindered by threats which account for the proportion of variances of 84.5% revealed by the model summary and analysis of variance (ANOVA) for determinants of supply chain resilience (see Table 6.13). This proportion is characterized by threats to geographical mobility of employee, self-review threats which can reveal sharp practices, unfair exploitation of suppliers and lack of data security. For example, due to inadequate independent monitoring by the Nigerian oil industry or the petroleum regulators, there is little data available to verify reports (Konne, 2014). These problems have prevented the progress of geographical diversification (RES8), investment in storage capacity/inventory management (RES9), managing supply chain risk and consequentially failing to build supply chain resilience. This identified supply chain capability could be among the factors hindering Nigeria's oil industry from achieving its sustainable competitive advantage.

7.6 Implementation Supply Chain Resilience and Superior Performance

The implementation of the value creating strategy helps an organisation to effectively and efficiently sustain its competitive advantage. This approach helps businesses to exploit opportunity (Barney, et al., 2001), which consequently eliminates threats to supply chain performance. This research has numbers of differentiated supply chain risk management strategies for gaining resilience in the supply chain of Nigeria's oil industry. For example, a firm with differentiation strategy over their rival, (Barney et al., 2001) suggested that these strategies should not be implemented simultaneously. However, competitive advantage remains sustainable if efforts to duplicate such strategy by a rival are unsuccessful (Rumelt, 1984). To ensure continuity in the dynamic operating environment of the Nigerian oil industry, this research suggests the integration of the supply chain risk management strategy, will facilitate the business process and structure development in the Nigerian oil industry. Supply chain integrated behaviour is a mutual sharing of information for planning and monitoring processes (Tyndall et al., 1998). This promotes the sharing of intelligence which will enhance Nigeria's oil industry capabilities, resources and save businesses from risks and costs. This however, restricts the effects of disruption to supply chain and enhances performance (Hallika et al., 2007; Salcedo and Grackin, 2000).

7.7 Conclusion

The discussion of this study was based on the empirical findings of the applied quantitative methodologies and approaches. The quantitative approaches created an understanding of the supply chain risk management practices in Nigeria's oil industry. The insights gained through this understanding suggests how well the Nigerian oil industry is performing. The collective findings from this study address the research gap highlighted in section 1.3, and suggest how Nigeria's oil industry, can improve their supply chain risk management practices and create resilience in the Nigerian oil industry supply chain. The conclusions, implications and recommendations drawn from this study are the focus of the next chapter.

CHAPTER EIGHT

Conclusions and Recommendations

8.0 Introduction

The aim of this study is to develop a model for understanding disruption risk to supply chain management in the Nigerian oil industry. This set to undertake and determine the risk management practices that can mitigate and create resilience in the petroleum supply chain performance in Nigeria. To achieve this purpose, a survey questionnaire was used to obtain information from the sampled oil industry employees in Nigeria. To confirm the results of the study, an analysis of the questionnaire was carried out using a number of statistical techniques. The area covered in the analytical process included the demographics of respondents, supply chain risk, efficiencies of risk management techniques, risk management strategy and supply chain effects on performance measure.

This chapter recaps the main conclusions of the study and links the research implications to theory, practice and methodology. In addition, the research contributes to the knowledge gap and provides appropriate recommendations. Finally, the limitations and suggestions for future research were presented.

8.1 An Overview of the Study

8.1.1 Findings and Conclusion

The aim of this study is to develop a model for evaluating disruption risk influence in the Nigerian petroleum supply chain. The risk mitigating strategy effects on supply chain disruption risk, supply chain and performance measure and dimensions of various supply chain risk management approaches in Nigeria's oil industry, were discussed in the study.

An exhaustive literature review was carried out prior to data collection, which informed the contextual items included in the survey questionnaires. Moreover, risk management practices of how upstream petroleum resources disruptions affect supply chain performance was reviewed. Theories such as agency theory and dynamic capabilities were used to explain the research constructs. This process provided the deduction upon which documented literature for supply chain risk management were established in the Nigerian oil industry. Based on the empirical data obtained from the research subjects, statistical analysis of the survey instrument was used to address the research questions.

Two hundred and seventy-one (271) survey questionnaires were administered to research respondents in the Nigerian oil industry. The responses of the research subjects provided the empirical information through which inferences and conclusions were reached. The research findings confirmed the hypothetical assertions which emerged from the research questions and the core opinion in the research model. It is evidenced from the findings that supply chain risk has a strong influence on the management of supply chain.

The revealed severity of risk is due to the inadequate government policies for regulating and structuring the management of upstream oil resource in Nigeria. Thus, the upstream oil supply chain operation involves all the logistics activities for feedstock of exploration, production and transportation into the refineries for refining operations. This assertion (see Figure 1.1) increasingly improves the value chain. This suggests that firms' ability to partake in the supply chain is strongly dependent on choices of the governing procedural policies. The study revealed that these policy-related factors influenced supply chain operations (see Figure 1.1). Furthermore, the investment policy linked to the factors has deterred foreign investors from participating in the development of petroleum supply chain management in Nigeria (see Table H3a and H3b). The key highlighted factors have significantly caused distortions to supply chain performance, and created inconsistencies in formulating a working procedural framework for the management of supply chain risk in Nigeria's oil industry. The effects of supply chain risk are lower productivity and reduced employee morale, which consequently reduce supply chain performance in the Nigerian oil industry. This study suggests the need for visibility in the supply chain with the aim of lessening the influence of geopolitical conflicts which currently cause disequilibrium to the demand and supply. This study further suggests the need to embrace legislative compliance regulation and collaborative practices as a process for risk management and creating resilience in the supply chain in Nigeria's oil industry. The presence of legislative compliance regulation will prompt the Nigerian oil industry to address all unsustainable practices hindering the management of its supply chain risk.

8.1.2 Recap on the Research Questions

The aim of this project is to develop a systematic approach to analysing and evaluating disruption risks in the supply chain of the upstream petroleum industry. Research objectives (section 1.5) were used to guide the directions of this research aim. Here, the research examined the supply chain risk management strategies explored in the Nigerian oil industry and its impact on supply chain and performance measure. Five research questions were developed to guide the directions of this study. The individual research questions and their respective tested hypotheses were operationalised, using the data obtained from research subjects' responses to the questionnaire survey. The research questions and their connection to the research themes are presented as follows:

RQ1: How are supply chain risks currently managed in the Nigerian oil industry?

This research question was sparked by the systematic method which consisted of the research theory and quantitative risk management techniques. The motive for these strategies is a concern with the current approach used for managing supply chain disruption risk in Nigeria's oil industry. Based on this, the study developed behavioural-based and buffer-oriented mechanisms as a risk management strategy for responding to the impact of supply chain risk. The behavioural-based and buffer-oriented approaches were examined with the aim of seeing their impact on the management of supply chain risk and the effective process for coordinating the supply chain in the Nigerian oil industry. The current supply chain risk management signify a coordinated process for improving the practice of supply chain management in Nigeria's oil industry.

Furthermore, this study indicated that the Nigerian oil industry has adopted a series of risk management techniques. Among the adopted risk management techniques, this study revealed three quantitative risk management techniques, game theory (RMT2), decision tree (RMT4) and statistical analysis ((RMT5) as the most effective and efficient quantitative approaches for managing supply chain disruption risks in Nigeria's oil industry. The predictive figures for risk management techniques in Table 6.13, show the coefficient of determination (R^2 = 0.164) for the current quantitative approaches to managing supply chain risk. This indicates that 16.4% of the total contribution among the identified risk management methods explains the influence of the current risk management techniques in Nigeria's oil industry. Vis-à-vis the revealed risk management techniques used for managing supply chain risk management, game theory method was identified as the most effective risk management technique that can be used for managing supply chain disruption risk in the Nigeria oil industry (Table 6.13).

The inadequate procedural risk management process in the management of supply chain risk has a diverse influence on supply chain risk quantitative techniques in the Nigerian oil industry. The current supply chain risk can be effectively managed through game theory simulations. Game theory would ensure team cross-functional generation of ideas which can be communicated to facilitate the procedural risk documentation process for supply chain risk management in the Nigerian oil industry.

In addition to the context of risk management techniques, this research addressed the conceptualisation of the various elements of a behavioural-based and buffer-oriented approach in relation to the context of the theoretical framing. The a priori opinions of the research subjects were obtained through a survey questionnaire which was administered to employees in the Nigerian oil industry. This process yielded information about the level of supply chain risk management and the documented process for current risk handling methods in the Nigerian oil industry.

RQ2: What are the oil industry risk factors that could affect supply chain management practices in Nigeria?

This research question (RQ2) is linked with research objectives 2 and 3 of this study. The research question (RQ2) involves the identification, prioritisation and mitigation of supply chain risk in Nigeria's oil industry. The supply chain risk factors explored in this research consisted of exploration and production, environmental regulatory compliance and geopolitical risk. These risk factors were recognised as supply chain risk militating against supply chain management and performance measure in Nigeria's oil industry. The structural equation modelling partial least squares (SEMPLS) further identified risk components (see Figure 6.5). These risk factors outputs were systematically integrated into the analytical hierarchy process (AHP) with the sole aim of obtaining a visualised and documented value for the severity of risk modes affecting supply chain management performance in Nigeria's oil industry. This study revealed the critical risk associated with exploration and production risk as, availability of capital investment funding (EPR12), ageing of oilfields /infrastructure use for oil exploration (EPR10) and lack of sufficient or short falls oil recovery quantities of hydrocarbon (EPR3). Moreover, cargo routeings and scheduling (ERC8), inadequate government policies on petroleum (ERC6), management of petroleum resources (ERC5), change to government economic policy (ERC7) were associated with environmental regulatory and compliance risk. Indeed, demand volatility (GPR5), supply variability (GPR6) and complexities of interaction with the oil community were identified as critical elements of geopolitical risk.

The disruption risk factors revealed in this study were considered high; the risk weights were evidentially prioritised on the AHP scale (see Figure 6.2, 6.3 and 6.4). The pairwise comparison matrix was used to obtained the normalised matrix and geometric means of priority vector (PV) for disruption risk factors. The supply chain risks are responsible for the decline in oil production in Nigeria, specifically, the supply chain risk responsible for shortfall in oil productions result from geopolitical conflicts, insurgent violence of the militants and attacks on oil infrastructures. Table 2.2 categorically identified and supported the various supply chain disruption risk which this study has revealed as critical risk factors affecting supply chain management performance from the literature review of this study.

RQ3: To what extent does risk associated with the oil industry in Nigeria impact significantly supply chain and performance measure?

The research question (RQ3) relates to research objective 4, which seeks to facilitate the guidance for managing supply chain risk based on the established relationship of influence of supply chain and performance measure in the Nigerian oil industry. The relationship between exploration and production, environmental regulatory compliance, and geopolitical risk have thus shown how the oil industry does impact supply chain and performance measure.

The structural model (Figure 6.5), tested the three hypotheses with partial least squares structural equation model (PLS-SEM) techniques. The structural model shows that exploration and production and geopolitical risk negatively impacts the supply chain performance. The environmental regulatory compliance is significantly related to supply chain and performance measure. The consequential change in supply chain components are positively significant with the performance measure. The findings provide an insight into the extent to which environmental regulatory compliance risk associated with the oil industry does significantly impact supply chain and performance measure in Nigeria.

Although, the severity risk modes for risks associated with the oil industry (exploration and production, environmental regulatory compliance, geopolitical risk) were prioritised on the AHP scale (see Figures 6.2, 6.3 and 6.4), the RQ3 only addressed the questions posed. Since the central focus of this study is aimed at developing a systematic method for mitigating disruption risk in the supply chain in the Nigerian oil industry, the study's emphasis is more concerned with the appropriate coping strategies for mitigating supply chain risk in Nigeria's oil industry. Among the coping strategies, the study revealed game theory as one of the most effective approaches for managing supply chain disruption risks in Nigeria oil industry. This suggests that game theory is the most likely risk management technique for building supply chain resilience and mitigating supply chain risk in the petroleum industry in Nigeria. However, Zhao et al. (2012) explored game theory for displaying lifecycle carbon emissions to aid the decision-making of prospective manufacturers when responding to environmental risk warning signs. This study acknowledged game theory as a mathematical modelling technique for coordinating and controlling incongruence in the supply chain. Supply chain coordination emphasises the decision-making process to identify disruption risk failure, assess and provide managing capability for ensuring maximisation of the overall supply chain processes in Nigeria's oil industry.

RQ4: What are the risk management strategies that can provide resilience to supply chain management in the Nigerian oil industry?

Research question (RQ4) established the appropriate risk management strategy for building supply chain resilience in the Nigerian oil industry. The motivation for the research question was to develop a behavioural risk management approach that can be incorporated into a supply chain risk management framework. Given the correlations analysis (see Table 6.14) which evaluated thirteen types of risk management strategies conceptualised from the literature , the results suggested that the Nigeria's oil industry can selectively implement: supplier capacity/production development (RES1), legislative compliance/regulations (RES2), contract strategy/collaboration (RES3), operational flexibility (RES4), postponement/delay of project (RES5), divestment (RES6), licensing/subcontracting arrangement (RES7), inter-firm personnel exchange/training (RES12) and joint business planning (RES13) as supply chain risk management strategies for building supply chain resilience in the Nigerian oil industry.

The bivariant correlation for supply chain resilience suggests that research question (RQ4) is significantly linked with the risk components used to elucidate the context of this study. The contextual components of the supply chain resilience were positively significant and concomitantly increase and decrease other constructs in the model. The fixture of the whole supply chain resilience factors into a regression model to predict the sum for determining the supply chain resilience can be implemented in the Nigerian oil industry. The research revealed that legislative compliance/regulations (RES2), contract strategy/collaboration (RES3), sourcing policy (RES10) and inter-firm personnel exchange/training (RES12) would appropriately create or build resilience into the petroleum supply chain in Nigeria.

8.2 Recommendations

This study assessed disruption risks in the supply chain in the upstream petroleum industry in Nigeria. Based on the research findings, several recommendations for supply chain practitioners, stakeholders, investors and government agencies are presented to manage disruption risks in the oil industry in Nigeria. The considered recommendations are relevant to other industries that adopt supply chain disruption risk management.

The interconnectedness of the supply chain implies that risks can emerge anywhere in the supply loop or link. The emergence of disruption risk in the supply chain can impose some socio-political, economic and environmental consequences for supply chain management practices. Consequently, this study firstly advocates the need to reinforce joint working commitments by those involved in managing supply chain activities so as to improve the emerging and re-emerging supply chain risks and conflicts in Nigeria's oil industry. Coulson-Thomas (2002), suggested that risk management practices should reflect inter-connected attributes of a contemporary network affiliation with customers, suppliers and stakeholders. The supply chain risk management approaches will help to boost productivity and build supply chain resilience to withstand the multiplicity of risk which may strike the supply chain activities in the Nigerian oil industry.

Second, there is a need for supply chain visibility emphasising access to key business information that prompts a faster response by the Nigerian oil industry. Access to key business information helps to check against unexpected risk occurrences and prevents instability in managing supply chain performance (Blackhurst et al., 2011). This study highlights the need for information sharing with various stakeholders, supply chain partners and people in the oil producing community in Nigeria. Information sharing captures and disseminates timely and relevant information to enable decision-makers to plan and control supply chain performance. In addition, effective information sharing provides improved information access to smooth the flow of materials in the supply chain. This helps to identify and resolve supply chain errors, delays and non-regulatory compliance to an environmental agenda, which could impose variability into the supply chain in Nigeria's oil industry.

Third, oil industry risk management community monitoring measures and governance structures should be explored in the management of supply chain performance in Nigeria's oil industry. This encourages the identification of the best practices for managing supply chain risk in order to strengthen risk management procedures. However, Coulson-Thomas (2007) advocated that monitoring practices help businesses to assess the impact of risk management practices and enable individuals and companies to cope and adapt to risk in their supply chain portfolios. This also develops the needed procedural capabilities required to create supply chain resilience in the Nigerian oil industry and also protects oil operators from potential opportunistic behaviours in the process of implementing a supply chain risk management agenda. Moreover, this creates strong stakeholder adherence to regulatory and legal practices established for managing supply chain events in Nigeria's oil industry. This study recognised the need for further developing the supply chain risk management literature and procedures by identifying gaps that this study has aimed to address (Section 1.3). The findings of this study will establish the expectation in contractual arrangement, regulation, policies and procedures in the Nigeria oil industry.

Fourth, in the course of this study, the data obtained from the research subjects was modelled and simulated to create supply chain risk management reality. The study acknowledged the need for regular game theory simulation exercises at all levels as a coordinating mechanism for supply chain in the Nigeria oil industry. Such simulating exercises would provide a distinctive prospect for testing supply chain capabilities and procedures for mitigating supply chain risk in Nigeria's oil industry. This facilitates a coordinated supply chain agility, accountability and transparency for supply chain risk management. In addition, game theory was presented as a valuable model for coordinating supply chain risk management. Therefore, this study recommended an effective communication system, as a significant constituent for matching the supply and demand. Balancing the supply chain events will eliminate the adverse effects of unsustainable practices in the Nigerian oil industry.

Finally, putting all the above recommendations together, there is a need to reinforce joint commitments, improve knowledge management, develop contractual agreements and collaboration, increase information sharing, introduce monitoring and governance structures and implement game theory simulating exercises in order to create resilience to supply chain disruption risk. The successful implementation depends on investment and commitment of supply chain partners and the oil producing community in Nigeria.

8.3 Contribution to Knowledge

This section presents the contribution of this research findings to the current body of knowledge; with specific concern to disruption risk in the petroleum supply chain in Nigeria.

The application of agency theory in this study contributes to the development of supply chain risk management. This creates the theoretical awareness for explaining observed reality for mitigating disruption risk in supply chain. This contributed to the development of scarce literature on disruption risk in supply chain in Nigeria. This research also contributes to;

- the allocation of resources in the supply chain and helps management to carefully plan its resources for petroleum production in Nigeria.

This is the first research to use integrated systematic approach such as; partial least square structural equation modelling (PLS-SEM), analytical hierarchy process (AHP) and multiple regression analysis (MRA); were applied to resolve disruption risk in supply chain in Nigeria. The systematic integrated approach enhances:

- Consistency in the assessment of disruption risk in supply chain in Nigerian oil industry.
- The method for testing, developing, maintaining and linking with theory in order to coordinate disruption risk factors especially in the petroleum supply chain.
- The procedure for documenting the management of disruption risk in supply chain.
- The framework for building resilience in supply chain.

The implementation of the systematic approach for disruption risk in supply chain in the Nigerian oil industry, contributes to knowledge in supply chain risk management. The applied methods shows' how modelling help businesses to focus on holistic process for identifying, prioritising and quantifying supply chain risk. The disruption risk assessment in supply chain can be generalised by supply chain professionals for managing supply chain disruption. In addition, the implementation process contributes to the conceptualisation of supply chain risk management. This brings originality to the formulation of risk management options for the decision-making process in the supply chain risk management.

This study sheds light on a new approach for attaining knowledge and understanding the phenomenon of disruption risk assessment in supply chain in the upstream petroleum industry. This approach enhances:

- a simplistic way for attaining knowledge and processing supply chain partners' information on risk management. This helps supply chain practitioners to communicate emerging risk and proactively responding to disruptions risks in the supply chain of the Nigerian oil industry.
- a dynamic approach to grouping, skills and resources for addressing emerging changes in both internal and external influence on supply chain.

This study is the first to proposed a simulative process through the use of game theory for managing disruption risk in supply chain in Nigeria. This create the value for:

- Managing supply chain incongruence.
- provide organisations with the ability to effectively coordinate supply chain risk.
- creating a novel way to synchronise the interconnected risk taxonomy affecting supply chain networks in Nigeria.
- Identify emerging problem from supply chain partners.
- Grouping resources and skills in order to set priorities for supply chain.

This finding will bring originality to the way supply chain practitioners collaborate to apply knowledge and skills to coordinate the assessment of disruption risk in Nigeria's petroleum industry supply chain.

In summary, this study creates the insight for effective disruption risk management structures; building supply chain resilience for a better organisational performance measure.

8.4 Managerial Implications

The research implication of this study is that supply chain practitioners will be able to update their knowledge of risks and the appropriate approaches for mitigating risk, based on the established procedural framework for responding to risk in the oil industry. The established procedures can be replicated by other industrial settings, where operations and activities are similar to the oil industry, such as aeronautics, agriculture and biotechnology businesses, which share a similarly complex supply chain as the petroleum industry. Research and development organisations could use these research findings to update and develop their curricular on sustainable supply chain management and environmental regulatory compliance programmes. This facilitate companies' ability to respond according to reported regulatory guidelines for sustainable practices in supply chain, and retain consumer trust in their supply chain (Chinta, 2017b).

Second, a further managerial implication for this research is that the risk procedural framework documentation can helps to improve and develop the knowledge and practice of supply chain practitioners and managers. Thus managers and practitioners will learn to manage the human aspect in a supply chain, develop the knowledge capability of supply chain teams and better understand the specific policy standards required for governing supply chain management in the Nigerian oil industry.

Third, the implication of this study would facilitates the development and implementation of the supply chain community who can organise simulation exercises upon which they can rehearse their responses to mitigating risk occurrence modes on supply chain performance. This process will help oil industry operators to analyse the causes of risks to supply chain management. Gaining these skills and experiences would have strong implications for the way in which supply chain practitioners objectively assess their supply chain risk management. These skills and experiences enforce the practice of specific competences by supply chain members for mutual benefits of parties in the network (Callaway and Dobrzkowski, 2009). Chinta (2017a) affirmed that supply chain operators needs to group their skills and resources to accommodate existing change in economic performance, customer choices and fluctuation of currency and skills. This assertion is viewed as source of specific assets, knowledge sharing routines, complementary resources and governance (Weingarten et al., 2016).

Furthermore, strong communication with the oil sector stakeholders can build the relationships and cooperation in the management of supply chain. Relationships among the key players in the supply chain is a significant capability for building supply chain resilience. The competence of game theory would improve negotiation processes with oil investors. The negotiation ability will help the shareholder have full knowledge of existing investment risk and the appropriate strategy for mitigating the various oil industry risks, such as exploration and production, environmental and regulatory compliance and geopolitical risk in the petroleum exploratory industry in Nigeria.

8.5 Limitations of this Study

In the process of conducting this study, several limitations emerged. Among the observed limitations is the administered survey questions with selected research subjects in the petroleum exploration industry in Nigeria. This implies that the methodology used is not frequently used to operationalise research of this dimensions. However, the research findings were generalised based on other studies across the globe. The applied methodology creates a simplified methodology for supply chain partners to acquire knowledge in understanding the way to manage disruption risk to supply chain.

Due to the nature of the sample drawn from the population, a purposive sampling method was used to collect data from selected research respondents. This sampling method reduced the researcher’s ability to randomise the research subjects. Although the sample for this research comprises various departments the focus was strictly on the upstream petroleum industry. For future studies, the sample might focus largely on supply chain professionals.

Furthermore, this study has deliberately omitted the inclusion of the recap of research question RQ5 in section 8.1.2. The analysis of RQ5 was addressed in chapter 7.

8.6 Potential for Future Research

Based on the literature review for this study, a prominent area from the global supply chain perspective that needs further research is the current risk management practices in Nigeria. The areas which need to be addressed for future research is: how risk management strategies can improve supply chain resilience in the developing and developed economy; the costs involved in developing and managing risk strategies – for instance they are extremely high, so how would these impact the business performance? For example, the past decades have witnessed the emergence and re-emergence of various viruses such as Ebola, Avian flu and drug-resistant superbugs, or new infectious diseases. Ninety percent of epidemiologists anticipated that one of these infectious diseases will cause a deadly pandemic for the future generations (Johnson, 2006), such infectious diseases have significantly affected the management of supply chains and pose challenges to global supply chains. Future research could investigate what needs to be done in order to facilitate risk management processes that create supply chain resilience in the event of the re-emergence of such infectious diseases.

Furthermore, the inadequacies of petroleum regulatory policies in Nigeria, have negatively impacted sustainable supply chain management practices, which have resulted in supply chain disruption risk in Nigeria's oil industry. Since this study does not aim to investigate the context of supply chain sustainability as it relates to disruption risk, this study hereby recommends future research which seeks to investigate risk management components that focus on sustainable supply chain management in the Nigerian oil industry.

Based on the literature review of the petroleum supply chain, the issues related to upstream supply chain risk in the petroleum industry were discussed within the global perspective in relation to Nigeria. Due to the interesting findings of this study, future research could investigate supply chain disruption risk issues related to the midstream and downstream supply chain management in

Nigeria's oil industry. Doing this will explicitly broaden the understanding of supply chain risk management in Nigeria.

8.7 Summary

The aim of this study is to develop model for analysing and evaluating the concept of supply chain risk management strategy as it relates to the identified disruption risks confronting supply chain performance in Nigeria's oil industry. Six research questions were posed in order to accomplish the research purpose and objectives. The evaluation of supply chain risk management practices revolved around exploration and production, environmental regulatory compliance and geopolitical risk. Survey questionnaire were carried out on the supply chain risk and supply chain performance measures. The research findings show how supply chain risk impacts supply chain practices. This implies that the existing relationship between oil industry risk and supply chain performance are significantly low.

Furthermore, the research emphasises the importance of risk management strategy as factors that can be used for attaining resilience in the supply chain in Nigeria's oil industry. The survey results indicated that some risk management strategy factors remain incapable of building resilience into the supply chain. This resulted in investors unwilling to commit resources across the geopolitical region to protect the petroleum supply chain and improve crude oil storage facilities, because of the uncertainty related to the return on their investment in the Nigerian oil industry.

Indeed, the research suggests the need for the oil operators to adhere to the regulatory policies and procedure could help to create a governing structure for managing supply chain disruption risk in Nigeria's oil industry. Investment in the implementation of supply chain risk management would create supply chain resilience in Nigeria's oil industry.

The implications of this study were submitted. Consequently, risk management strategy has confirmed that behavioural-based mechanism and buffer-oriented approaches as the theoretical dimension, can create awareness for explaining supply chain risk management. Furthermore, supply chain practitioners can categorise supply chain risk into their relative taxonomies, which enables the identification of the appropriate treatment for addressing the respective type of risk. Taxonomies allow for well-organised solutions in the management of business risk in a given complex environment.

Indeed, the empirical analysis of risk factors suggested the need for decisions to be taken so that risk managers can prioritise supply chain or related risks into their respective severity modes. In fact, research in other areas of endeavour can be replicated in other industries. In addition, the limitations of the study is that purposive sampling adopted for this study have not given the opportunity for the randomization of the research data.

Recommendations were based on the analysis and interpretation of the findings as they relate to the literatures. This study ultimately calls for the Nigerian government to encourage and intensify support to help the improvement of the existing risk management structure in order to build resilience into the supply chain in Nigeria's oil industry. Improved supply chain resilience practices would lead to better performance, mitigation and even prevention of supply chain risk. It is upon these established characteristics that this study has explored a systematic approach to implement the concept of disruption risks in the supply chain in Nigeria oil industry.

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Appendices

Appendix 1

Research Questionnaire

The University of Bradford

Faculty of Engineering and Informatics

United Kingdom

Survey Questionnaire

Dear Sir / Ma,

The researcher is undertaking a Doctorate Degree (PhD) Programme in Faculty of Engineering and Informatics at the University of Bradford. UK; and he is undertaking an academic study of your organization. The questions contained in this questionnaire are designed to find out your opinion and feelings about the "Assessment of Disruption Risk Supply Chain the Case of Nigeria's Oil Industry". This is strictly an academic exercise and whatever information you provide will be treated confidentially. This research work will not mention your organisation or name of research respondents.

Consequently, ethics approval has been granted by the Chair of the Humanities, Social and Health Sciences Research Ethics Panel at the University of Bradford on 22/12/16. The researcher will appreciate as much assistant you can possibly provide for this study. If you require any clarification on any aspect of this survey questionnaire, please do not hesitate to contact me, Olatunde at +234 - 803 - 682 - 5228 or +447808518869 and Email: o.aroge@student.bradford.ac.uk

Please keep or print this copy of informed consent information sheet for your reference.

Please click the links below this will take you to the survey.

Thanks for participating in this study

Yours Faithfully,

Olatunde O. Aroge

Section A - Socio Demographic Data

Please read each question carefully and tick or fill in the appropriate answer that represents your personal data.

1. Respondent's Positions -----------------------------
2. Business Units:
    - Exploration & Production ☐
    - Service Providers / Contractors ☐
    - Business Development ☐
    - Engineering & Construction ☐
    - Marketing & Distribution ☐
    - Logistics & Transport/Supply Chain ☐
    - Others ---
3. Experience of Respondent 1-5years ☐ 6-10 years ☐ 11-20 years ☐ 21 years -Over ☐

Section B - Supply Chain Risk

1. These questionnaires are developed for data collection on the oil industry risk affecting supply chain. Your opinion among this oil Industry risk can be ranked (x) in appropriate response column on 1 to 5 scale (1 is the **least and 5 highest).**

Items	Oil Industry Risk Factors	Very Low	Low	Medium	High	Very High
EPR1	Uncertain oil reservoirs					
EPR2	Uncertainty in underground water during drill operations					
EPR3	Lack of sufficient recovery quantities of hydrocarbon					
EPR4	Low permeability of oil reservoir					
EPR5	Error in reserve oil forecast					
EPR6	Delivery inappropriate production equipment /lead time					
EPR7	Formation damages / unexpected drilling conditions					
EPR8	Regulatory time limits for exploration					
EPR9	Experience of rigs workers / Inadequate production capacity					
EPR10	Ageing of oilfields /infrastructure					
EPR11	New technology to enable access to oilfields					
EPR12	Availability of capital investment fund					

ERC1	Blow out / oil blast discharge					
ERC2	Oil spillage as a result of ageing infrastructure					
ERC3	Pipelines vandalization /sabotage to production facilities					
ERC 4	Uncoordinated disposing process for crude oil waste					
ERC 5	Management of petroleum resources					
ECR 6	Inadequate government policies on petroleum					
ERC 7	Change to government economic policy					
ERC8	Cargo routeings and scheduling					
ERC 9	Complexity of transportation network due to oilfield clusters					
ERC10	Adverse weather conditions					
ERC11	Environmental impacts & legislative policy compliance					
GPR1	Theft of oil infrastructures					
GPR 2	Armed conflicts / militant attacks on oil rigs					
GPR 3	Unsustainable operational practices					
GPR4	Complexities of interactions with oil communities					
GPR 5	Demand volatility					
GPR6	Supply variability					
GPR7	Piracy threats to the security of oil carrying vessels employee					

2. These questions deal with your organization's approach to managing risk in supply chain. Please check or mark an "x" with the appropriate response in the provided columns.

Items	Applicable understanding of risk analysis techniques	Do Not Understand	No Understanding	Least Understand	Partially Understandable	Highly Understandable
RMT1	Linear programming					
RMT2	Game Theory					
RMT3	Monte Carlo Simulation					
RMT4	Decision Tree					
RMT5	Statistical Analysis					
RMT6	Analytical Hierarchy Process					
RMT7	FMEA.					
RMT8	Structural Equation Modelling					
RMT9	Multiple Regression Analysis					
RMT10	Real Option Theory					
RMT11	Portfolio Analysis Model					

3. Does your organisation used any of this risk analysis techniques to analyse supply chain risk?

Yes	No	Does Not Know

4. Others (Please specify) ---

5. In your opinion of these risk analysis techniques. Rank their effectiveness and efficiency of these techniques from scale 1 - 5. (1 is least and 5 is high).

Items	Effectiveness and efficiency of risk analysis	Very Low	Low	Medium	High	Very High
ERT1	Linear programming					
ERT 2	Game Theory					
ERT3	Monte Carlo Simulation					
ERT4	Decision Tree					
ERT5	Statistical Analysis					
ERT6	Analytical Hierarchy Process					
ERT7	FMEA.					
ERT8	Structural Equation Modelling					
ERT9	Multiple Regression Analysis					
ERT10	Real Option Theory					
ERT11	Portfolio Analysis Model					

6. From the assumptions of risk, how effective are the following supply chain elements being managed in your organisation.

Items	Managing supply chain elements	Do Not Know	Not Effective	Least Effective	Effective	Highly Effective
SCM1	We share demand information with supply chain partners.					
SCM2	We maintain close working relation across the supply chain.					
SCM3	We integrate our remote demand requirements plan in the supply chain.					
SCM4	We effectively provide much details for improving our supply chain					
SCM5	We adequately link and communicate key logistics activities.					
SCM6	We sequentially managed and improve supply chain					

	planning process.					
SCM7	We depends on supply chain partners from a given geographic zones.					
SCM8	We deepened our commitment with key customers to reduce unanticipated changes in demand.					
SCM9	We deal with multiple requirements to achieve our supply chain objectives					

7. How has risk significantly impacted on the following performance measure in your organisation

Items	Performance measure	No impact	Some Negative Impact	Partial Impact	Positively Impact	Strong Positive Impact
PM1	Quality of service /customer satisfaction					
PM2	Customer Responsiveness					
PM3	Flexibility to requirement					
PM4	Costs					
PM5	Innovation					
PM6	Dependability (Order Fulfilment) / Inventory level					
PM7	Throughput Efficiency					
PM8	Productivity					
PM9	Return on investment					

8. In your organization what are the most currently employed approaches for managing risk in your supply chain

Items	Current risk management in supply chain	Do Not Use	Not Used	Least Used	Used	Frequently Used
BBM 1	We develop processes with supply chain members					
BBM 2	We maintain policies standard in order to create value in our supply chain					
BBM 3	We established long contractual agreement and relations with chain members					
BBM 4	We substitute existing technology and practices for specialized business commitments.					
BBM 5	We maximize the possible benefits and reduce risk by delaying our investment plans					
BBM 6	We eliminate unprofitable assets that impacts on investments.					
BBM 7	We ensure that licensed and regulated contractors are screened and selected for contractual arrangement.					
BBM 8	We relocates our operation to other regions in order to minimax risk on investment					
BBM 9	We provide the resources to Improving logistics operations.					
BBM10	We strive to plan materials that entirely minimise risk in our supply chain.					
BBM11	We effectively manage our supply chain operational for maximum benefits.					
BBM12	We strive to foster cross organisational exchange of knowledge to develop risk management culture.					
BBM13	We foster and share business operational intelligence with partners.					

9. In your organisation, what would be most the risk management approaches you think can provide resilience to supply chain in the next five years.

Items	Building Resilience to supply chain	Do Not Know	Not Appropriate	Least Appropriate	Appropriate	Highly Appropriate
RES1	We help our supply chain partners to build their technical competences for productivities.					
RES2	We adhere to established regulatory policies and procedures in order to prevent supply chain disruption					
RES3	We creates a long term contractual agreements with supply chain partners.					
RES4	We emphasize on skills and competencies to absorb the negative influence on supply chain disruption risk.					
RES5	We redesigning our supply chain processes to prevent the impacts of disruption risk.					
RES6	We strive to develop existing competencies and commitments for efficiency.					
RES7	We strive to involve certificated supply chain partners in contractual arrangement.					
RES8	We invested across the geographical regions to secure our supply chain.					
RES9	We strive to improving our logistics operations to prevent our supply chain from disruption.					
RES10	We strive to minimize costs of buffer stock to reduce excessive inventory in supply chain					
RES11	We ensure control in supply chain operations to prevent disruption risk.					
RES12	We strive to facilitate inter-firm knowledge exchange with our supply chain partners.					
RES13	We strive to jointly creates risk management plans with supply chain partners.					

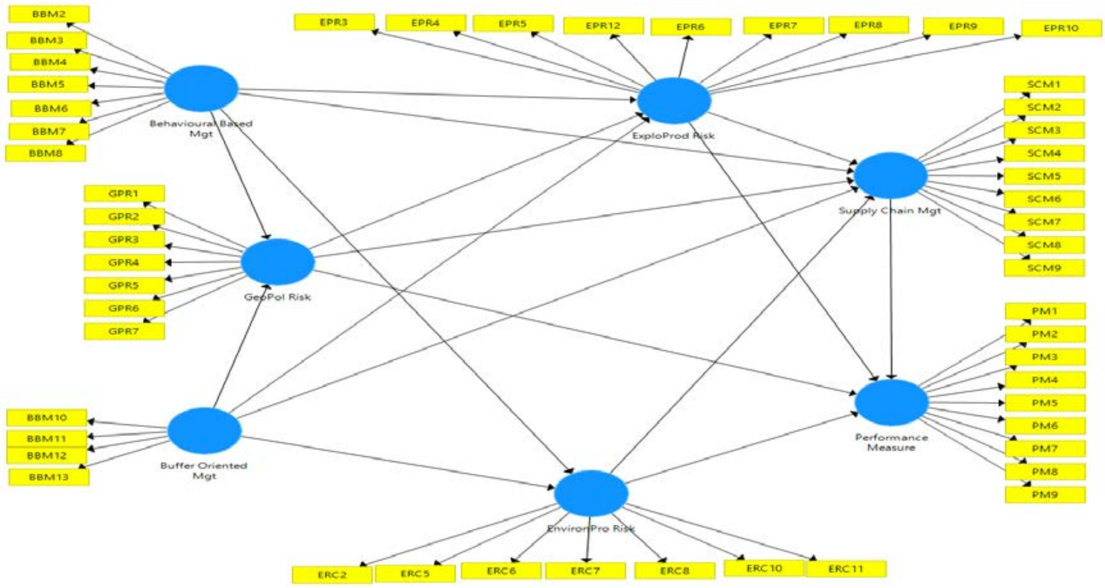
Appendix 2

Toyota Global Production Network

Continents	Reference Keys	Countries	Continents	Reference Key	Countries
North America	1 - 9	USA	Africa	24	South Africa
	10 – 11	Canada		25	Kenya
				26	Egypt
Latin America	12	Mexico	Asia	27 - 28	India
	13	Argentina		29	Pakistan
				30	Taiwan
	14	Brazil		31 - 33	Indonesia
	15	Venezuela		34 -35	Thailand
				36	Malaysia
				37 – 38	Philippines
				39	Vietnam
Europe	16	Poland	China	40	Bangladesh
				41 - 49	China
			Oceania	50	Australia
	17	France			
	18	United Kingdom			
	19	Turkey			
	20	Russia			
	21	Czech			
	22	Poland			
	23	Portugal			

Appendix 3

Adjusted research model



The following research items were dropped from the research model 3. Environment procedural risk variables - ERC 1; ERC 3; ERC 4; ERC 9. Also, exploration risk - EPR 1; EPR 2; EPR 11; and Behavioural Management - BBM 1; and Buffer Based tech BBM 9.

Appendix 4

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.695	10.976	10.976	6.695	10.976	10.976
2	2.788	4.571	15.547	2.788	4.571	15.547
3	2.719	4.457	20.003	2.719	4.457	20.003
4	2.318	3.799	23.803	2.318	3.799	23.803
5	2.136	3.502	27.305	2.136	3.502	27.305
6	2.009	3.293	30.598	2.009	3.293	30.598
7	1.944	3.186	33.784	1.944	3.186	33.784
8	1.777	2.914	36.698	1.777	2.914	36.698
9	1.715	2.811	39.509	1.715	2.811	39.509
10	1.580	2.591	42.100	1.580	2.591	42.100
11	1.534	2.515	44.614	1.534	2.515	44.614
12	1.458	2.391	47.005	1.458	2.391	47.005
13	1.388	2.276	49.281	1.388	2.276	49.281
14	1.364	2.236	51.517	1.364	2.236	51.517
15	1.313	2.153	53.670	1.313	2.153	53.670
16	1.254	2.056	55.725	1.254	2.056	55.725
17	1.201	1.970	57.695	1.201	1.970	57.695
18	1.154	1.892	59.587	1.154	1.892	59.587
19	1.119	1.835	61.422	1.119	1.835	61.422
20	1.068	1.751	63.173	1.068	1.751	63.173
21	1.042	1.707	64.881	1.042	1.707	64.881
22	1.017	1.668	66.548	1.017	1.668	66.548
23	1.004	1.646	68.194	1.004	1.646	68.194
24	.974	1.597	69.790			
25	.933	1.530	71.320			
26	.891	1.461	72.781			
27	.877	1.437	74.219			
28	.857	1.405	55.624			
29	.842	1.381	77.005			
30	.801	1.314	78.318			
31	.782	1.283	79.601			
32	.766	1.256	80.857			
33	.708	1.161	82.018			

34	.698	1.145	83.163
35	.684	1.122	84.284
36	.640	1.049	85.333
37	.622	1.019	86.352
38	.593	.972	87.324
39	.564	.925	88.249
40	.553	.907	89.156
41	.502	.824	89.980
42	.492	.806	90.786
43	.460	.754	91.540
44	.441	.723	92.263
45	.435	.713	92.975
46	.425	.697	93.672
47	.393	.644	94.315
48	.383	.628	94.943
49	.365	.599	95.542
50	.362	.593	96.135
51	.328	.538	96.674
52	.305	.500	97.174
53	.272	.446	97.620
54	.255	.418	98.038
55	.235	.385	98.423
56	.231	.379	98.803
57	.212	.348	99.150
58	.189	.310	99.460
59	.163	.267	99.728
60	.158	.259	99.986
61	.008	.014	100.000

Extraction Method: Principal Component Analysis

Appendix 5

Communalities Communalities (Cont.)

Communalities		
	Initial	Extraction
EPR1	1.000	.651
EPR2	1.000	.669
EPR3	1.000	.615
EPR4	1.000	.712
EPR5	1.000	.762
EPR6	1.000	.754
EPR7	1.000	.778
EPR8	1.000	.712
EPR9	1.000	.765
EPR10	1.000	.672
EPR11	1.000	.709
EPR12	1.000	.555
ERC1	1.000	.757
ERC2	1.000	.698
ERC3	1.000	.712
ERC4	1.000	.685
ERC5	1.000	.684
ERC6	1.000	.717
ERC7	1.000	.740
ERC8	1.000	.659
ERC9	1.000	.698
ERC10	1.000	.663
ERC11	1.000	.575
GPR1	1.000	.951
GPR2	1.000	.630
GPR3	1.000	.649
GPR4	1.000	.670
GPR5	1.000	.592
GPR6	1.000	.953
GPR7	1.000	.691

SCM1	1.000	.702
SCM2	1.000	.721
SCM3	1.000	.638
SCM4	1.000	.706
SCM5	1.000	.628
SCM6	1.000	.606
SCM7	1.000	.675
SCM8	1.000	.599
SCM9	1.000	.629
PM1	1.000	.613
PM2	1.000	.613
PM3	1.000	.651
PM4	1.000	.631
PM5	1.000	.688
PM6	1.000	.676
PM7	1.000	.757
PM8	1.000	.749
PM9	1.000	.732
BBM1	1.000	.670
BBM2	1.000	.576
BBM3	1.000	.681
BBM4	1.000	.644
BBM5	1.000	.593
BBM6	1.000	.638
BBM7	1.000	.601
BBM8	1.000	.610
BBM9	1.000	.700
BBM10	1.000	.718
BBM11	1.000	.747
BBM12	1.000	.657
BBM13	1.000	.671
Extraction Method: Principal Component Analysis.		

Appendix 6: Pair Wise Comparison Matrix of Exploration and Production Risk

		EPR 3	EPR 4	EPR 5	EPR 6	EPR 7	EPR 8	EPR 9	EPR 10	EPR 12	**Sum**
		0.469	0.462	0.434	0.570	0.561	0.587	0.548	0.463	0.522	
EPR 3	0.469	1	1.015	1.081	0.823	0.836	0.799	0.856	1.013	0.898	8.321
EPR 4	0.462	0.985	1	1.065	0.811	0.824	0.787	0.843	0.998	0.885	8.197
EPR 5	0.570	1.215	1.234	1	1.000	1.016	0.971	1.040	1.231	1.092	10.113
EPR 6	0.561	1.196	1.214	1.293	1	1.000	0.956	1.024	1.212	1.075	9.953
EPR 7	0.587	1.252	1.271	1.353	1.030	1	1.000	1.071	1.268	1.125	10.414
EPR 8	0.548	1.168	1.186	1.263	0.961	0.977	1	1.000	1.184	1.050	9.722
EPR 9	0.548	1.168	1.186	1.263	0.961	0.977	0.934	1	1.184	1.050	9.722
EPR 10	0.463	0.987	1.002	1.067	0.812	0.825	0.789	0.845	1	0.887	8.214
EPR 12	0.522	1.113	1.130	1.203	0.916	0.930	0.889	0.953	1.127	1	9.261

Appendix 7: Normalized Vector of Exploratory and Production Risk

1	1.031	1.168	0.677	0.699	0.638	0.732	1.026	0.807	2.789
0.970	1	1.133	0.657	0.678	0.619	0.711	0.996	0.783	2.747
1.477	1.522	2	1.000	1.032	0.943	1.082	1.516	1.192	3.390
1.431	1.474	1.671	1	1.000	0.913	1.048	1.468	1.155	3.336
1.567	1.614	1.829	1.061	1	1.000	1.147	1.607	1.265	3.491
1.365	1.407	1.594	0.924	0.954	1	1.000	1.401	1.102	3.259
1.365	1.407	1.594	0.924	0.954	0.872	1	1.401	1.102	3.259
0.975	1.004	1.138	0.660	0.681	0.622	0.714	1	0.787	2.753
1.239	1.277	1.447	0.839	0.866	0.791	0.907	1.271	1	3.104

Appendix 8: Pair Wise Comparison Matrix of Environmental and Regulatory Compliance Risk

		ERC 2	ERC 5	ERC 6	ERC 7	ERC 8	ERC 10	ERC 11	**sum**
		0.389	0.622	0.453	0.477	0.621	0.529	0.429	
ERC 2	0.389	1	0.625	0.859	0.816	0.626	0.735	0.907	5.568
ERC 5	0.622	1.599	1	1.373	1.304	1.002	1.176	1.450	8.903
ERC 6	0.453	1.165	0.728	1	0.950	0.729	0.856	1.056	6.484
ERC 7	0.467	1.201	0.751	1.031	1	0.752	0.883	1.089	6.685
ERC 8	0.621	1.596	0.998	1.371	1.302	1	1.174	1.448	8.889
ERC 10	0.529	1.360	0.850	1.168	1.109	0.852	1	1.233	7.572
ERC 11	0.429	1.103	0.690	0.947	0.899	0.691	0.811	1	6.141

Appendix 9: Pair Wise Comparison Matrix of Geopolitical Risk

		GPR1	GPR2	GPR3	GPR4	GPR5	GPR6	GPR7	**sum**
		0.420	0.387	0.571	0.598	0.680	0.690	0.401	
GPR 1	0.420	1	1.085	0.736	0.702	0.618	0.609	1.047	5.797
GPR 2	0.387	0.921	1	0.678	0.647	0.569	0.561	0.965	5.341
GPR 3	0.571	1.360	1.475	1	0.955	0.840	0.828	1.424	7.881
GPR 4	0.598	1.424	1.545	1.047	1	0.879	0.867	1.491	8.254
GPR 5	0.680	1.619	1.757	1.191	1.137	1	0.986	1.696	9.385
GPR 6	0.690	1.643	1.783	1.208	1.154	1.015	1	1.721	9.523
GPR 7	0.401	0.955	1.036	0.702	0.671	0.590	0.581	1	5.535