Information Risk Management within Supply Chains

By

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DECLARATION

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ABSTRACT

A supply chain is an integrated process wherein different organizations combine their efforts in acquiring raw materials, transforming the raw materials into finished products and delivering the finished products to the final consumers. Organizations are continuously searching for means to reduce costs and simultaneously making effort to enhance the quality of their products, and ultimately satisfying customers' demand. There are three major components essential to achieving these: information flow, cash flow and material flow.

In this research, we evaluate modern competitive global market, where it is challenging for any organization to function in isolation of its trading partners, and where organizations need the enhanced flow of information as well as an easier, reliable and faster access to the necessary information; as information has been identified as the foundation upon which decisions regarding the other supply chain process and activities are made, and is the link between all operations in any supply chain.

This research considers the supply chain as a concept which is centred on the development of a value chain network. This network consists of entities that are committed to providing information, cash and resources in order to achieve the goals of an effective supply chain. In the global economy, this network is expanding, and this expansion is causing the extent of information flow in the supply chain to increase and hence become complex. The increasing length of information flow in the supply chain and the complexity of the value chain network are presently exposing information within the supply chain to risk.

Hence, the objectives of this research are to identify information risks and consider ways in which these risks may be managed within supply chains. This study helps in identifying what information flows and how information flows within the supply chain. It provides an understanding of information vulnerabilities and risks associated with these vulnerabilities. It also helps identify how these information vulnerabilities and risks may be managed.

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LIST OF ACRONYMS

APS	Advanced Planning and Scheduling
CIO	Chief Information Officer
COSO	Committee of Sponsoring Organizations
CAS	Complex Adaptive System
CASN	Complex Adaptive Supply Network
CS	Control Strength
CLM	Council of Logistics Management
DBMS	Database Management Systems
DIS	Demand Information Sharing
DC	Distribution Centers
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
FAIR	Factor Analysis of Information Risk Framework
FMCG	Fast Moving Consumer Goods
GSCF	Global Supply Chain Forum
IM	Information Management
IS	Information System
IT	Information Technology
IP	Internet Protocol
ISP	Internet Service Provider
LAN	Local Area Network

LEF	Loss Event Frequency
KDD	Knowledge Discovery in Databases
MRP	Manufacturing Resource Planning
MRPII	Manufacturing Resource Planning II
NIS	No Information Sharing
OLAP	On-Line Analytical Processing
OLTP	On-Line Transaction Processing
OIS	Order Information Sharing
PC	Personal Computer
P.O.S	Point-of-Sale
PLM	Probable Loss Magnitude
RFID	Radio Frequency Identification
RIMS	Risk and Insurance Management Society, Inc.
SQL	Structured Query Language
SCIRM	Supply Chain Information Risk Management
SCOR	Supply-Chain Operations Reference-Model
SCRM	Supply Chain Risk Management
TCap	Threat Capability
TEF	Threat Event Frequency
VANs	Value Added Networks
VMI	Vendor-Managed Inventory
Vuln	Vulnerability

LIST OF SYMBOLS

F	Function
R	Total Risk
R_i	Individual Risk

Chapter 1

INTRODUCTION

1.1 Introduction

In today's global market, it is challenging for any organization to function in isolation of its trading partners. Organizations are therefore concentrating on what they consider their core competencies, then collaborating, outsourcing and partnering with other companies for their non-core competencies. The resulting international collaboration and partnerships has lead to the globalization of businesses. Globalization and the swift pace of technological development are now causing markets to become more competitive, dynamic, and customer driven. "This competitive pressure in the global marketplace has greatly impacted on the traditional nature of the consumers' choice," (Suhong & Binshan, 2006, p. 1645). "Consumers are now demanding more variety, better quality, greater reliability and more efficient delivery," (Thomas & Griffin, 1996). The continual increase in consumers' choice and demand for variety has steadily increased, and this has stimulated an integrated manufacturing process between companies, wherein cash, information and raw materials are converted into final products.

The intense global competition is forcing organizations to offer lower price, better quality, more quantity and dependable products with better design flexibilities, (Tan, 2001). This competition is now shifting towards a knowledge-based economy, (Faisal, Banwet, & Shankar, 2007) "where organizations are trying to improve their agility with the objective of being flexible and responsive, in order to meet changing market requirements," (Gunasekaran & Ngai, 2004, p. 271). Success in this changing market environment now comes from delivering the highest levels of service that is required in moving a product to the appropriate place at the appropriate time, and at lowest cost. Today's market now demand and pay for all kinds of innovations, strategies and services which enables decision makers to plan, design and execute ideas that will facilitate an enterprise-wide profitability. In response to these market demands, companies now deal with several tiers of suppliers, service providers, and distribution partners.

The increasing drive to reduce costs and the consumers' demand for diversity has led to the creation of supply chains. The supply chain is a key area that every organization should examine because it plays an important role in fueling growth and profitability. Businesses of today now rely on their supply chain in order to survive. "The term supply chain evokes the image of a

predefined and fixed series of linkages, which are serially connected and unidirectional," (Hawker, Nelson, & Terry, 2004, p. 7). It encompasses the organization and their business activities required to plan, source, make and deliver a product. In its simplest form, a supply chain is made up of suppliers, manufactures, distributors and consumers. Every organization fit into one or several supply chains. However, "the doubt on how market will change has made it essential for organizations to be cognizant of the supply chain they partake in", (Hugos, 2003, p. 12).

For supply chain activities to be synchronized, organizations must possess and share information about the different members of their supply chain. "Information flow improves the coordination between supply chain processes and this enables material flow and reduces inventory costs," (Suhong & Binshan, 2006, p. 1642). Lack of information sharing among partners in any supply chain may substantially affect their overall performance. As such, it is important that information is shared, and properly managed so as to improve the supply chain success. "The supply chain involves a value information web from which emanates connections and many trading partners conforming to their information technology mandates," (Angeles, 2009, p. 229). Technology serves as a means of improving performance, and it also supports an organization to be of service to its customers, (Hugos, 2003).

The advantages of global sourcing and partnership depend on factors such as the product purchased, supplier's location, the mode of transportation, and information exchange. "In comparison to sourcing from local markets, global sourcing is usually associated with increased uncertainty as well as poorer transparency and visibility," (Wagner & Bode, 2006, p. 306). In the past, when companies sourced and manufactured locally, there was less risk and these risks could easily be managed, but the advent of extended supply chains has generated risk which "managers need to identify and manage from a more diverse range of source and context," (Clemons, 2000). As products move from one node to another within the supply chain, the attendant information handover has to be accurate so as to minimize information disruption, vulnerability and risk. The boundaries of risk have also extended beyond the organization, and now include the countless inter-organizational relationships, (Sutton, 2006).

1.2 Evolution of Supply Chain

According to Maha and Narayan, (Maha & Narayan, 2001) the supply chain has evolved overtime in three major phases, as presented in table 1.1. The first phase signifies the evolution "from the post World War II through the late 1980s;" the second phase signifies the transformations that happened "from the late 1980s through the late 1990s," where advanced

planning and scheduling (APS) systems and enterprise resources planning (ERP) systems were key factors; and the third phase represents the present changes "from a linear supply chain to a network supply chain," where increased access to real-time information makes the supply chain decisions proactive rather than responsive. The pattern of supply chain development have also been tracked through decades, and it was discovered that; in the first developmental phase, the primary attention was on operational efficiency; while in the second developmental phase, the attention moved to the achievement of effectiveness, (Miles & Snow, 2007).

Phased Evolution of Supply Chain Management			
	Phase 1: "Functional"	**Phase 2: "Integrated"**	**Phase 3: "Value Networked"**
Supply Chain Planning	"Done in functional silos" "Ineffective due to limited information visibility and standardization across the enterprise"	"Shift to a business process focus" "Increase in effectiveness due to standardization of information across the enterprise" "Integrated supply chain planning: demand forecasting, & planning"	"Collaborative planning" "Extension of the planning process beyond the enterprise to include contract manufacturers, key customers and suppliers"
Supply Chain Execution	"Silo-based execution" "Decisions often made by functional managers & key associates"	"Integrated cross-functional decisions." "Limited collaboration"	"Decisions taken at the most appropriate level" "Greater proportion of collaborative, pre-emptive decisions"

Table 1.1 Phases of the Supply Chain Evolution, (Maha & Narayan, 2001).

In the manufacturing environment of the 1980s, experts in logistics took the concept of material management a step further by incorporating the transportation and distribution functions, and this resulted in an integrated logistics concept, called supply chain management. The supply chain management concept also "emerged as manufacturers experimented with strategic partnerships with their immediate suppliers," (Tan, 2001, p. 41). Prior to the emergence of supply chain

management, organizations used terminologies such as “logistics” and “operations management” instead. There is a distinction between the concept of supply chain management and conventional logistics. The concept of logistics deals majorly with the activities within an organization, while supply chain management expands beyond an organization, and includes the organizations trading partners.

According to Lambert and Cooper, (Lambert & Cooper, 2000, p. 67) the “Council of Logistics Management” (CLM) define logistics as “that part of the supply chain process that plans, implements, and controls the effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers’ requirements.” Logistics signifies the activities that take place within the scope of an organization while supply chain signifies the network of organizations that are working together and managing their activities so as to deliver a product to the consumers. Also, “traditional logistics focuses on activities such as procurement, production, distribution, maintenance, and inventory management, whereas supply chain management acknowledges all of traditional logistics but also include activities such as finance, new product development, marketing, and customer service”, (Hugos, 2003, p. 15).

In the 1990s, the evolution of supply chain management continued as organizations expanded their practices in controlling and coordinating resources to include logistics function, (Tan, 2001). Over the years, supply chain management have moved through three distinct stages; from the decentralized stage, to the centralized stage, and finally to the combination of both. “The pendulum is currently swinging toward centralized planning combined with decentralized execution”, (Hugos, 2003). An important enabling factor in the transformation of supply chain management is a consumer-centered concept that motivates changes across an organization’s internal and external relationships, (Tan, 2001). Kuei *et al*. (Kuei, Madu, & Lin, 2002) explained that the “Supply Chain Management is now a system of autonomous or semi-autonomous business entities that are collectively responsible for sourcing, manufacturing and distribution activities associated with one or more families of related products.”

Traditionally, “supply chain exists within the four walls of an enterprise, where material, cash and information flow linearly along fixed route starting with the receipt of raw material through to shipment of the customer orders,” (Hawker, Nelson, & Terry, 2004, p. 7). In the 1950s and 1960s, manufacturers pointed out mass production as a primary strategy to reduce unit production cost, but then, “the development of new product was slow and depended on in-house capacity and

technology," (Tan, 2001, p. 40). In the 1970s, Manufacturing Resource Planning (MRP) was introduced, and after a while, manufacturers realized it effect on the cost of manufacturing, delivery time and the development of new product. In the 1980s, manufacturers still had challenges with data communication within the supply chain, but the evolution of high speed data communications networks and computer technology in the 1990s made it easier for organizations to manage the supply chain with a level of precision that was not achievable even as recently as in the1980s.

1.3 Motivation for Research

A supply chain is an integrated process wherein different organizations combine their efforts in acquiring raw materials, transforming the raw materials into finished products and delivering the finished products to the final consumers. Organizations are continuously searching for means to reduce costs and simultaneously making effort to enhance the quality of their products, and ultimately satisfying customers' demand. There are three major components essential to achieving these: information flow, cash flow and material flow. Information is the connection between the other two components. It is also considered an integral component of any supply chain network because it is the foundation upon which decisions are made. When information is well managed, timely and accurate, "the organizations within a supply chain will each be able to make decisions for their own operations, and also maximize the profitability of the supply chain as a whole," (Hugos, 2003, p. 16).

Increasing competition, the drive to reduce costs, the consumer's demand for diversity, and the globalization of supply chain have resulted into international collaboration and partnerships that have stimulated and impacted upon the sharing of information, materials and cash between companies. In the present global world, the supply chain networks are expanding, and this expansion is causing the length of information flow within a supply chain to increase. This increasing length of information flow is presently exposing information to risk. Risk within any supply chain can adversely affect the performance of organizations in the chain. Modern supply chains have become global and the boundaries of the inherent risk have extended beyond the organization, and now include the organization's trading partners. Hence, we investigate and suggest ways in which information risk within supply chains may be managed, so that competitive value for companies and stakeholders may be increased locally and globally.

1.4 Research Objectives

There are numerous research activities concerning the concept of supply chain, for example the Desbarats (Desbarats, 1999), Ellram& Cooper (Ellram & Cooper, 1990), and the Oliver & Webber (Oliver & Webber, 1992) studies. However, the comprehensive studies of supply chain information, information flow, information risk and information system that performs the function of coordinating the information exchange among all the parties (suppliers, manufacturers, distributors/wholesalers, retailers and customers) in a supply chain have not received the attention needed. This research aims at investigating the information that flows within supply chains, how this information flows, the vulnerabilities and the risk that this information is exposed to within supply chains. The research also evaluates the impact of risk within supply. In brief, the following are the objectives of this research:

1. To evaluate supply chain information systems by investigating information and information flow within supply chain.
2. To identify information risks within supply chains by investigating the supply chain information risks sources.
3. To propose strategies in which information risk within supply chains can be managed.

1.5 Significance of Research

Simchi-Levi *et al.*, (Simchi-Levi, Kaminsky, & Simchi-Levi, 2004) stated in their work that "information has the potential to reduce variability in supply chains, enable suppliers to make better forecasts, enable the coordination of manufacturing and distribution strategies, enable lead time reduction, and enable retailers to service their customers better". As stated above (1.4), the objective of this research is to investigate information, information flow, and information risk within the supply chain, and consider ways that this risk may be managed. This is of significance because it gives an insight into what information flows within the supply chain and how this information provides support to all the parties involved in the supply chain. It also helps these parties understand the relationship between information, cash, and material flow within supply chains.

According to Stephan and Christoph, (Stephan & Christoph, 2006) today's supply chains have become more susceptible to distortions and disruptions. Supply chain managers must therefore manage information risk in their increasingly competitive environment by identifying potential losses that can be caused by information distortion or disruption, (Hugos, 2003). With accurate

information about vulnerabilities, it may be easy to coordinate the activities and operations of trading partners in any supply chain network. This research provides an understanding of information vulnerability and the risks associated with these vulnerabilities. It also provides a framework for information risk management within supply chains, which information and risk officers within any supply chain can adapt to their respective companies, so as to increase value for their organization and stakeholders.

1.6 Problem Statements

Information is a very valuable asset, and its vulnerability, which may be exploited, may cause serious disruption in a supply chain. When information and information risk is well managed, it makes a supply chain function optimally. Macbeth & Ferguson (Macbeth & Ferguson, 1994) stated that attitudes should be changed, "it does not help if the other players in our supply chain are frequently regarded as the enemy, because we think our information is at risk when shared with them." To ensure that a supply chain is effective, information should be shared. However, the growing complexity of supply chains creates more complicated information flows, thus increasing the information vulnerabilities, and hence increasing risks. If information risk within a supply chain is not well managed, disruptions in the supply chain may result, thus endangering its overall performance. This study investigates information, information flow, and information risk within supply chains.

1.6.1 Sub-problems

In order to ensure that information risk is well understood, and to ensure that strategies to manage information risk can be developed, this research has been decomposed into the following sub-problems

1.6.1.1 First sub-problem

Information is one of the main components flowing within a supply chain, and its flow occurs not only within an organization but also encompasses its business partners. In order to manage information risk within a supply chain, information flow must be well understood. For proper understanding of information within supply chain, information flow was investigated.

1.6.1.2 Second sub-problem

Deloach (Deloach, 2000) define risk as "the level of exposure to uncertainties that the enterprise must understand and effectively manage as it executes its strategies to achieve its business objectives and create value." The risks that information within supply chain may be exposed to were investigated.

1.6.1.3 Third Sub-problem

Risk management is focused on understanding and making decisions regarding risks, and also minimizing their impact. A proper evaluation of the best strategy that can be used to manage risk must be carried out; therefore strategies to manage information risk within supply chain were investigated.

1.7 Research Questions

The critical questions as drawn out from the problem statement, so as to achieve the objectives of this research are;

- How much information in terms of data is collected within the supply chain?
- How timely, accurate and complete is the information collected within the supply chain?
- How much of information collected is shared across the supply chain?
- How much of information do companies within the supply chain share about themselves?
- What are the risks associated with information flow within the supply chain?
- What are the threats to information within the supply chain?
- What are the business impacts of the threats on supply chain information?

These questions have been further decomposed in the interview and questionnaire used for the research.

1.8 Research Methodology

In order to get sample of personnel from all relevant parties/organizations involved with information and information flow within the supply chain, and also tap into the experience of supply chain professionals, qualitative research methodologies are implemented. The research was exploratory, and the methodology was implemented through interviews, questionnaires, technical reports, general statement and associated support documents. The sample population technique used for the research was a target population, so a purposive sampling was

implemented in this research. The organization and personnel used for the study were carefully selected. The source of primary data was personal interviews and structured questionnaires. Interviews were conducted based on a schedule and were recorded digitally, after which analysis procedures were used to determine similarities and differences between the interviews. Questionnaires were used to complement the information obtained from the interviews. They were distributed by hand and were also administered online to personnel of parties/companies within the supply chain that were used as case studies.

In particular, a qualitative method was chosen for this research because this allows the researcher to uncover important questions and processes, and also understand relationships in the data. The criterion for this research was carefully chosen. The selected companies are members of supply chains that extend beyond the geographical boundaries of the nation (South-Africa) and as a result depend so much on information flow. The research for this study was conducted in fast moving consumer goods (FMCG) companies (as a case study), so that the context under investigation could be properly understood. An initial visit was made to the selected organizations so as to be sure that the organizations to be investigated have a functioning supply chain, and also to understand their supply chain operation, structure and performance. The companies chosen for this research had to satisfy the following criteria:

1. The company had a structured supply chain in place.
2. The company had implemented supply chain information technology (IT) infrastructure such as JD Edwards EnterpriseOne, SAP etc.
3. The company had a work force of not less than three thousand people working across the different units of their supply chain.
4. The company should be willing to allow access to its employees at the different units of the organization, and also be willing to share any information the researchers consider important to the research.

In the first phase, data acquisition was done by using a questionnaire. The questionnaire was administered online and was also distributed to staff of the organizations under study. The data from the questionnaire was carefully analyzed in order to see correlations. In the second phase, an exploratory qualitative methodology was adopted, so interviews were conducted. The personnel interviewed were those that had significant roles to play in their respective units, such as; IT, procurement, planning, logistics, warehousing and distribution, among others. Attention was given to employees' stories because it represents the understanding of their organization's supply

chain. However, “with qualitative methodology, the type of information obtained evolves as the study proceeds,” (Larry & Sue, 1998, p. 40).

1.9 Limitations of the Study

The researcher is based in KwaZulu-Natal, South-Africa. Various logistical and financial factors constrain this research and the researcher within the province. This constraint may limit the applicability of the research to a wider geographic area. Business sensitivity also inhibits respondents from volunteering sensitive data and/or information. The interviews conducted were targeted at personnel who had the required knowledge, experience and skill, and as such, there availability was a constraint. For those that were available, time allocated for interview was a constraint because the researcher avoided monopolizing their time during office hours. Another drawback of this research is the presence of bias responses from the respondents of the fast moving consumer goods (FMCG) companies that the research was conducted. However, the adverse effects of the respondent’s bias are not considered substantial enough to influence the integrity of these research findings.

1.10 Original Contribution in this Research

The data that was collected and analyzed in this research produced results which generated new ideas and perceptions about the topic under study. From this data, the following significant contributions were made:

- Benefits and adverse effects that are associated with the use of information systems in enhancing information flow within supply chains were identified.
- A framework called “SCIRM” (Supply Chain Information Risk Management) was developed. This framework identifies vulnerable points with which information within supply chains are exposed to risk. The framework also suggests ways in which supply chain information risk can be managed.

1.11 Publications

The findings of this research project have been presented as publications by the authors. The publications are as follows:

- N. Ajayi and M. Maharaj, “Effects of Information Sharing within Supply Chains”, “SACLA, South-Africa”, June, 2010.

- N. Ajayi and M. Maharaj, “Mitigating Information Risk within Supply Chains”, “IRSSM, Mauritius”, August, 2010.
- N. Ajayi and M. Maharaj, “Managing Information Risk within Supply Chains”, “International Journal of Information Systems in the Service Sector (IJISSS), 2011” “*under review*”.

1.12 Dissertation Overview

In order to ensure a detailed presentation of the literature related to the topic under study, and to also ensure a detailed presentation of the research findings, this dissertation has been divided into six chapters.

In this chapter, an overview of the study is presented. A brief discussion of evolution of supply chains has been presented. The motivation, objectives and significance of the study were explained and clearly stated. The problem statement and limitations of the study were also given. In what follows, a brief overview of the remaining five chapters in the dissertation is presented.

Chapter 2 presents the literature review of information flow within supply chains. The chapter also explores globalization, supply chain integration, supply chain networks and the components of supply chain networks. This is followed by literature review on risk, information risk and risk management within the supply chains.

Chapter 3 presents a review of the literature on the information systems that support supply chains. The chapter discusses the role of information system within the supply chain. The chapter presents the effects of information technology in supply chains, and also the functions of the major information technology tools that are being used to optimize the performance of supply chains. The chapter finally discusses the integration of information technology infrastructure as applicable in supply chains.

Chapter 4 explains the methodology used in this research. The chapter begins by explaining the design of this research. This is followed by the criterion that was considered in the choice of the research methodology. The chapter also explains the sequence in which the research methodology for this research was conducted. In addition, the chapter presents the analysis method used in this research and how this analysis method helps in understanding the responses from the interviews that were conducted.

In chapter 5, the outcome and findings from the survey and the interviews that were conducted is presented. Discussion on the survey as related to the interviews is also presented. A new framework developed for information risk management within supply chain, “SCIRM” (Supply Chain Information Risk Management) is presented in this chapter. Lastly, the explanation on how this developed framework would help in the management of supply chain information risk is also presented.

Chapter 6 concludes the dissertation by presenting the holistic summary and conclusion. The chapter also presents areas of further research in supply chains.

1.13 Conclusion

In this introduction a brief overview of supply chains, a motivation for the study and research questions were presented. An overview of the thesis was also provided. From this chapter, it may be concluded that the drive to move a product to the appropriate location at the appropriate time and while minimizing cost requires improved efficiencies; not only within the organization, but also within the entire supply chain network, (Hugos, 2003). It is apparent that business success is no longer about analyzing the individual organization, but rather about analyzing the chain of supplying and delivering organizations, because the individual organization is only a part of the entire supply chain, (Chyan & Yi-fen, 2010). It is also obvious that a better understanding of information flow, cash flow and material flow would facilitate better business performance and achievements, (Disney & Towill, 2003) within the supply chain. In chapter two the literature review is presented.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

In the previous chapter, a brief overview of the supply chain evolution was presented. In this chapter, a literature review on supply chain and its concept is presented. In the literature, authors have indicated that to achieve success within today's rapidly growing supply chain; organizations are developing new dimension to their business processes and actively making use of emerging technologies. Consequently, "one of the most significant paradigm shifts of modern business management is that individual businesses no longer compete as solely autonomous entities, but rather as supply chains," (Lambert & Cooper, 2000, p. 65). The paradigm shift of modern businesses, the use of partnerships and the use of technology have now made supply chains global. In the present global supply chain, it is challenging for a single organization to coordinate all the supply chain components, therefore organizations are concentrating on their strength in supply chain and partnering with other organizations for what they consider not to be their strength. Bourdé and Butner (Bourdé & Butner, 2004) emphasized the importance of true collaboration and partnership. Collaboration and partnership which forms the basis of globalization should enable companies to cut cost and simultaneously improve the quality of their product, (Buzacott, 1995).

Moreover, organizations are realizing that working efficiently with their trading partners is essential for time compression, quality and service enhancement, organizational integration, and globalization. In order to achieve all these, Clark and Lee (Clark & Lee, 1997) explained that supply chains must be enhanced by establishing a information flow, cash flow and material flow among supply chain partners, as this will also open up a wide range of business opportunities; it will also results in synergistic rewards. Hence, "the outcomes of collaboration and partnership as a whole is greater than the sum of what individual organization contribute," (Brinkerhoff, 2002, p. 215). Most discussions on supply chains emphasizes the essence of information in establishing a successful partnership, and also the importance of sharing information among trading partners in order to achieve an efficient response to the need of consumers.

The quantity of publications in the supply chain discipline is also growing rapidly because researchers are continuously investigating the various designs, processes and technologies within

supply chains. “Traditionally, researchers and practitioners have limited their analyses and scope to individual stages within the larger chain,” (Beamon, 1998, p. 18). Many authors including Premkumar and Ramammurthy (Premkumar & Ramamurthy, 1995) also noted that “traditional research on supply chains have focused on the flow of material and information independently,” but lately, authors have critically assessed the independent flow of material and information, and the individual stages of the supply chain in theory and practice, and through this assessment they have identified the need to expand the scope of supply chains beyond individual stages, and also the need to create an integrated supply chain. So, rather than studying and analyzing individual stages within supply chains, researchers and practitioners are now focusing on studying and analyzing the dynamics of supply chains across a broad spectrum.

Furthermore, researchers and practitioners have identified the fact that supply chain is a concept “consisting of individual functional entities committed to providing resources and information,” (Lau & Lee, 2000, p. 599). In agreement, Omar and Ballal (Omar & Ballal, 2009) in their work, explained that the concept of a supply chain is about coordinating information flow, material flow, and cash flow through a common set of established strategies and principles. Most research authors and practitioners have highlighted the fact that to work efficiently and effectively with trading partners and still implement integrated information and material flow which benefits all the trading partners, the supply chain concept must be properly understood by all the collaborating parties. This chapter presents a literature review on supply chain. It also presents a literature review on information, information sharing, and risk within supply chain.

2.2 Supply Chains

A supply chain may be described as an integrated process that involves Planning, Sourcing, Making, Delivering and Returning, “spanning the suppliers’ supplier to the customers’ customer, and aligned with operational strategy, material, work and information flow”, (Morrow, Wilkerson, & Davey, 2009, p. 6). Similarly, it may also be described as; “all activities associated with the flow and transformation of goods from the raw material stage through to the end user, as well as the related information flows through improved supply-chain relationships”. Fig 2.1 adopted from New and Payne (1995) as cited in Tan (Tan, 2001) portrayed the activities and organizations involved in a supply chain. These activities start from the extraction of raw materials, through to the suppliers, manufacturers, distributors, retailers, and the final consumers. In accordance, Hugo (Hugos, 2003) indicated that organizations in a supply chain must make individual and collective decisions with regards to their actions in the following areas:

1. *Production:* Companies need to decide on the product that the market they serve want, and what quantity of these products should be produced. The activities here also include workload balancing, generation of master production schedules which takes into account the capacity of the equipment, equipment maintenance and the overall quality control.
2. *Inventory:* In order to ensure a consistent production, companies must decide on the inventory to be stocked at every stage of the supply chain. These inventories should include raw materials, semi-finished goods or finished goods. The main objective of inventory should be to serve as a cushion in the case of any uncertainty. However, keeping inventory can be expensive.
3. *Location:* Another decision that must be made is where the production and inventory facilities should be situated. These decisions should also include the cost effectiveness of production and inventory facilities. The main focus of this decision is to help determine the paths that will be available for products to flow from producers to final consumers.
4. *Transportation:* The decision should take care of how inventory should be moved from one location to another using the different transportation modes. The transportation mode could be by air, water, and road. The cost and when to use each mode of transportation should also be considered.
5. *Information:* Companies should make decision on how much information to be collected and shared between them and their trading partners. This is because accurate and timely information facilitates better coordination and decision-making with regards to the other aspects (location, production, inventory, and transportation) of supply chain.

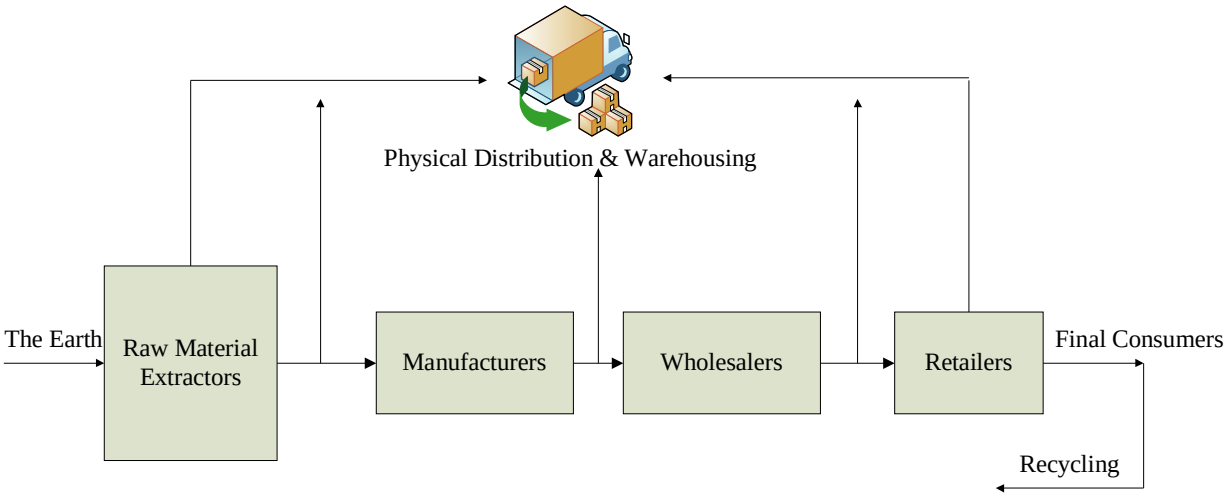

Figure 2.1 Activities in a supply chain, (New & Payne, 1995).

In a research performed by AMR Research in 2006, it was shown that, "over 42% of companies manage more than 5 different supply chains mainly because of the need to produce multiple products for multiple markets," (AMR, 2006) as cited in (Christopher & Brian, 2008, p. 13). Wibowo *et al.* (Wibowo, Ramachandran, Kui, Fei, & Iswanto, 1999, p. 1) explained that the supply chain includes "all the efforts involved in the production and distribution of a finished product to the consumers." Furthermore, they explained that the four major processes which define these efforts are: Plan, Source, Make and Deliver. Bourdé and Butner (Bourdé & Butner, 2004, p. 7) in their work showed that, "companies are organizing their supply chains horizontally (as opposed to the traditional functional silos) and are orchestrating end-to-end, extended supply chains (value chain networks)". From the literature, it is apparent that supply chains have processes, and to make these processes work optimally, supply chain must be coordinated and managed. However, "each supply chain has its own unique set of processes, market demands and operating challenges," (Hugos, 2003, p. 5).

A supply chain can also be perceived as a system that consist of "material suppliers, production facilities, distribution services, and customers who are all linked together via the downstream feed-forward flow of materials (deliveries) and the upstream feedback flow of information (orders)," (Disney & Towill, 2003, p. 200). To this effect, supply chains are now been seen as a network of interconnected subsystems forming a composite global system that consist of suppliers, manufacturers, retailers, distributors, and final consumers. The continuous growth in supply chains requires that information, fund and material flow be dealt with in an integrated manner. Malhotra *et al.* (Malhotra, Gosain, & El Sawy, 2005) defined the different levels of a supply chain integration that may be ensured in any supply chain that is willing to stand the present global competition. The integrations are:

- *Information flow integration*: This is the level to which an organization shares information with other trading partners.
- *Physical flow integration*: This is the level to which an organization manages the flow and stock of raw materials and finished goods.
- *Financial flow integration*: This has been explained to be the degree in which an organization shares financial information and resources with its trading partners, in a method driven by workflow events.

2.2.1 Supply Chain Management

The activities of a supply chain need to be managed so that the basic processes of a supply chain can be properly coordinated to achieve its objectives. “Supply chain management is a well established discipline that involves the coordination of an organization’s internal planning, manufacturing and procurement efforts with those of its partners,” (Mclaren, Head, & Yuan, 2002, p. 348). The “Global Supply Chain Forum” (GSCF), define supply chain management “as the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders,” (Lambert & Cooper, 2000, p. 66). “The efficient management of a supply chain requires close coordination of different parties and functions. However, since different stages in a supply chain may have different owners, it is very likely that they optimize their own profits without taking into account the impact of their decisions on other parties in the supply chain. But also under the same ownership different stages may have conflicting objectives, which results in decisions that are only locally optimal. Therefore, it is a very challenging task to achieve coordination in a supply chain,” (Kiesmuller & Broekmeulen, 2010, p. 406).

Furthermore, supply chain management may be seen as the “management of product, cash and information flow both in and between facilities, such as vendors, manufacturing, assembly plants and distribution centers (DC),” (Thomas & Griffin, 1996, p. 1). Meixell and Gargeya, (Meixell & Gargeya, 2005) indicated that the supply chain management is not just a phenomenon; it involves the management of supply chains that transcend national boundaries. Supply chain management enables the capturing of the interaction between intra-organizational and inter-organizational integration, (Lambert & Cooper, 2000). Williamson *et al.* (Williamson, Harrison, & Jordan, 2004) emphasized that the supply chain management processes should enable business partners to integrate their information resources. Moreover, it should be noted that business process integration is one of the best practice in the management of supply chain because it deals with the coordination of decisions across various facilities, (Meixell & Gargeya, 2005).

Fig 2.2 as adopted from Lambert and Cooper, (Lambert & Cooper, 2000) shows that supply chain management “depicts a simplified supply chain network structure; the information and product flows; and the key supply chain business processes penetrating functional silos within the company and the various corporate silos across the supply chain. Thus, business processes become supply chain business processes linked across intra- and intercompany boundaries,” (Lambert & Cooper, 2000, p. 66). As stated by Tang, (Tang, 2006) managing a supply chain

involves the coordination of activities across different organizational functions, e.g. sales, marketing, product design, production, procurement, finance, and information technology (IT). Furthermore, Gunasekaran and Ngai (Gunasekaran & Ngai, 2004) stated that the management of supply chain should be centered on the harmonization of all the processes that add value to consumers.

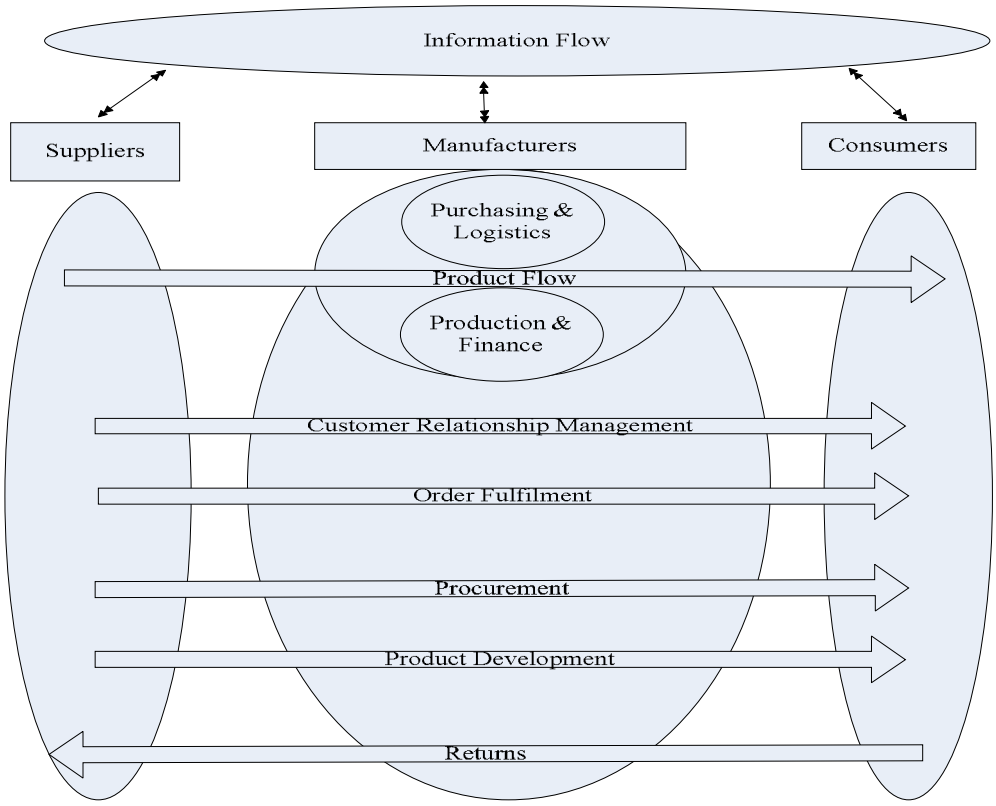

Figure 2.2 Supply Chain Management Processes, (Lambert & Cooper, 2000).

According to Simchi-Levi *et al*., (Simchi-Levi, Kaminsky, & Simchi-Levi, 2000) "supply chain management are set of approaches utilized to effectively integrate suppliers, manufacturers, distributors and consumers, so that goods and services are produced and distributed to the appropriate location at the appropriate time." Supply chain performance has been categorized into two broad categories; Qualitative and Quantitative performance, (Swaminathan, Smith, & Sadeh, 1998). According to Swaminathan *et al.*, (Swaminathan, Smith, & Sadeh, 1998) qualitative performance relate to customer satisfaction, integration of information and material flow, and effective risk management, while quantitative performance relate to cost minimization, profit maximization, fill-rate maximization, customer response-time minimization, supply reliability and lead-time minimization. From their categorization and the work of other authors, it may be

deduced that the management of supply chain depends largely on the integration of information, cash and material. Hence, trading partners are forming supply chain networks that will enable the free flow of information.

2.3 Supply Chain Networks

To efficiently manage the ever increasing supply chain and still perform their role within the chain, organizations are beginning to form supply chain networks. Bourdé and Butner (Bourdé & Butner, 2004, p. 1) in their work, explained that the "traditional supply chain business models are giving way to the emergence of new horizontally integrated, high-performance, on demand value chain networks". Harland *et al.* (Harland, Brenchley, & Walker, 2003, p. 51) also showed in their work that the "increasing product/service complexity, outsourcing and globalization have led to increasingly complex, dynamic supply networks". In the same vein, Lau and Lee (Lau & Lee, 2000, p. 599) explained that, "supply chain is a concept which is based on the formation of a network that consists of individual functional entities that are committed to providing resources and information in order to achieve the objectives of an efficient management of suppliers and distributors." Furthermore, they explained that, "a supply chain network comprises of physical elements (physical supply chain) and information elements (information supply chain)."

The literature shows that the consistency of data is essential in the whole supply chain network because it enhances the performance of information. However, "to have data consistency in the network, the supply chain channel master and its trading partners need to determine and agree on which piece of information needs to be shared across thenetwork, and also decide on the manner in which this information will be captured, distributed, and used," (Angeles, 2009, p. 228). Bourdé and Butner (Bourdé & Butner, 2004) in their work explained that leading organizations are creating network transparency (by sharing information) as they combine global purchasing, improve global sourcing and leverage procurement so as to reform the supply chain network. According to Tang, (Tang, 2006) one should consider the following issues when planning a supply chain network:

1. *Network configuration*: "which available suppliers, manufacturers, distributors and warehouses should be selected?"
2. *Product assignment:* "which manufacturing facility should be responsible for processing subassemblies, semi-finished products, or finished products?"
3. *Customer assignment:* "which facility at an upstream stage should be responsible for handling the demand generated from downstream stages?"

4. *Production planning:* "when and how much of product or process should each facility be producing or processing."
5. *Transportation planning:* "which mode of transportation should be used?"

As companies are increasingly realizing that they can't work in isolation, they are forming a network in which partnership is a key component.

2.3.1 Outsourcing

There is an increasing acknowledgement that no single organization can be excellent at everything. Johnson and Pyke (Johnson & Pyke, 1999, p. 2) highlighted that "companies are increasingly thinking in terms of competing as part of a supply chain against other supply chain rather than as a single organization against other individual." This has made companies to be re-appraising their supply chain network by outsourcing the activities that they consider not to be their core, (Juttner & Christopher, 2000). The other force that drives outsourcing is the growing sophistication of the markets that supply chains serve, (Hugos, 2003). "The use of outsourcing for cost and capability enhancement has increased dramatically, expanding the number of players involved in delivering a product or service to the customer," (Bourdé & Butner, 2004, p. 7). As these number of players increases, so also is the length of information exchange between outsourcing partners. However, for outsourcing to be consistent, a reasonable amount of information about the outsourcing partners needs to be shared.

Organizations are concentrating on their essential capabilities within supply chain, while non-essential activities and processes are increasingly being outsourced. "The relentless pressure on profit margins that free markets create is a driving force behind the growth of outsourcing. What may be considered as overhead for company A may be a service that company B can offer and make a profit doing so. Company B may be able to offer this service for a price lower than it costs company A to do it in-house. Company A is going to consider outsourcing," (Hugos, 2003, p. 98). In agreement to the fact that companies are increasingly outsourcing their activities, Tang (Tang, 2006) stated that many companies executed different initiatives such as manufacturing, distribution and product variety in order to gain market share. Increased outsourcings allow access to the global market, and thus allow organizations to seek international sources for better performance. Though, it has to be stated that outsourcing has also contributed to the continuous globalization of supply chain networks, (Harland, Brenchley, & Walker, 2003).

2.3.2 Partnerships

A partnership is defined by Brinkerhoff, (Brinkerhoff, 2002, p. 216) as "a dynamic relationship among diverse actors, based on mutually agreed objectives, pursued through a shared understanding of the most rational division of labor, based on the respective comparative advantages of each partner." Likewise, a partnership has been described as a relationship (Duffy, 2008), (Maloni & Benton, 1997), (Ploetner & Ehret, 2006), (Brinkerhoff, 2002) that is initiated to improve the financial, operational and managerial performance of its member through an open, frequent and increased level of material and information exchange. Organizations are increasingly enhancing their supply chain network by forming partnerships with suppliers, distributors and consumers so as to minimize procurement wastage and enhance order fulfillment processes. Partnerships are gaining attention in management and in academic research (Ploetner & Ehret, 2006), and because of the increasing product and service complexity, the supply network is forcing companies to expand their partnership rapidly.

Survey results by Bourdé and Butner (Bourdé & Butner, 2004) showed that many organizations have continued to concentrate their effort on process optimization and partner collaboration. "A supply chain partnership has been perceived as a relationship formed between two independent entities in a supply channel in order to achieve specific objectives and benefits," (Maloni & Benton, 1997, p. 420). Partnerships are also considered one of the best means of sensing consumers' requirements and propagating information up to the suppliers, (Bourdé & Butner, 2004). Supply chain partnerships require mutual coordination and cooperation in order to get a greater market share and hence higher revenues, (Chauhan & Proth, 2004). Fiala (Fiala, 2005) also stressed the fact that supply chain partnership means cooperation and coordination of actions through the chain. However, Tang (Tang, 2006, p. 453) explained that, "supply chain partners can only enhance their coordination and collaborative effort if they can access various types of private information that is available to the individual partners."

To become part of a supply chain network, companies are forming partnerships with other companies that will provide complementary functions in a supply chain. It has been argued that, companies should partner with their upstream partners so as to ensure an effective supply of materials along the supply network, and should also partner with their downstream partners so as to enhance demand in a beneficial manner. Christopher and Lee (Christopher & Lee, 2004) emphasized that supply chain partners should collaborate in order to identify the important points in which information and material flow through the supply chain, as this leads to better flow of

information, minimized uncertainty and a beneficial supply chain, (Fiala, 2005). There should be a common concern among supply partners about any information that can potentially impact the effectiveness of their partnership. However, "the divergent interests and opportunistic behavior of trading partners, and the information asymmetries across supply chains have affected the quality of information," (Feldmann & Mrller, 2003) which is shared among partners.

2.4 Supply Chain Networks as a Complex Adaptive System

Thompson (Thomas, 1967) as cited in Daniel and Thomas, (Daniel & Thomas, 2006) defined a system "as a collection of inter-related entities and components that work together in order to acquire resources from outside, transforms these resources, and delivers them as products back to the outside." The present global supply chain has been described as a network that has become complex as a result of multiple numbers of partners, partner's location, and processes involved in getting products or services to its destination. Similarly, "the choices in products which includes the price, quality and quantity available, delivery time and the preference of the ultimate customers adds to the complexity of the supply chain network," (Selwyn, 2005, p. 220). Hence, researchers and practitioners have been encouraged to adapt to the complexity of supply chains.

According to Gang *et al.* (Gang, Hongjiao, Linyan, Ping, & Lei, 2009, p. 1) "a supply chain should be treated not just as a supply chain but also as a complex adaptive supply network (CASN)." Similarly, Thomas *et al.* (Thomas, Kevin, & Manus, 2001, p. 352) suggests that a supply chain network "should not just be seen as a system, but also be acknowledged as a complex adaptive system (CAS)." The term "complex adaptive system refers to a system that emerges over time into a coherent form, and adapts and organizes itself without any singular entity deliberately managing or controlling it," (Holland, 1995) cited in (Thomas, Kevin, & Manus, 2001, p. 352). Though Dmitry *et al.* (Dmitry, Boris, & Joachim, 2010, p. 411) stated that a supply chain should be considered adaptive if it can adapt to "changes in the market environment, changes in the operations execution environment, and internal changes in the supply chain itself by means of additional structural–functional reserves and better coordination through an extensive application of information technologies, especially web services."

The concept of perceiving a supply chain as a complex adaptive system is to enable us "understand how supply chains, considered as living systems, adapt to, and co-evolve with, the rugged and dynamic environment in which they exist, and to also identify patterns that arise in such a condition of co-evolution," (Surana *et al.*, 2005) cited in (Gang, Hongjiao, Linyan, Ping, & Lei, 2009, p. 1). According to Thomas *et al.* (Thomas, Kevin, & Manus, 2001, p. 352) "CAS

focuses on the interplay that is between a system and the system's environment and the co-evolution of both the system and the environment. In the context of the supply chain, a system would refer to a network of firms that collectively supply a given part or subassembly to a buying firm. The environment would consist of end consumer markets that exert demand for the products and services provided by the supply chain." However, one of the least studied areas of supply chains is the dynamic or adaptive nature of supply chains, (Selwyn, 2005).

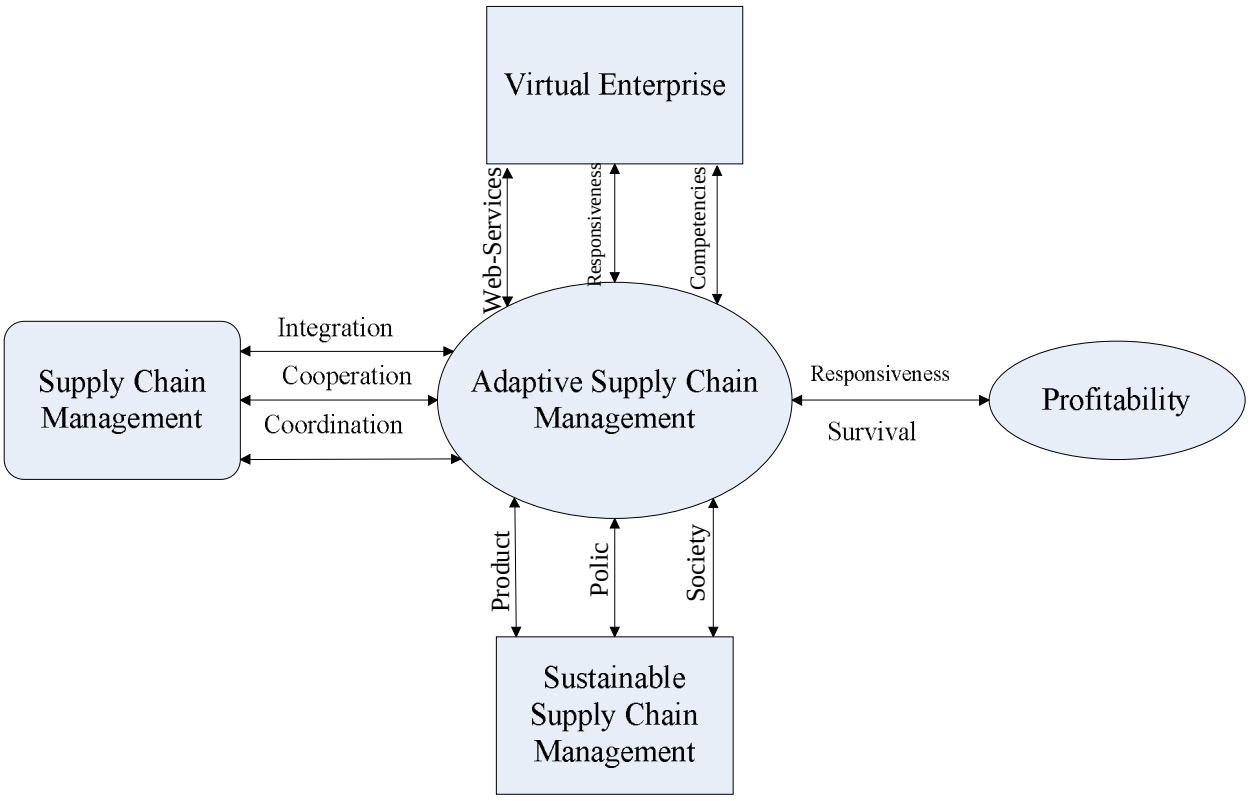

Figure 2.3 Framework of adaptive SCM, (Dmitry, Boris, & Joachim, 2010).

By considering the supply chain network as a complex adaptive system, researchers and managers can interpret the network's activities and performance in a more holistic manner and hence be able to develop and manage actions that should produce more effective results. However, it has been identified that researchers and managers are still struggling with the complex characteristics of the supply chain networks. "One of the major challenges of supply chain managers is to develop and manage a network structure that can facilitate flexible, adaptive and synchronized behaviors in a dynamic environment," (Gang, Hongjiao, Linyan, Ping, & Lei, 2009, p. 1). Gottinger (Gottinger, 1983) cited in Daniel and Thomas (Daniel & Thomas, 2006, p. 638) stressed that, "to manage a system, the complexity of that system must be understood first;

otherwise, interventions would lead to sub-optimization." As ashown in Fig 2.3, Dmitry *et al.* (Dmitry, Boris, & Joachim, 2010) developed a framework that enables adaptive supply chain management.

2.5 Globalization in Supply Chains

International partnership and outsourcing, that result in the transfer of information, material and funds between organizations has necessitated a global supply chain. The information flow between members in any supply chain is essential in achieving an efficient transition of products and services in the present global environment, (Stefansson, 2002). Fombrun and Wally (Fombrun & Wally, 1992) explained that the international mobility of information, people, cash, product and services is increasing, and this increase is leading to a global entanglement. The restructuring of organizations so as to achieve a company-wide collaborative culture is extending the supply chain, but also making a flexible specialization of independent organizations possible, (Ploetner & Ehret, 2006). Globalization is becoming the foundation to establishing a world-class organization, and it is also considered as one of the key factors when integrating a supply chain.

Globalization is a lasting phenomenon. Hence, all business enterprise in today's increasing global competitive environment are working towards increasing their inter-organizational collaboration, and also creating an efficient information, material and financial flow across the supply chain, so as to satisfy customer expectation. As organizations expand their business operations, more business partners would be involved in their supply chain and most of the supply chain exchanges will be between various organizations that seek to maximize their own revenue. The increasing competitive pressures are making organizations develop supply chains that can respond rapidly to their consumers, (Thomas & Griffin, 1996). However, Meixell and Gargeya (Meixell & Gargeya, 2005) noted that integrating decisions within a supply chain has been an emerging issue that also influences global supply chains.

2.6 Supply Chain Integration

The interest in dealing with supply chains on an integrated basis so as to gain competitive advantage has steadily increased. Beamon (Beamon, 1998, p. 2) explained that a supply chain is "an integrated process wherein various business entities (i.e., suppliers, manufacturers, distributors, and retailers) work together in an effort to: acquire raw materials, convert these raw materials into specified final products, and deliver these final products to retailers." Tan (Tan, 2001) on the other hand has identified the components towards an integrated supply chain. These

components should include changes in organizational culture, trust and communication among all trading partners, information sharing, suppliers' evaluation and sharing of common goals so as to enhance waste elimination and increase efficiency.

Supply chain integration may be explained to mean the exchange of organizational resources between trading partners. These trading partners may be separate units within the same organization or different organization, (Juha-Miikka, 2008). According to Mclaren *et al.*, (Mclaren, Head, & Yuan, 2002) supply chain integration should be concentrated on enhancing the flow of information among links in the chain. Information integration and visibility with trading partners is very crucial in order to improve efficiency and enable a responsive delivery across organizations, (Bourdé & Butner, 2004). Furthermore, this integration enhances the automation of business operations and substantially minimizes manual tasks and loss of information, (Themistocleous, Irani, & Peter, 2004). Some of the advantages of supply chain integration include; gaining competitive advantage, reducing operational costs and achieving a more cohesive collaboration and coordination among the supply chain partners.

Unfortunately, supply chain integration is not simple, as information systems are often not interoperable because of the differences between organizations, (Juha-Miikka, 2008). Juttner and Christopher (Juttner & Christopher, 2000) also emphasized in their work that integration is easily achieved when there is transparency of consumer requirement and when there is information sharing. Kalakota and Robinson (Kalakota & Robinson, 1999) explained that business process integration and the integration of material and information of trading partners can help achieve a significant improvement in supply chain integration. Ashley (Ashley, 2002) and Damien (Damien, 2005) cited in Atul and Satish, (Atul & Satish, 2008, p. 12) studied various aspects on integration and suggested that "the integration of various units across different organizational levels achieves above average financial and performance results." Juha-Miikka (Juha-Miikka, 2008) in his work, categorized supply chain integration into the following categories:

- *Manual supply chain integration:* This means human-to-human information sharing. In this integration, information sharing takes place using means such as phone calls, faxes or e-mails.
- *Semi-automation in supply chain integration*: This means human-to-system information sharing. It is performed by an information system, at one end e.g. the web. While at the other end, the intervention of human is necessary.

- *Full-automation in supply chain integration:* This means system-to-system information sharing. It takes place between information systems, e.g. computer systems. Human intervention is not needed in this integration.

An organization can improve on its delivery time "if its sales order entry and manufacturing software are integrated," (Mendelson, 2000, p. 5). Integrated solutions often leverage the advantages of having an integrated store of information. Operating a supply chain that is integrated requires the continuous flow of information, and this in turn helps in creating an efficient and effective product flows, (Lambert & Cooper, 2000). It has been argued that integration processes should be enhanced so that organizations can experience benefits which can positively influence revenue growth, (Greenfield, Patel, & Fenner, 2001). Furthermore, Cooper *et al.* (Cooper, Ellram, Gardner, & Hanks, 1997) stressed that it is necessary for the management of all the integrating organizations to understand their functions. Heinrich and Simchi-Levi (Heinrich & Simchi-Levi, 2005) in their study identified different categories of integration processes useful for business process maturity, the integration categories are:

- *Internal integration*: In this type of integration, organizations have business processes that are integrated in order to achieve objectives such as increase in efficiency, reduced cost and decrease in inventory levels.
- *Intra-company integration and limited external integration*: In this type of integration, organizations are organized in a way that optimizes supply chain decisions. The integration here is usually cross-functional.
- *Multi-enterprise integration*: In this type of integration, companies agree on common business goals and financial objectives with their trading partners.

Bourdé and Butner (Bourdé & Butner, 2004) showed that a reasonable percent of organizations are willing to invest both in internal and external integration with their partners. Fawcett *et al.* (Fawcett, Magnan, & McCarter, 2005) in their work suggested that, two dimensions of information integration exist, and they are; connectivity and willingness. These two dimensions should come together for information to bridge supply chain gaps. Hawker *et al.* (Hawker, Nelson, & Terry, 2004) also explained that when organizations integrate their internal applications and partners' external applications, consistent cross-business metrics will be delivered, and project synchronization across functions and divisions will also be achieved. However, the barriers towards successful information integration are quite daunting, (Fawcett,

Magnan, & McCarter, 2005) so organizations are still skeptical of integrating their supply chain activities and processes with their trading partners.

2.7 Information within Supply Chain

The world witnessed liberalization across majority of economies around the world and this has resulted in international ties and transfer of information, funds and materials between nations, (Gunjan & Rambabu, 2008). The global supply chain is expanding, and to match up with this expansion, Lau and Lee (Lau & Lee, 2000) stated that organizations must establish an environment where there will be a controlled sharing of information, function and processes. Furthermore, they suggested that surviving in this environment needs reliable access to information. "The more information about product supply, customer demand, market forecasts, and production schedules that companies share with each other, the more responsive they are," (Hugos, 2003, p. 18). However "In reality, information can often be costly. For instance, when the information about demand is inadequate, companies conduct market surveys, which can be expensive." Also, even "with the availability of historical sales data, to analyze data and obtain reliable forecasts, companies may want to purchase or develop data-mining or scientific-management software packages," (Qi & Kaijie, 2009, p. 454).

Information generation and management in any supply chain are imperative, because information serves as the foundation on which decisions concerning other supply chain activities are made, and also the link between all the operations and processes in a supply chain. Lau and Lee (Lau & Lee, 2000) stressed the necessity of information in supply chains by stating that information enhances the material flow in a supply chain. Bothma (Bothma, 2006) described information as data that has been processed, manipulated and organized in a way suitable for human interpretation and that adds to the knowledge of the person receiving it, while data, "on the other hand, are streams of raw facts representing events occurring in physical environment," (Pereira, 2009, p. 373). Bothma (Bothma, 2006) in his work stated that information should usually be compiled in response to a specific need, and often with the purpose of revealing trends or patterns. In accordance to this, Hugo (Hugos, 2003) stated in his work that information serves two major purposes in most supply chains:

1. *Coordinate daily activities:* Information is used to coordinate the other activities (inventory, location, production) of a supply chain. "The companies in supply chain also use available information on supply and demand to decide on weekly production schedules, inventory levels and transportation routes."

2. *Planning and Forecasting:* Information is used to predict and meet demands. It is also used in making tactical forecast so as to guide the planning of production schedules and timelines. Information also helps in making decisions with regards to building of facilities, entering a market or exiting it.

Information is shared successfully in a supply chain when information visibility is created. Christopher and Lee (Christopher & Lee, 2004) stated that the key to improved supply chain visibility is information exchange among trading partners. Fiala (Fiala, 2005) further explained that sharing of information is a necessary action for coordinating operations of supply chain units. Apart from enhancing the supply chain activities, supply chain partners now use information as a means of arriving at perceptions that enhances strategic planning such as anticipating changes in market place, enhancing competitive strength and sound knowledge of consumer needs, (Angeles, 2009). To facilitate information exchange, Suhong and Binshan (Suhong & Binshan, 2006) emphasized that understanding the factors that influences information sharing is vital. However the analysis of Chu and Lee (Chu & Lee, 2006) highlights that cost may hinder information sharing.

The role of information in customer satisfaction has also been emphasized by various researchers and supply chain practitioners. A publication by Lambert and Cooper (Lambert & Cooper, 2000) stated that to achieve a customer-centered situation, information should be processed accurately. A paper by La Londe, (La Londe, 1998) also explained that the management of material flow and the associated information and funds from sourcing through consumption will enhance the effective and efficient delivery of consumer product and also ensure economic value. However, to enable a continuous flow of activity within the supply chain, information collected should be shared between trading partners.

2.7.1 Information Sharing within Supply Chain

To implement successful supply chain integration, there must be proper and continuous flow of information. Lee *et al.* (Lee, Padmanabhan, & Whang, 1997) showed in their work that information flow impacts directly on the supply chain members. While, Lau and Lee (Lau & Lee, 2000, p. 598) explained that "whether or not a company is able to compete depends heavily on the implementation and the actual running of an efficient and effective information flow system, not only within the company itself but also encompassing its business partners and suppliers." Clark and Lee (Clark & Lee, 1997) explained further that information flow between trading partners will enhance partnership, and also open up other opportunities. Information flow

improves the management of the whole value chain activity and reduces the system inventory, (Christopher & Lee, 2004). Zhao *et al.*, (Zhao, Xie, & Leung, 2002) in their work categorized information sharing into three cases which are:

- *No information sharing (NIS):* no information is shared among the trading partners; therefore the supplier makes decisions according to retailer orders.
- *Demand information sharing (DIS):* retailers share forecasted demand with suppliers; therefore suppliers make production-planning decisions using both the order and forecasted demand information from the retailer.
- *Order information sharing (OIS):* retailers will share future demand forecasts, present and future order plans with suppliers, hence a supplier can plan production activities using this information.

A company can enhance its effectiveness and efficiency, and also still respond to their ever-changing consumers' need by sharing information with its trading partners. Also, organizations should learn to establish better relationships with their trading partners by sharing information. "Information sharing refers to the act of capturing and disseminating timely and relevant information for decision makers to plan and control supply chain operations," (Simatupang & Sridharan, 2005, p. 45). "Studies indicate that buyer-supplier relationships are becoming more dependent on factors like quality, delivery performance, flexibility in contract, information sharing and commitment to work together, as opposed to traditional relationships like cost," (Helper, 1991). "Typical information sharing practices include sharing production schedules, demand forecasts and point-of-sale data," (Themistocleous, Irani, & Peter, 2004, p. 395).

However, Macbeth and Ferguson (Macbeth & Ferguson, 1994) stated that attitudes towards information sharing must be changed. Tang (Tang, 2006, p. 476) also supports this view when he explained that, "while many companies reported that sharing information such as customer demand, inventory level, or demand forecast among supply chain partners is beneficial, there are several obstacles preventing supply chain partners from sharing private information, for instance, retailers are reluctant to share information with their manufacturer because of fear of lower bargaining power, information leakage, etc." "It appears that there is a built-in reluctance within organizations to give away more than minimal information," (Berry, Towill, & Wadsley, 1994) because disclosure of information is seen as loss of power, and organizations fear that information disclosure could lead to possible rivalry, (Suhong & Binshan, 2006). "Partners'

willingness to communicate openly and honestly is either the bridge or barrier to seamless information sharing," (Fawcett, Magnan, & McCarter, 2005, p. 13).

It has been argued and proven that managers must include improved information flow within their business strategies and processes to gain competitive advantage. Consequently, Premkumar (Premkumar G. P., 2000, p. 3) explained that unless "there is a positive proof that sharing information is equally beneficial to all members of the supply chain it will be difficult to convince all members to share information." Furthermore, Feldmann and Mrller (Feldmann & Mrller, 2003) stated that the quality of information has been affected by the informational asymmetries within supply chains. "When there is no information sharing, the manufacturer has the information about the underlying demand distribution and the retailer's ordering policy; but, the manufacturer does not have the information about the actual demand realized. When there is information sharing, the retailer would share the information about the actual demand realized in the period as well," (Tang, 2006, p. 476).

2.8 Risk within Supply Chains

In the past, when companies sourced and manufactured locally, there was less risk and these risks could easily be managed, but the advent of supply chain which also brought about partnerships, globalization and integrated networks have generated a lot of risk which managers need to identify and manage, (Clemons, 2000). Globalization has been identified to increase supply chain risks, (Berry J. , 2004). Johnson and Randolph (Johnson & Randolph, 1995) showed in their work that all supply chain relationships contain inherent risk. "Current business trends are leading to complex and dynamic supply chain networks, and one of the consequences of this is that risk is increasing within the supply chain," (Harland, Brenchley, & Walker, 2003, p. 51). In accordance, Bourdé and Butner (Bourdé & Butner, 2004) also explained that trends toward global sourcing and partnership is set to continue, and driving this trend is important so as to manage risks.

Risk may be described as the state of uncertainty, threat or likelihood that an action or event will adversely or beneficially affect desired event and objectives. While business risk as defined by Deloach (Deloach, 2000) is the amount of exposure to uncertainties that a company is exposed to as it executes its strategies. "Risk can differ in type from supplier to supplier, in duration and in the degree of impact that the good or service at risk has on the organization," (Steele & Court, 1996). Tang (Tang, 2006) categorized risk in supply chain into two types; Operational risks and Disruption risk. He explained that, "an Operational risk refers to the inherent uncertainties such as uncertain customer demand, uncertain supply, and uncertain cost. While disruption risk refers to

the major disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, terrorist attacks, etc., or economic crises such as currency devaluation or strikes. In most cases, the business impact of risk associated with disruption risk is much greater than that of the operational risks."

Disruptions in supply chain may have a severe impact on an organization's output and financial performance. "A supply chain disruption is the situation that leads to the occurrence of risk," (Wagner & Bode, 2006, p. 304). "Potential disruptions can either occur within the supply chain (e.g. insufficient quality, unreliable suppliers, machine break-down, uncertain demand etc.) or outside the supply chain (e.g. flooding, terrorism, labor strikes, natural disasters, large variability in demand etc.)." However, "the information transferred in the form of orders within the supply chain tends to be disrupted or distorted as it moves from downstream to upstream. This phenomenon is called as bullwhip effect," (Balan, Vrat, & Kumar, 2009, p. 282). Lee and Billington (Lee & Billington, 1993) provided a study on common pitfalls in current supply chain practices. Whereas, Hendricks and Singhal (Hendricks & Singhal, 2005) reported that, "organizations that suffered from supply chain disruptions experienced 33–40% lower stock returns relative to their industry benchmarks." Additionally, Tang (Tang, 2006) stated that many organizations implemented various initiatives that are productive in a stable market, but these initiatives also make a supply chain vulnerable.

2.8.1 Information Risk within Supply Chain

The more complex a network is, the more interfaces do exist, the more information is shared and the higher the information vulnerability will be, (Peck, 2005). Juttner *et al.* (Juttner, Peck, & Christopher, 2003) showed in their work that one of the causes of the increasing supply chain vulnerabilities and risks is the trend towards outsourcing. Wagner and Bode (Wagner & Bode, 2006) also share this view by stating that the high dependence on information from external sources increases the vulnerability of information to disruption. However, it has been explained that, organizations deliberately disrupts information that can reach not only their competitors, but also their own suppliers and customers, (Mason-Jones & Towill, 1997). This is backed by the fact that "the willingness to share information is based largely on trust and expected mutual benefit," (Fawcett, Magnan, & McCarter, 2005, p. 9).

Information is a very important asset, and its vulnerability that can be exploited may lead to a huge disruption in a supply chain. Information flows between different drivers in a supply chain, and this increases information vulnerability and risk. Every company within a supply chain needs

to acquire and share information so as to perform its own function within the supply chain. Varying degrees of risk from a diverse range of source and context are connected with the process of acquiring and sharing this information. However, when information and information risk is well managed, it makes a supply chain function optimally. “Withholding of information by any member in the supply chain can lead to loss of trust and dysfunctional behavior among all supply chain members, even when the best strategy and technology is used in ensuring information flow,” (Premkumar G. P., 2000, p. 3).

If risk affecting information within a supply chain is not well managed, disruptions in the supply chain may result, thus endangering the overall performance of the supply chain network. Morrow *et al.* (Morrow, Wilkerson, & Davey, 2009) indicated that managing supply chain information networks by sharing information with partners will minimize the risk in a supply chain, it will also assist all parties within the supply chain to be aware of potential disruptions, so as to respond rapidly to the management of the disruptions. Furthermore, Bourdé and Butner (Bourdé & Butner, 2004) emphasized that management of risk should also include the continuous development of strategies that are designed to control, reduce or eliminate risk. Maloni and Benton (Maloni & Benton, 1997) also highlighted this by stating that to create a mutually beneficial relationship which results into an increased information flow, minimized risk, and a beneficial supply chain, the competitive barriers between supply chain members must be properly managed.

2.8.2 Risk Management within Supply Chains

Supply managers should manage risk in their environment, by identifying a potential loss, as this is a more effective and efficient means of dealing with uncertainties and disruptions in information. Unfavorable occurrences may affect a company so much, that it distorts their supply chain activities; this may influence the perception of other partners about the company or their brand, (Harland, Brenchley, & Walker, 2003). Risk Management may be described as the active process of identifying, monitoring, assessing, and responding to risks, in order to ensure that desired objectives are achieved. There should be alignment of objectives between the supplier and the purchasing organizations, so as to work towards managing risk, (Zsidisin & Ellram, 2003). However, “despite the increasing awareness among researchers and practitioners, the perception of supply chain vulnerability and its managerial counterpart, supply chain risk management are still in their infancy,” (Juttner, Peck, & Christopher, 2003, p. 2).

Managing risk is not an easy task. It consists of organizational efforts that mitigate or avoid the occurrence and the severe impact that harmful supply chain events may have on an organization, (Zsidisin & Ellram, 2003). Supply chain risk management may be described as, "the identification and management of risks, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole," (Juttner, Peck, & Christopher, 2003, p. 9). Similarly, Morrow *et al.* (Morrow, Wilkerson, & Davey, 2009, p. 14) described supply chain risk management as "the identification, assessment, and quantification of potential supply chain disruptions, with the objective of controlling the risk or reducing its adverse impact on supply chain performance." However, there have been a variety of different foci in research into risk management, especially in purchasing and supply, but little in supply chain risk management, (Zsidisin & Ellram, 2003).

2.9 Conclusion

Findings from the literature show that companies should be intensely focusing on enhancing their information-sharing capabilities by sharing available information with other members within the supply chain. Substantial cost can be saved through information sharing, therefore information which serves as the central hub of any supply chain must be well managed. However, research concerned with information, information flow, information risk and information risk management from a supply chain viewpoint is negligible, (Mohd, Banwet, & Ravi, 2007). The literature also reveals that the essence of managing risk, especially information risk within supply chain must always be emphasized. Supply chains have become noticeably more complex than they previously were, because companies now deal with multiple tiers of suppliers, outsourced service providers, and distribution channel partners, (Hugos, 2003). Long and complex supply chains seem more vulnerable to risk. Risk within supply chain can adversely affect the overall performance of the organizations in a supply chain, therefore researchers and practitioners are now placing supply chain risks on their agendas, (Stephan & Christoph, 2006). In this chapter, the thesis discusses the literature on supply chain and its concept. In the next chapter, the thesis presents the literature on information systems that enhance information sharing and information management within the supply chain.

CHAPTER 3

INFORMATION SYSTEMS THAT SUPPORT SUPPLY CHAINS

3.1 Introduction

In the previous chapter, a review of the literature on supply chain, information sharing and information risk within supply chain was presented. In this chapter, a literature review on the information systems that facilitate the flow of information within supply chains is presented. Information is regarded as an integral element of a supply chain because it is the link between all its operations and activities. Organizations in a supply chain are increasing collaboration with their trading partners and enhancing their competitiveness by gaining control from information, (Yi-fen & Chyan, 2009). Trading partners are being encouraged to share information within the supply chain as this provides their partners a competitive advantage in the long run, (Suhong & Binshan, 2006). For information sharing to be successful, an information system (IS) for sharing information along the supply chain on various value-adding activities is essential, (Gunasekaran, Lai, & Cheng, 2008). New technologies that enable information to be gathered, processed and shared more rapidly and in larger quantity, (Fawcett, Magnan, & McCarter, 2005) are now being adopted by companies. However, these technologies are also contributing to the shift in power from the producers to the consumers.

We are in an era where information sharing enhances control and organizational achievements, thanks to IT tools such as satellites, telephones, computers, etc. that facilitate information sharing. Information sharing enables the monitoring and coordination of various business activities and processes by using information technology (IT) tools and solutions. These IT tools and solutions have enhanced inter-organizational information systems performance and capability, and for this reason it has been adopted as a means of information systems development, (Williamson, Harrison, & Jordan, 2004). The performance of information within a supply chain depends on the information system that provides support to information within the supply chain, (Lau & Lee, 2000). Thus, “appropriate IT infrastructures are important in enabling faster supply chains with a far-reaching scope that spans the globe,” (Simchi-Levi, Kaminsky, & Simchi-Levi, 2004). IT tools and infrastructures are some of the resources influencing today’s supply chain. However, studies of these tools and infrastructures have not received the attention deserved. This chapter presents a review of information systems that supports supply chain.

3.2 Information systems (IS)

Since the late 1960s, organizations have been using information systems to share information, (Hayes, 2002) cited in, (Juha-Miikka, 2008). Bothma (Bothma, 2006) described Information System as an organized set of interrelated components that manages the information that supports decision making and visualization in an organization. Davies (Davies, 1993) also stated that, "information systems should be regarded as an essential ingredient that provide the customer and supply chain partners with the ability to see, know, anticipate, model, link, and trade off available resources." As stated by Stefansson, (Stefansson, 2002, p. 135) "the overall information systems structure must be capable of coordinating the information systems of the individual parties in a supply network into a cohesive whole, so that each company's information system can support both proprietary and shared data." Information systems should minimize costs and also be able to facilitate a faster response to consumer orders, (Suhong & Binshan, 2006).

An information system contain technologies that include; application software, web-based system, XML (which is an example of middleware), or a combination of all these, (Premkumar G. P., 2000). Lau and Lee (Lau & Lee, 2000) proposed an ideal supply chain information system as shown in Fig 3.1. In their proposal, an information system should contain the above-mentioned technologies and other technologies like; Database, Internet, and Business Intelligence tools which can be used for forecasting, analyzing etc. To reduce the supply chain inefficiencies, organizations are continuously making use of information systems to harmonize their operations, (Mclaren, Head, & Yuan, 2002). The integration of information systems means the use of information technologies to access and transmit information, (Shawnee, Jayanth, Cornelia, & Roger, 2003). A model by Chyan and Yi-fen (Chyan & Yi-fen, 2010) shows that an organization's competency in process, consumer, relationship and planning integration is driven by the operational benefits of information systems.

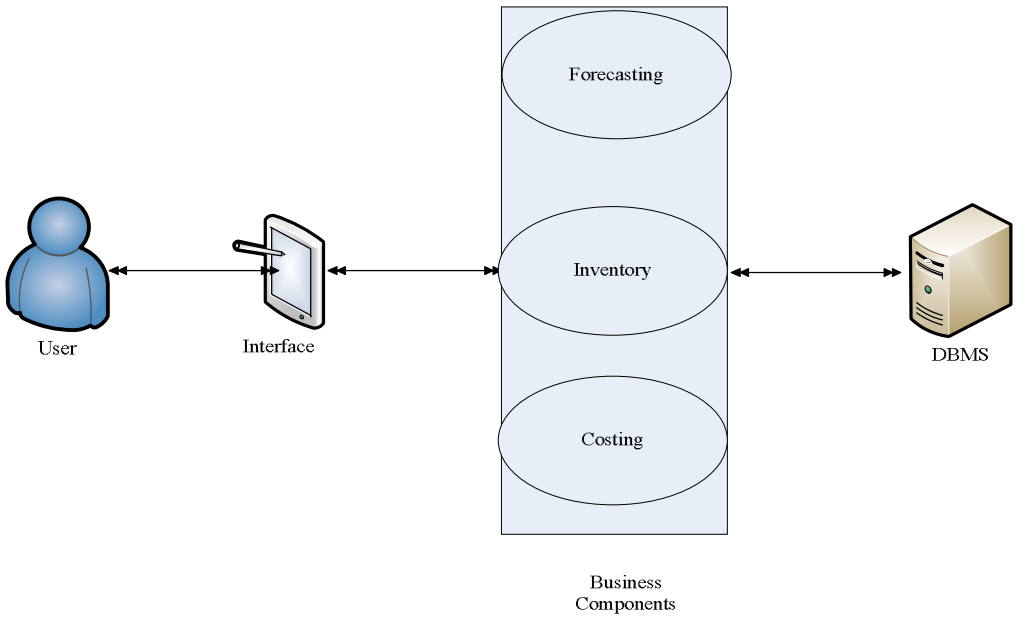

Figure 3.1 Proposed supply chain information system, (Lau & Lee, 2000).

Information systems support all functional areas of a supply chain by facilitating the transfer of information from one point to another. Bothma (Bothma, 2006) stated that the objectives of an information system which includes supporting the strategic direction of organizations, allowing access to a broad group of users and enhancing organizational learning, must be achieved in a cost-effective manner. “Different information systems have different capabilities in their functional areas. The combination of these capabilities is dependent on the demands of the job that a system is designed to perform. Information systems that are employed to support various aspects of supply chain management are created from technologies,” (Hugos, 2003, p. 121). However, it has been noted that “these technologies does not provide only opportunities, but also provides threats, for individual organizations,” (Suhong & Binshan, 2006, p. 1645). According to Hugo, (Hugos, 2003) information systems are made up of technologies that helps with three major functions, these functions are:

1. Data collection and communication
2. Data storage and retrieval
3. Data analysis and reporting

3.2.1 Data Collection and Communication

Information systems improve the performance of a supply chain and also help to enhance the activities of supply chain partners by coordinating the collection and communication of data

across the supply chain. This function of an information system is achieved with the use technology such as; the web and the internet. These technologies create a high speed data capture and communication functions. “Since the inception of the World Wide Web in 1993, documents of all sorts of formats, content and description have been collected and inter-connected with hyperlinks,” (Osmar, 1999, p. 3). Premkumar (Premkumar G. P., 2000, p. 6) in his work showed that “a web-based user interface is a better means of online interaction and data collection.” With its dynamic and heterogeneous nature, the web has emerged as the most important and effective point of data collection. According to Premkumar, (Premkumar G. P., 2000) the evolution of the Internet has created a communications infrastructure that provides a highway for information communication.

Suhong and Binshan (Suhong & Binshan, 2006, p. 1646) also showed this when they stated that “the Internet is a global data communications network that offers connectivity over a local area network (LAN) or Internet service provider (ISP),” by using what is known as Internet Protocol (IP). Before the Internet, companies had to put in expensive dedicated networks to connect themselves to other companies and move data between their different computer systems. Now, with the Internet already in place, different companies have a way to quickly share data between their different systems, (Hugos, 2003). The Internet helps facilitate the sharing of information by providing a degree of privacy and security for supply chain trading partners. However, the Internet experiences high level of insecurity and unreliability. If adequate security measures are used, the willingness of trading partners to share and collect information will be increased.

3.2.2 Data Storage and Retrieval

The second functional capability of an information system is made up of the technologies that retrieves and stores data, and this function is carried out by database technology, (Hugos, 2003). At present, there is far more collected information to be stored. This information ranges from business transactions to reports, (Osmar, 1999). The massive collection of data stored on disparate structures has consequently constituted to the development of database management systems (DBMS). “Since the 1960's, the database has grown steadily from primitive file processing systems to database management systems,” (Jiawei & Micheline, 2000, p. 3). According to Hugo, (Hugos, 2003, p. 125) “the most common type of database uses what is called relational database technology. Relational databases store related groups of data in individual tables and provide the retrieval of data with the use of a standard language called

structured query language (SQL)," A query language allows for the retrieval of specified sets of data, (Jiawei & Micheline, 2000).

Presently, one of the benefits of managing supply chain comes from the use of database systems for better management of information among trading partners, (Chyan & Yi-fen, 2010). As events occur in a business process, there are database transactions; these transactions can be recorded as soon as they happen (real-time updating) or they may be captured and recorded in batches i.e. on a periodic basis (batch updating), (Hugos, 2003). Confronted with huge collections of data, new requirements to help make better managerial decisions have become important. These needs include, "the automatic summarization of data, the extraction of the essence of stored information, and the discovery of patterns in information," (Osmar, 1999, p. 1). A database management system (DBMS) is a system that is made up of a set of software programs that helps with the retrieval of data in the form of information from the database. DBMS are also used to manage access to data, and to ensure consistency and security of stored data. Recovery procedures of DBMS are designed to prevent the loss of information and of transactions being processed, whereas restart procedures relate to the resumption of computer processing, (Takashi, Masato, & Norihisa, 2003). Some examples of databases used for storage are:

- *Flat files*: These are data files in binary or text format. "The data in these files can be time-series data, transactions, scientific measurements, etc," (Osmar, 1999, p. 5).
- *Relational Databases*: A relational database is a collection of tables, each of which is assigned a unique name. Each table consists of a set of attributes (columns or fields) and usually stores a large number of records or rows, (Hugos, 2003). "Each records or rows in a relational table represent an object identified by a unique key and described by a set of attribute values," (Jiawei & Micheline, 2000, p. 9).
- *Data Warehouses*: According to Osmar, (Osmar, 1999, p. 6) "a data warehouse is a repository of data collected from multiple data sources (often heterogeneous), and is intended to be used as a whole under the same unified schema." It allows for all data to be stored at a single site with a similar structure, and this structure allows for analysis. "Data warehouses are constructed via a process of data cleansing, data transformation, data integration, data loading, and periodic data refreshing; the data are stored to provide information from a historical perspective, and are typically summarized," (Jiawei & Micheline, 2000, p. 5). According to Hartmut, (Hartmut, 2005, p. 578) data warehouses "enable decision makers anywhere in the SC to store and retrieve historical mass data at a

level of detail and in dimensions (e.g. time interval, geographical region and product type) most suitable for decision making".

- *Transaction Databases*: Transaction databases are set of records that represent transactions. "Transactions are mostly stored in flat files or in two normalized transaction tables, in which one is for the transactions and one for the transaction items," (Osmar, 1999, p. 7).

3.2.3 Data Analysis and Reporting

Different systems have been created by combining various processing logics that are used to analyze and report data with the aid of technologies that are needed to capture, store and share data, (Hugos, 2003). "The way a system processes and reports the information that flows through it is dependent on the specific business operations that the system has been designed to support," (Hugos, 2003, p. 126). All business transactions is usually memorized for permanence, hence storage space is usually not the main problem, but the appropriate and efficient use of the information in a good time frame for making decision is absolutely one of the most vital challenges to be solved, especially for organizations that are struggling to survive in the present global market, (Osmar, 1999).

Efficient methods such as data mining, on-line transaction processing (OLTP), and on-line analytical processing (OLAP) are contributing extensively to the development and acceptance of technology as one of the main tools for effective analysis of large amounts of data, (Jiawei & Micheline, 2000). These methods have been extensively used for the analysis and reporting of data stored in the database. "The On-Line Analytical Processing (OLAP) is an analysis technique with functionalities such as consolidation, summarization and aggregation, as well as the ability to view information at different angles," (Jiawei & Micheline, 2000, p. 5). "Although OLAP tools support multidimensional analysis and decision making, additional data analysis tools are required for in-depth analysis, such as data classification, clustering, and the characterization of data changes over time," (Jiawei & Micheline, 2000, p. 5).

Data mining tries to overcome the challenges of uncovering patterns from large quantity of data. "This data are stored in databases, data warehouses, data mart, or other information repositories," (Jiawei & Micheline, 2000, p. 7). Data mining by principle can be applied to any type of data repository. It is a technique that works most effectively when combined with the data warehouse or data mart. According to Osmar (Osmar, 1999, p. 3) "data mining refers to the nontrivial extraction of implicit, previously unknown and potentially useful information from data in

databases." Data mining is part of a knowledge discovery process that is also called the Knowledge Discovery in Databases (KDD). "The KDD comprises of a few steps which starts from raw data collections and leads to some form of new knowledge. The iterative process consists of the following steps," (Osmar, 1999, p. 4):

- *Data cleaning*: This is the stage where irrelevant data are extracted from the collected data.
- *Data integration*: This is the stage, where heterogeneous data sources are integrated into a common source.
- *Data selection*: This is the stage where the relevant data for analysis is decided on and then retrieved from the collected data.
- *Data transformation*: This is the stage where the selected data are transformed into appropriate forms for the mining procedure.
- *Data mining*: This is the stage where techniques to extract useful patterns are applied.
- *Pattern evaluation*: this is the stage where patterns representing knowledge are identified based on given measures.
- *Knowledge representation*: This is the final stage. It is where the knowledge discovered is represented visually to the user.

3.3 Information Technology (IT)

To meet the new challenges of a proficient supply chain, "organizations around the world are investing heavily in Information Technology (IT), and taking advantage of IT to alter the conduct of business in both domestic and global markets," (Yi-fen & Chyan, 2009, p. 81). Information technology can support both internal and external processes, and also enhance partnership between organizations in a supply chain, (Hugos, 2003). "Technologies like extensible markup language, web services, service-oriented architecture, among others, are now available and making IT challenges less formidable to deal with," (Simchi-Levi, Kaminsky, & Simchi-Levi, 2004). Those organizations that have learnt to use these technologies and techniques that are now available can build a supply chain that will have competitive advantage in the global market. Although modern information-technology tools are available, the costs for setting up and operating them is still substantial, (Zhao, Xie, & Leung, 2002).

"The transparency of information and the use of technology to create connectivity (i.e. the ability of companies to share information in real time)," (Gunasekaran, Lai, & Cheng, 2008, p. 559) within supply chains has been of interest to both researchers and practitioners. Supply chains may

be seen as examples of an IT-enabled inter and inter-organizational arrangement, where "the coordination between organizations is crucial to good performance," (Lewis & Talalayevsky, 2004). With the advent of technologies like broadband, it has become possible for organizations within a supply chain to easily connect with each other and exchange large volumes of data in real-time, (Hugos, 2003). These technologies "enable applications to describe their function to each other so that they can integrate with little or no constraint," (Angeles, 2009, p. 229). The emergence of IT have made true supply chain integration possible. However, as much as these technologies create new opportunities, they also create new form of threats and risks to supply chains.

Information sharing using IT will be less prone to error and faster than sharing information through meetings, mails, phone calls, etc, (Juha-Miikka, 2008). The proper use of technology is an important feature of an organization's success, (Hugos, 2003). According to Hawker *et al.*, (Hawker, Nelson, & Terry, 2004) organizations need to exploit these technologies so as to achieve full control across the extended supply chain networks. With the recent advances in information and communications systems, new business ideas enabled by technologies have facilitated the development of many supply chain information sharing strategy. "These technologies facilitates information management (IM) and speed up the free flow of information upstream (e.g. information on capacity and demand that can help to reduce stockpiles and improve fill rates) and downstream (e.g. information about disruptions in the supply chain network), thus making the supply chain more robust and resilient without undermining its efficiency," (Pereira, 2009, p. 375). The major technologies that have facilitated information sharing within supply chain are:

- Manufacturing Resource Planning (MRP II) Systems
- Enterprise Resource Planning (ERP) Systems
- Electronic Data Interchange (EDI)
- Vendor-Managed Inventory (VMI)
- Radio Frequency Identification (RFID)

3.3.1 Manufacturing Resource Planning (MRP II)

The most prominent basics of Manufacturing Resource Planning (MRP II) utilizes ideas from Material Resource Planning (MRP) which uses a technique "where net requirements of raw materials and products to be manufactured or ordered from vendors to meet demands are properly calculated," (Liping & Stefan, 2009, p. 502). As shown in Fig 3.2, Takashi *et al.* (Takashi,

Masato, & Norihisa, 2003, p. 772) explained that, “business processes overcomes the challenges of balancing the product demand forecast and the resource supply capacity in real-time with a high speed material requirement planning package.” The material requirement planning approach is widely used in industry for production planning and supply management, (Mohamed-Aly & Alexandre, 2010). The MRP input data are “the master production schedule, material inventory, and material backlog, while material requirements are its output data. MRP enables quicker and more correct sourcing planning,” (Takashi, Masato, & Norihisa, 2003, p. 773). “Despite several shortcomings, the MRP concept is still widely used in practice for materials planning and control,” (Karl, 2009, p. 474).

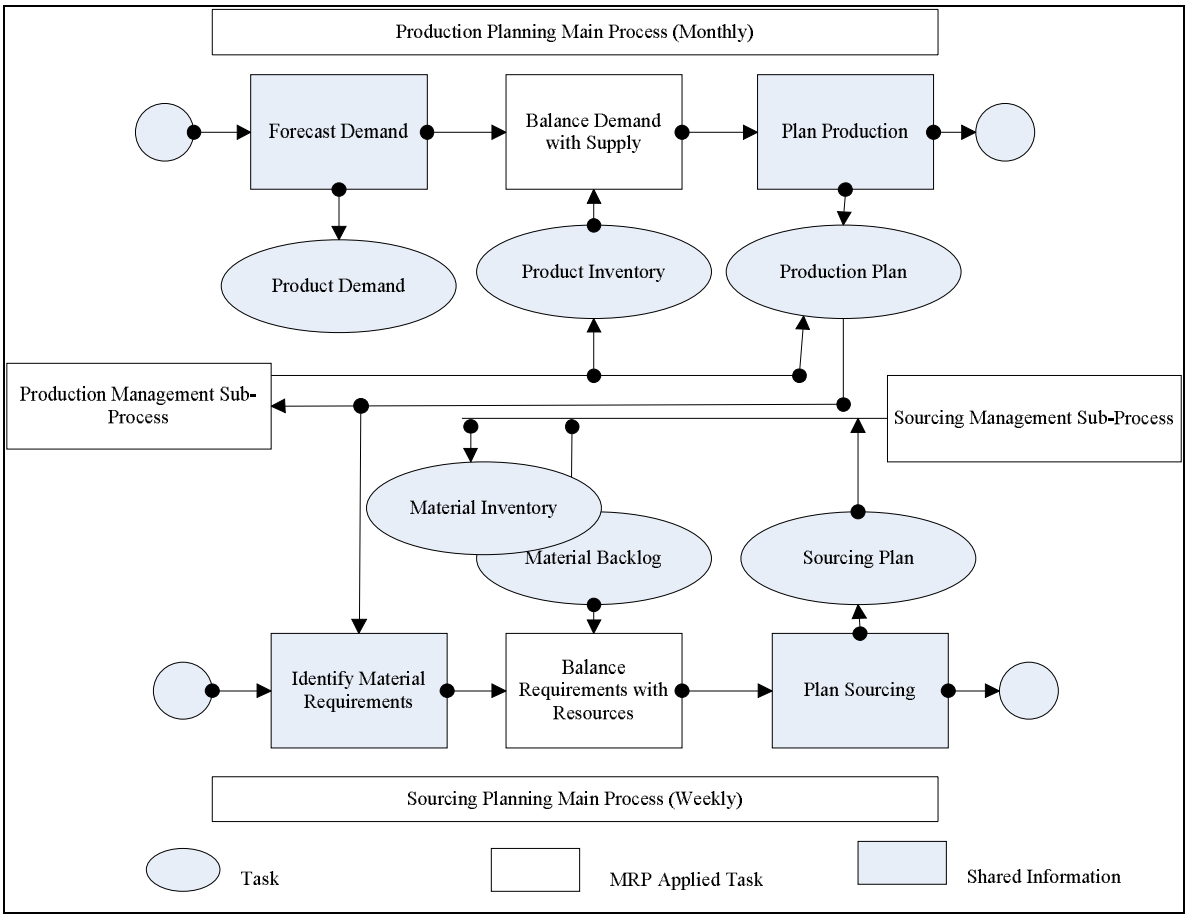

Figure 3.2 Business process template, using MRP, (Takashi, Masato, & Norihisa, 2003).

The major practical interest of MRP II certainly lies in the fact that, it is a concept that provides a clear and simple to understand framework for material planning; and also used as a powerful information system to help decision makers, (Mohamed-Aly & Alexandre, 2010). Takashi *et al.*

(Takashi, Masato, & Norihisa, 2003, p. 773) in their work stated that "MRP II plays a central role of a sourcing solution, although the business process for the solution has to include the minimum set of interaction sequences between persons who must share the input/output information in real-time." To enable the effective operation of MRP II, the shared information should include; "input: production plan, material inventory, and material backlog; output: sourcing plan (daily)," (Takashi, Masato, & Norihisa, 2003, p. 773). However, one major setback of MRP II is that it does not consider any inherent uncertainty that is present in the planning data, (Karl, 2009).

3.3.2 Enterprise Resource Planning (ERP)

ERP utilizes idea from the MRP and its successor, MRP II, (Liping & Stefan, 2009). According to Hugo, (Hugos, 2003, p. 126) "ERP systems monitor orders, production schedules, raw material purchases, and finished goods inventory; they support a process-oriented view of business that cuts across different functional departments. For instance, an ERP system can view the entire order fulfillment process and track an order from the procurement of material, to filling the order, and to delivering of the finished product to the customer." On the other hand, Demirkan and Cheng (Demirkan & Cheng, 2008) stated that the only way to earn the rewards of an ERP system is to make significant financial investments in ERP software and other computing resources. Consequently, the successful implementation rate of ERP systems is still quite low, (Liping & Stefan, 2009).

The ERP project yields a software solution that integrates information and business processes throughout a company, (Swartz & Orgill, 2001). According to Mendelson, (Mendelson, 2000, p. 2) "ERP is a software architecture that facilitates the flow of information among the different functions and units within a supply chain; Cisco Systems, for example, harnessed ERP to help it become the market leader in the global networking industry." As the demand for the integration of both the internal and external organizational systems intensified, "there was the need to use a technology that addresses integration problems and that achieves business processes integration," (Marinos, Zahir, & Peter, 2004, p. 396). However, Pereira (Pereira, 2009) in his work indicated that integrated systems, like the ERP can cause system compatibility problems for trading partners in a supply chain.

During the 1990s, ERP technology was developed as an approach to business process integration, (Marinos, Zahir, & Peter, 2004) through an integrated database environment, (Williamson, Harrison, & Jordan, 2004). An ERP system is now important in enhancing the continuous information integration and organizational processes across all the units of an organization, (Law

& Ngai, 2007). Additionally, Liping and Stefan (Liping & Stefan, 2009, p. 501) also stated that "ERP systems are among the most important enablers of business intelligence and planning functionality in supply chains." ERP system comes in modules that perform and monitor daily transactions; "these modules can be installed on their own or in combination with other modules; these modules usually are in finance, procurement, manufacturing, order fulfillment, human resources, and logistics," (Hugos, 2003, p. 127).

Today, ERP systems are still evolving and adapting to the developments in technology, and also to the demands of the global market, (Mark, 2002). Nevertheless, ERP systems still have limitations as they still have to be customized so that they can support organizational operations and processes. "Customization is also another difficult task that causes significant integration problems as ERP systems are complex, non-flexible and often not designed to collaborate with other autonomous applications," (Marinos, Zahir, & Peter, 2004, p. 396). A survey performed by Themistocleous and Irani, (Themistocleous & Irani, 2002) showed the organizations experience significant challenges when they customize ERP systems with their existing information system solutions.

3.3.3 Electronic Data Interchange (EDI)

EDI was first deployed in the 1980s by large companies in the manufacturing, automobile, and transportation industries; It was developed to facilitate the transmission of common types of data between organizations, so as to automate back office transactions such as the sending and receiving of purchase orders, invoices, advance shipment notices, backorder status, etc, (Hugos, 2003). "EDI is the exchange of data in an agreed upon electronic format from one organization's system to one or more organizations' systems," (Suhong & Binshan, 2006, p. 1646). "It originally was built to run on big, mainframe computers using value added networks (VANs) to connect with other trading partners; however, that technology was expensive. EDI systems can now run on any type of computer from mainframe to personal computer (PC) and it can use the Internet for data communications as well as Value Added Networks (VANs)", (Hugos, 2003, p. 123). Every business has application files that are used to manipulate their data in a way that is familiar to the business. Hence, communication and document standards are both critical, as document standards are the heart of EDI. The sequence of events in any EDI transaction is as follows:

- The sender's own business application system assembles the data to be transmitted.
- This data is translated into an EDI standard format (i.e., transaction set).

- The transaction set is transmitted either through a third party network (e.g. VAN) or directly to the receiver's EDI translation system.
- The transaction set, in EDI standard format, is translated into files that are usable by the receiver's business application system.
- The files are processed using the receiver's business application system

It is believed that, "the long-term strategic importance of EDI is believed to lie in the potential comparative advantage that could be gained from learning how to integrate the technology effectively into supply chains," (Tuunainen, 1999, p. 362). According to Jens and Lars-Erik, (Jens & Lars-Erik, 1996, p. 223) the use of EDI have two major direct impact on information flow within supply chains. "Firstly, information handling is substantially simplified, because the creation, transmission and reception of commercial documents are carried out automatically, and are paperless. Information can thus be fed directly into the receiving party's computer applications without manual intervention, and the information exchanged can be reused for various purposes without rekeying. Secondly is that the quality of information is improved. By reducing the amount of manual work, an important source of error is eliminated (errors caused by inaccurate rekeying are often difficult to trace)." However, the absence of openness in the present EDI-practice and the high costs of software and hardware components have contributed to the gradual evolution of EDI, (Tuunainen, 1999).

3.3.4 Vendor-Managed Inventory (VMI)

Since vendor managed inventory (VMI) system was initiated in the early 1980s by organizations like Wal-Mart, researchers have made effort to find out how this system delivers benefits, (Yan, Kefeng, & Martin, 2007). Disney and Towill (Disney & Towill, 2003, p. 201) described VMI to be "a supply chain strategy where the vendor or supplier is given the responsibility of managing the customer's stock, orders and in some cases factory activities." Yan *et al.* (Yan, Kefeng, & Martin, 2007, p. 355) in their work also described VMI as, "a supply chain system whereby a supplier assumes responsibility of maintaining inventory levels and determining order quantities for its consumers." Consequently, the supplier would have access to information about the inventory quantity of retailers. This however requires information technology tools and trust in the supply chain relationship, (Kiesmuller & Broekmeulen, 2010). However, Bruce and Ireland (2002) as cited in (Yan, Kefeng, & Martin, 2007) stated that, information inaccuracies hinder the opportunities that can be achieved from VMI.

Information sharing practices facilitated by VMI allow manufacturers the access to correct demand information, e.g., sales data, (Atul & Satish, 2008). "The distinct feature of VMI is the transfer of decision making over inventory and orders, and an important function of VMI is the sharing of information (demand, inventory, etc.) among trading partners," (Yan, Kefeng, & Martin, 2007, p. 357). Kiesmuller and Broekmeulen (Kiesmuller & Broekmeulen, 2010, p. 407) proposed VMI policies where "the vendors have information about the retailers' inventory levels with the help of technologies such as EDI or RFID." According to Disney and Towill, (Disney & Towill, 2003) VMI could help in the reduction of bullwhip effects by eliminating information flow time delays. "The Bullwhip Effect is a new term coined by Lee *et al*. (1997a, b); it refers to the scenario where the orders to the supplier tend to have larger fluctuations than sales to the buyer, and the distortion propagates upstream in an amplified form," (Disney & Towill, 2003, p. 202).

3.3.5 Radio Frequency Identification (RFID)

"The radio frequency identification device (RFID) was first developed and implemented by the military as a radar transponder technology to discriminate between friends and foes," (Simon & Jacques, 2009, p. 693). In recent times, new business initiatives enabled by emerging technologies such as EDI and RFID have enhanced workflow management and also enhanced information sharing in decentralized business environments, (Zhiling, Fang, & Andrew, 2006). RFID brings a new dimension to the management of supply chain by providing a more effective means of identifying and tracking items at the different stages within the supply chain. Although, the long developed technologies like barcode are not expensive and difficult to use as compared to RFID, especially when considering their implementation. The basic idea of RFID in supply chain is to do away with barcode systems which use line of sight scanning to a proximity scanning system that uses radio frequency, (Simon & Jacques, 2009).

One of the advantages of using RFID technology is that, "it can be used in detecting an item's location, the distribution history of items, and item quantities in stock," (Simon & Jacques, 2009, p. 693). It could also be used to simplify the challenges of managing raw material, and the inventory of finished product, especially in today's modern supply chains, (Simchi-Levi, Kaminsky, & Simchi-Levi, 2004). Nevertheless, the use of RFID is still controversial, "while some praise the technology to be revolutionary; others warn of the hype over a technology that still has many challenges to overcome," (Simon & Jacques, 2009, p. 693). Qi and Kaijie (Qi & Kaijie, 2009, p. 454) also noted that "improving the accuracy of information by leveraging on

new technologies, such as RFID, typically requires investments in deploying, maintaining, and upgrading equipment, in addition to costs expended on personnel training."

3.4 Information Technology (IT) Infrastructure Integration

The integration of Information Technology (IT) infrastructure has been defined as, "the degree to which a focal organization has established its IT capabilities for the consistent and high-velocity transfer of supply chain-related information within and across its boundaries," (Angeles, 2009, p. 220). It has also been noted as a way of enhancing the effectiveness of information interchange among members within the same supply chain network. The availability of many technologies is resulting into huge number of technological permutation to enhance integration efforts. Although, as highlighted by Marinos *et al.,* (Marinos, Zahir, & Peter, 2004) integration is a challenge for many organizations as it seems that there are no single integration technologies that support all integration problems. However, balancing the openness that this integration brings is the concern that most company have about sharing information.

With the use of IT infrastructures, a number of organizations are now sharing common information. The integration of this information and organizational processes with the IT infrastructures should be considered essential. Marinos *et al.* (Marinos, Zahir, & Peter, 2004, p. 396) showed this with the case of a food retailer. "When the food retailer and its suppliers integrate their IT infrastructures, they control and improve their supply chain. In this case, suppliers might also gain access to retailer's IT infrastructure and retrieve information relating to their own products and promotions. With this information, suppliers could analyze the availability and sales of their products, and replace them. In this scenario, both suppliers and retailer share common business processes and IT infrastructures." The interconnection and integration of IT infrastructures that are owned by different organizations is important for their trading partners to manage their decisions, (Pereira, 2009). However, a survey by IBM showed that fewer than 5% of businesses are integrating their IT infrastructures with external partners, (Williamson, Harrison, & Jordan, 2004).

3.5 Conclusion

In this chapter, a literature review on the information systems that enhances the supply chain information and information sharing was presented. In this review, it may be concluded that the development of information systems provided numerous opportunities for organizations. It has been shown that information sharing has been made easier and better with the advent of

information systems. The implementations of information system and technology tools now demand organizations to change their traditional business practices and learn a new strategy to deal with unforeseen challenges, (Liping & Stefan, 2009). In today's business, technology is important insofar as it enables an organization to deliver valuable products and services to its consumers profitably, (Hugos, 2003). The usage of Information systems and technology provides not only opportunities but also risks, therefore sharing information systems and its inherent information with consumers or suppliers has been considered too risky, (Tan, 2001). In the next chapter, the thesis discusses the research methodology used in achieving the objectives of this research.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

In the previous chapter, the thesis presented a review of literature on the information systems that support information and information sharing within supply chains. In this chapter, the thesis discusses the research methodology used in accomplishing the objectives of this research. When embarking on a research project, "the methodology one chooses to use is very important in determining both the form as well as the success of the whole research project," (Megan, 2005, p. 2). In order to guarantee credibility and make sure that any unexpected theme is given the opportunity to emerge, the methodology used for this research has been carefully chosen. Pamela and Susan, (Pamela & Susan, 2008, p. 544) stated that the methodology employed in a research should ensure that, "the research is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the research to be revealed and understood." This chapter explains the design and criterions considered in this research. It also describes the research methodology that includes the data collection method and instruments, the sampling method and the analysis done in this research.

4.2 Research Design

Research design harmonizes the activities of a research, and it promotes the efficient and effective functioning of the methodology applied in a research. It provides a systematic flow that supports the construction, reconstruction and deconstruction of the context under investigation. According to Ragin, (Ragin, 1994) it is a plan for collecting and analyzing evidence that will make it possible for the investigator in a research to answer whatever questions he/she has posed. A properly designed research supports the development of logics for linking components within the research. It also supports the development of theories that becomes a criterion in gaining a sharpened understanding of a phenomenon, and for interpreting research findings. The criterion for designing this research was carefully chosen, as investigation was carried out within its real-life context. In order to answer the critical questions and to achieve the objectives of this research, the following steps were outlined and implemented;

- Companies were visited in order to be sure that they have a functioning supply chain and also to understand their supply chain operation, structure and performance.
- Companies with functioning supply chain were selected. The companies with functioning supply chain have to satisfy the following criteria:

1. The companies have a structured supply chain in place that extend beyond the geographical boundaries of the nation and as a result depend mainly on the sharing of information.
2. The companies have implemented supply chain information technology (IT) infrastructure such as JD Edwards EnterpriseOne, SAP etc.
3. The companies have a work force of not less than three thousand people working across the different units of their supply chain.
4. The companies have to be "willing to allow access to employees at various organizational levels and be willing to disclose any information the researchers considered pertinent to the study."

- The appropriate research step to suite the purpose of this study was employed and these are:

1. Research Methodology: Qualitative Research Methodology.
2. Data Collection & Analysis.
    a. Analysis Unit: Case Study.
    b. Sampling Method: Purposive.
    c. Data Collection Means: Interviews & Questionnaire.
    d. Analysis Method: Content Analysis.

- Results were obtained, analyzed and presented.

4.3 Research Methodology

In order to obtain sample of personnel from all relevant parties/companies involved with information, information flow and information risk within supply chain, and also tap into the experience of supply chain professionals, an exploratory qualitative research methodologies was implemented in this research. This is because an exploratory qualitative methodology describes, interpret and explore the richness, depth and complexity of a phenomenon within its context; from the view point of those who participate, through a comprehensive description of their actions. It does not begin from a predetermined starting point or proceed through a fixed sequence of steps. It contributes to a better understanding of realities, and draws attention to processes, patterns and structural features of any phenomenon under investigation. The principle of

qualitative research is the understanding of complex relationships rather than the explanation of a single relationship. It is also characterized by the principle of openness, because questions usually have open formulation, (Uwe, Ernst, & Ines, 2004).

The research for this study was conducted in two fast moving consumer goods (FMCG) companies. Qualitative research, like any other reliable research, needs a logical approach in implementing the research design. It is a type of research methodology, which is mainly an inductive rather than deductive analytical process that helps in developing explanations and answering; "what", "how", and "why" questions. Information obtained during the data collection process was recorded in a manner that allowed the data to be properly analyzed, so as to develop a framework which can be adapted to the study. Data collection and analysis in qualitative research requires a proper review and interpretation so as to describe the phenomenon being studied.

The plan for the stages of conducting this research includes planning for sampling and data collection, planning for data analysis, interpretation and reporting. The analyzed and interpreted data were useful in developing empirically supported new ideas and theories, and to form the basis for conclusions about the phenomenon under study. There is no predominant outline or a single accepted framework for which qualitative research should be conducted; rather it is guided by individual logical positions that are chosen in relation to the research context. Qualitative research methodology is a methodology that is concerned with the understanding and experience of its participants, by collecting evidence and producing results that were not determined in advance.

In the first phase, questionnaires were physically distributed and collected from personnel of parties/companies within the supply chain being investigated. An online survey questionnaire was also used in this phase of data collection. In the second phase, an exploratory qualitative methodology was adopted, so interviews were conducted. Interviews were conducted based on schedule and were recorded digitally, after which analysis procedures were used to determine similarities and differences between the interviews. The personnel interviewed were those that have significant roles to play in their respective units, such as IT, procurement, planning, logistics, warehousing and distribution, among others. Participants' stories and representations were given attention because this shows their understanding of their company's supply chain.

4.4 Case Study

A case study is the comprehensive study of a specific context that is used as a unit of analysis when a thorough investigation is needed, because it helps in the understanding of complex issues. As a unit of analysis, it is the point where actual data collection is done, but before the commencement of data collection, there is always a need for sampling in order to determine those that will be involved in the data collection. Yin (Yin R. , 1993) identified some case study types. These are "Exploratory: considered as a prelude to social research, Explanatory: used for doing causal investigations, and Descriptive: require a descriptive theory to be developed before starting the project." Stake (Stake, 1995) identified three others, "Intrinsic: when the researcher has an interest in the case, Instrumental: when the case is used to understand more than what is obvious to the observer, Collective: when a group of cases are studied." According to Robert K. Yin, (Yin R. , 1994) case study approach have four major stages:

1. Design the case study.
2. Data collection.
3. Data Analysis.
4. Develop the conclusions, recommendations and implications.

This research was done using the FMCG companies as case study and the research methodologies were implemented through interviews, questionnaires, technical reports, and general statement and associated support documents. "When case study methodology is used, it is important that bias does not develop toward the criticality of information," (Larry & Sue, 1998, p. 40). Robert Yin, (Yin R. K., 2003) define the case study research as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident." It is a research approach that could be used as a unit of analysis when a thorough investigation is needed, because it helps in the understanding of complex issues.

A case study is a research type that no single method has been established for conducting. It enables the researcher to explore individual person, a group, an event, or an institution through interactions or observations. "A hallmark of case study research is the use of multiple data sources; a strategy that enhances data credibility," (Patton, 1990) and also allows the researcher to provide a convincing argument as an answer to questions posed in the research. It is a research approach that describes the process or sequence of incident in which a behavior occurred. It is

also a research approach that describes the overall situation of a phenomenon as a combination of different factors within the phenomenon.

4.5 Interview

For the supply chain to be adequately explored, the source of primary data for this research was personal interviews. A total of 40 interviews were conducted. “Interviews are one of the most important sources of case study information,” (Tellis, 1997, p. 9). Interviews were recorded digitally, and were subjected to content analysis. Information gathered during interviews was used to obtain similarity and differences between interviews, and was also combined with concepts from the literature review to form a framework. The interviews conducted in this research took the following forms: structured, focused and open-ended. According to Tellis, (Tellis, 1997, p. 9) “a structured interview requires formal survey, while in a focused interview the respondent is interviewed for only a short time, and the questions asked could have come from the case study protocol; while in an open-ended interview the researcher could ask for the informant's opinion on events or facts.”

The interviewing process for this research focused mainly on three areas as stated by Tesch, (Tesch, 1990) and these areas are: “Language as a means to explore processes of communication and patterns of interaction with interviewed personnel; Description and Interpretation of subjective meanings attributed to situations and actions of interviewed personnel; and Theory building through discovering patterns and connections.” Interviews are invariably and directly influenced by the interviewers’ perspectives and by the unique perspectives of their interview participants. During the interview, notes were also used to take note of questions that needed to be re-visited so as to get more complete information. The interview conversation was properly guided towards producing a full account of the phenomenon being investigated. There is no common procedure for research interviews but this research interview followed the seven stages outlined by Kvale, (Kvale, 1996) and the stages are:

1. **Thematizing**: -Formulates the purpose of the investigation and clarifies the “what” “why” and “how’’ components of a research.
2. **Designing**: -Involves developing a plan for the study.
3. **Interviewing**: -Conduct the interview based on an interview guide and with a reflective approach to the phenomenon within the context under study.
4. **Transcribing**: -Prepare the data gathered during interview for analysis, which commonly includes a transcription from oral to a written text.

5. **Analyzing**: -Decide on the purpose of the investigation, and on the nature and methods of analysis that are appropriate.
6. **Verifying**: -Ascertain the authenticity and reliability of the interview results with respect to the phenomenon under investigation.
7. **Reporting**: -Communicate the findings of the study based on scientific criteria. Ethical aspects of the investigation are also taken into consideration in this stage.

4.5.1 Interview Schedule

As outlined by Kvale, (Kvale, 1996) in his stages of interview, the design stage of this interview followed a structured pattern. The interview schedule was divided into three main sections, with each section addressing different core areas of the research. The sections are as follow:

- Job and Experience

This section gave an insight into what role the individual being interviewed plays in the supply chain. It also examined the experience these individuals have in their job roles, as this helped to determine the kind and level of question to ask. The core questions in this section were:

1. Job and Job role
2. Experience in Supply chain & Risk management

- Supply Chain

This section allowed the interviewer to understand the supply chain type that a company participates in, and how information is collected and shared within the supply chain. The importance and method of sharing information was also properly understood in this section. The core questions that were asked in this section include:

1. Information within supply chain
2. Sharing of Information within supply chain
3. Relationship with supply chain partners

- Risk management

This section was used to understand the vulnerabilities, threats and risk that information is exposed to while it flows within the supply chain. It was also used to understand the business impact of risk on supply chain information and information systems. It also helped understand

if there were measures in place to mitigate or prevent the risks information is exposed to within the supply chain. The key questions that were asked in this section include:

1. Information Risk within supply chain
2. Risk of sharing information within supply chain
3. Risk with supply chain partners

4.6 Questionnaire

Data acquisition for this research was also done using a formal standardized survey questionnaire. The questionnaire was distributed in hardcopy and was also administered online to members of the companies under study. Maria and Nadia, (Maria & Nadia, 2005, p. 3) stated that, "a questionnaire is said to be standardized when each respondent is to be exposed to the same questions and the same system of coding responses." Responses to questionnaires were analyzed using Microsoft excel and SPSS to get similarities and differences between responses, and also to obtain statistical results. The aim here was to ensure that the differences in responses to the questions asked in the questionnaire "can be interpreted as reflecting differences among respondents, rather than differences in the processes that produced the answers," (Maria & Nadia, 2005, p. 3). Since the questionnaire was used to complement the responses from the interview, most of the questions asked were extracts from the interview schedule.

4.7 Sampling

In qualitative research, only a subset of a population is chosen for a study. The objectives of a research study determine how many people to select for the study. The sample selected to participate in a research is chosen from the study population that is commonly referred to as the "target population". As identified in the literature, the two major types of sampling techniques in qualitative research are: random sampling technique and non-random sampling technique. Since the participants in this research were selected based on their experience of the context under study, a non-random sampling technique was used in this research. There are four most common non-random sampling techniques used in qualitative research, (Yin R. , 1994) and they are: "convenience sampling, purposive sampling, quota sampling and snowball sampling." A purposive sampling was implemented in this research.

4.7.1 Purposive Sampling

Qualitative sampling is referred to as purposive when, “it aims to select appropriate information sources to explore meanings and emerging ideas.” Patton (Patton, 1990) explained that purposive samplings are information rich sampling types from which one can learn about issues of importance to the purpose of any research. Purposive sampling group participants according to selected conditions that are relevant to the research question, and this makes it useful for situations where the researcher needs to reach a targeted sample. Its sample sizes are based on theoretical saturation (i.e. the point in which the collection of data is no longer bringing additional value to the research questions). “Purposive sampling is concerned with information richness, therefore most successful when data review and analysis are done in conjunction with data collection,” (Natasha, Cynthia, Kathleen, Greg, & Emily, 2005, p. 6).

In this research, those used as sample were those that have significant roles to play in their respective supply chain units. Samples were chosen from selected units, and these units include; Information technology (IT), procurement, planning, logistics, warehousing and distribution, among others. A minimum of five personnel were interviewed across these units. The questionnaires were also given to people with appropriate supply chain skills; hence a minimum of twenty questionnaires was administered across these units. Two key considerations also guided the sampling used in this research, and these considerations are appropriateness and adequacy. “Adequate sampling of information sources (i.e. people, places, events, types of data) so as to address the research question and to develop a full description of the phenomenon under study,” (Morse, 1995) was also ensured.

4.8 Data Analysis

Analysis in qualitative research is largely inductive and often iterative. “The analysis of data requires careful and hermeneutically reflected interpretative work so as to understand, beyond the idiosyncrasies of the researcher, the ideal types of world experience,” (Uwe, Ernst, & Ines, 2004, p. 104). “Data analysis in qualitative research is a process of reviewing, synthesizing and interpreting data to describe and explain the phenomena or social worlds being studied," (Ellie, Carol, Fiona, & Larry, 2002, p. 728). It is also a process of transforming data with the objective of highlighting useful information. There are so many methods of data analysis in qualitative research, but content analysis method is the main data analysis method used in this research, while Microsoft excel (where applicable) was used for analysis of the questionnaire.

4.8.1 Content Analysis

Content analysis is based on the procedural analysis of texts. Content analysis is generally applied to all sort of recorded communication such as, "political speeches, transcribed interviews, and published literature, because it seeks to elucidate, through close examination of the content and language of these texts, what can be learned about authors' or respondents' understanding of phenomena and terminology, as well as their beliefs," (Ciaran, 2001, p. 1). In using content analysis, the aim was to get at similarities by examining the data qualitatively. The method of data gathering may influence the ease of data analysis and consequently the findings from the data. The information that was gathered during the data collection process was recorded in a way that enabled the researcher to analyze the data conveniently using content analysis. This information was analyzed by looking at themes and patterns, and this involves exploring the data.

Content analysis analyzes not only the manifest content of a material as the name may suggest; it actually analyzes the primary content which includes the themes and main idea of a transcribed data, (Mayring, 2000). It also analyzes the latent content, which is the contextual information within a text. In this research, the researcher determined where the emphasis lies after the data have been gathered and transcribed. The researcher also searched for structures and patterned regularities in the text, and made inferences from these regularities. "The categories of analysis was based on the research questions, and refined by the process of analysis," (Megan, 2005, p. 11). By the end of the research cycle, the researcher was able to account for the evolution of the research questions into the more sophisticated structures of data analysis, and subsequent development into the clearly defined concepts, explanations, and theories generated by the data," (Megan, 2005, p. 14).

4.9 Conclusion

In this chapter, the research methodology, the research criteria, the sampling technique and the analysis method used in achieving the objectives of this research was presented. From the literature on research methodology, it may be said that there are no single realities, but numerous realities of phenomenon within any context, and these realities can differ with respect to time, people and place. This research followed well-sequenced steps and carefully selected criteria in its design. Interview as an exploratory research tool was conducted in this research. The exploratory research allowed for content to develop naturally without any influence and bias by both the interviewer and the respondent. A questionnaire was also used for data collection, so as to supplement the information that was obtained from the interview. In the next chapter, the thesis

will discuss the findings from the research conducted for this study. The next chapter will also present and discuss the framework that has been developed through the findings of this research.

Chapter 5

DISCUSSION AND PRESENTATION OF RESULTS

5.1 Introduction

In the previous chapter, the research methodology and the analysis method used in accomplishing the objectives of this study was presented. In this chapter, the findings from the data analysis are discussed. In the course of the data analysis, it was realized that the unrelenting growth in supply chains, the increasing competition, the drive to reduce cost and the consumers' demand for diversity has necessitated a strategic approach of dealing with information, cash and material flow in an integrated manner and it has also led to the globalization of supply chains. The consequent inevitable expansion of these globalized supply chains and their inherent supply chain networks are causing the related information flow to become ever more complex. The complexity of information flow exposes the information to risk. By examining different supply chain, information risk and risk management frameworks and models, and also by discussing and presenting the findings from this research study, this chapter offers ways in which risks that affects information within supply chain can be managed.

5.2 Frameworks

In recent times, numerous publications and various organizations have improved on the clarity of the various terminologies used in the field of supply chain management, risk management and information risk. This has been done through the development of various frameworks and models in these subject areas respectively. But yet there are still no generally agreed categorizations or best practice of any of these phenomena within their context. The section will outline and explain some frameworks and models that formed the basis of this research.

5.2.1 Supply Chain Management Frameworks

Supply chain management frameworks have been developed in order to increase the understanding of the supply chain and its management process as a whole. The "Global Supply Chain Forum" (GSCF), which comprises of a team of researchers and a group of firms that are non-competing, have developed a supply chain management framework which consists of three major elements. "This framework emphasizes the interrelated nature of supply chain management and the need to proceed through several steps in order to design and successfully manage a supply

chain," (Lambert & Cooper, 2000, p. 69). Each element in this framework forms an important part of supply chain management. The framework encourages trading partners to integrate their activities rather than to manage their individual function. The elements of the GSCF framework are:

- *The supply chain network structure:* This consists of supply chain member Company and the links they form within the supply chain they participate.
- *The supply chain business processes:* Business processes are the supply chain activities that produce specific value as output to the customer.
- *The supply chain management components:* These are the managerial components by which business activities and processes across the supply chain are integrated and managed.

The "Supply-Chain Operations Reference-model" (SCOR) also describes supply chain as "the integrated process of Plan, Source, Make, Deliver and Return, spanning from suppliers' supplier to customers' customer, aligned with Operational Strategy, Material, Work and Information Flows," as shown in Fig 5.1, (Dave, Taylor, & Melinda, 2009, p. 6). This framework, if well understood will facilitate supply chain management. Many authors including, Hugo (Hugos, 2003), Dave *et al.* (Dave, Taylor, & Melinda, 2009), Juha-Miikka (Juha-Miikka, 2008, p. 723) have described the SCOR model "as a process reference model that links the process elements, metrics, best practice and features associated with supply chain." The SCOR model has been identified as a managerial tool that enhances supply chain decision making process.

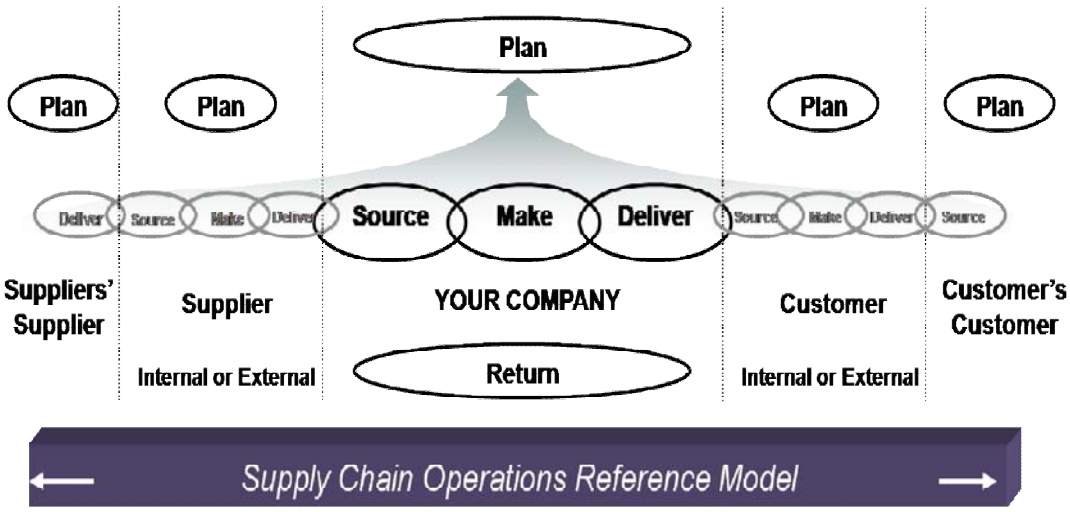

Figure 5.1 The SCOR Process Framework, (Dave, Taylor, & Melinda, 2009).

In order to present an understanding of the SCOR model, the supply chain processes in the SCOR model are described as follow:

- *The Plan Process*: "This refers to all the operations needed to plan and organize the operations in the other supply chain processes," (Hugos, 2003, p. 44). It is the process that, "consists of business functions that balance aggregated demand and supply, and it also covers the demand forecasting function, e.g. to send strategic forecasts to suppliers, and the resource management function, e.g. to receive inventory reports from customers," (Juha-Miikka, 2008, p. 723).
- *The Source Process*: "This refers to the activities necessary to acquire the inputs to create products or services," (Hugos, 2003, p. 44). It is the process that contains the business functions that procure products used to meet the planned demand. It performs the purchasing function which includes sending orders to suppliers, (Juha-Miikka, 2008).
- *The Make Process*: This process includes the operations required to develop a product or service provided by a supply chain, (Hugos, 2003). It includes the organizational processes that convert raw materials to finished product. It is the process that also takes care of process design function, (Juha-Miikka, 2008).
- *The Deliver Process*: "This operation encompasses the activities that are part of receiving customer orders and delivering products to customers," (Hugos, 2003, p. 46). It is the process which consists of the organizational function that provides finished products to the final consumer. It also performs the sales functions which include sending purchase order responses to consumers, (Juha-Miikka, 2008).

- *The Return Process*: "This is the process that deals with managing a reverse flow of materials and information related to defective, surplus, maintenance, repair or operating products," (Juha-Miikka, 2008, p. 724).

5.2.2 Risk Management Frameworks

Risk has been explained as "a negative deviation from the expected value of a certain performance measure, resulting in negative consequences for a company," (Stephan & Christoph, 2006, p. 303). Many authors including; Tuncel and Alpan, (Tuncel & Alpan, 2009) Teresa and Jennifer, (Teresa & Jennifer, 2009) have given explanation about different supply chain risk management frameworks in their work. There are also organizations and indepent bodies such asCommittee of Sponsoring Organizations (COSO), Risk and Insurance Management Society, Inc. (RIMS) respectively, that have also worked and suggested frameworks, models and ideas of risk management. As extracted from the literature, a typical risk management process would combine the activities that span from management setting objectives of risk management to the point of risk monitoring, as shown in Fig 5.2. Communication has also been identified as an important factor in the risk management of any organization.

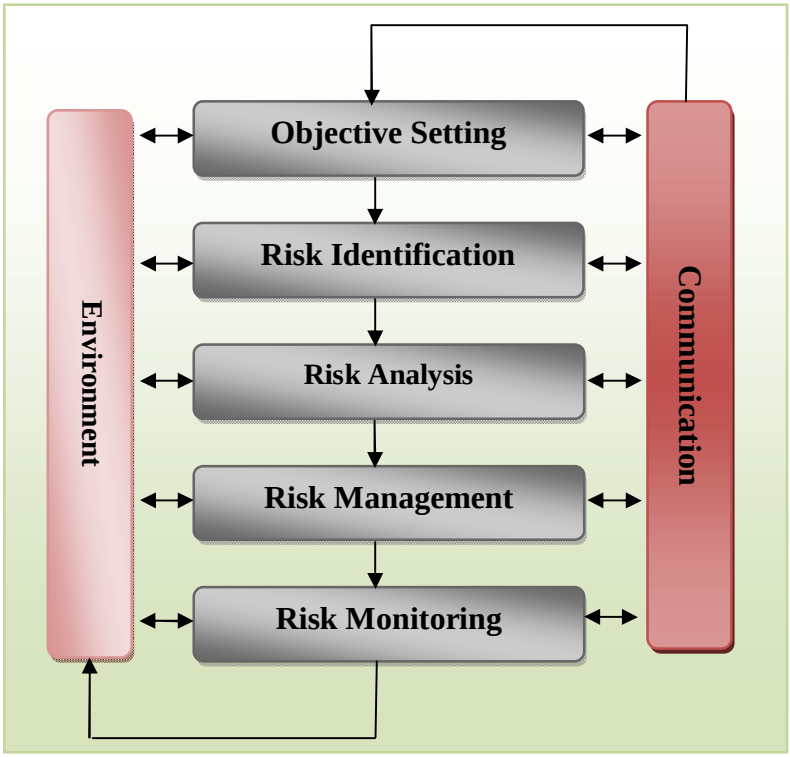

Figure 5.2 Risk Management Framework

The supply chain risk management (SCRM) process typically follows the same process as shown in fig 5.2. Teresa and Jennifer (Teresa & Jennifer, 2009, p. 16) in their work explained that, "the SCRM approach represents an integrated decision making approach. In essence, SCRM represents a more pro-active approach to managing risks and performance in the supply chain. Such a pro-active approach does not necessarily ensure that all such potential risks can be identified in advance or if identified, sufficiently well resolved to prevent some or all of the undesirable consequences." The SCRM activities seem to receive consensus by authors that have worked extensively on risk and risk management within supply chains. These activities are:

- *Risk Identification and Modeling:* This stage of SCRM includes the identification of the sources and characteristics of threats and risks, and their relationship to supply chain performance. "It also helps to develop a common understanding of the future uncertainties surrounding the supply chain, thus recognizing the potential risks in order to manage these scenarios effectively," (Tuncel & Alpan, 2009, p. 2).
- *Risk Assessment, Analysis and Impact Measurement:* "Risks are analyzed, considering likelihood and impact, as a basis for determining how they should be managed; hence, they are assessed on an inherent and a residual basis," (COSO, 2004, p. 4). This stage of SCRM includes assessing and analyzing the likely risk and their impact within the supply chain. Tuncel and Alpan (Tuncel & Alpan, 2009, p. 2) explained that this stage "refers to the assignment of probabilities to risk bearing events in the system, and identifying the consequences of these risk events."
- *Risk Management:* The actions here includes; "generating and considering alternative scenarios and solutions, judging their respective merits, selecting solutions and undertaking the implementation," (Teresa & Jennifer, 2009, p. 16). This stage of SCRM is where the risks that have been identified and analyzed are been managed. Practical actions of this stage could for instance be "backup actions, should any pre-identified risk actually occur (i.e. reactive actions), or a mitigation action to act on any pre-defined risk in order to reduce either the occurrence probability or the degree of severity of its consequences (i.e. proactive actions)," (Tuncel & Alpan, 2009, p. 2). The literature also reveals that organizations can manage risk in any of the following ways:
    - *Avoidance:* This is a risk management strategy in which organizations avoid performing activities that would involve or bear risk. An example would be when a trading partner does not want to share information with another member within the same supply chain so as to prevent being exposed to competitive rivalry. However, it

should be noted that such an action could affect the overall performance of a supply chain activity.

- *Acceptance:* This is a situation where an organization accepts and retains whatever comes out their action. The organization accepts the loss or gain from a risk. An example is when a trading partner cares less about what is happening to other partner with regards to their risk, knowing fully that whatever happens to a member in the chain affects them. It invariably means that the organization is willing and ready to accept whatever form of risk that goes within the supply chain.
- *Reduction/Mitigation:* This strategy involves the reduction in the severity of loss or the reduction of the likelihood of any loss from occurring. An example is when an organization implements a knowledge transfer process. With this, there will be a huge reduction in loss of project knowledge and information, especially in event of any member of the project been absent.
- *Transfer:* This is also referred to as "risk sharing". A good example of this is when organizations share/transfer its risk to a third party like an insurance company. Rather than an organization having to deal with loss when they occur, they will leave it to the insurance company whose responsibility will be to manage the risk. Another way to transfer/share risk is through outsourcing.

➢ *Risk Monitoring and Evaluating:* "Monitoring is accomplished through, ongoing management activities, separate evaluations, or both," (COSO, 2004, p. 4). At this point, the entirety of the SCRM activities are monitored, and necessary modifications are made when essential.

➢ *Knowledge Transfer:* "This stage in the SCRM process seeks to capture, explore, process and disseminate lessons and experiences to others within the organization, and the supply chain at large," (Teresa & Jennifer, 2009, p. 16).

5.2.3 Information Risk Frameworks

In the Factor Analysis of Information Risk (FAIR) framework developed by Jack, (Jack, 2005) it was stated that, in modern supply chain environment, information risk and its management is treated as an art when it should be treated as a science. Jack (Jack, 2005, p. 6) further explained that, "science begins by analyzing the nature of the subject, thus, forming a definition and determining the scope of the problem, while Art, on the other hand, doesn't operate within a clearly defined framework or definition." The FAIR framework comprises of ten steps but in four stages. These are:

- *Stage 1: "Identify scenario components"*
  1. *Identify the asset at risk:* In order to estimate the control and value characteristics within a risk, there is need to first identify the asset (organization) under evaluation.
  2. *Identify the threat community under consideration:* A specific threat community must also be identified. This could be human or malware, and internal or external, e.g. network engineers, etc.
- *Stage 2: "Evaluate Loss Event Frequency" (LEF)*
  3. *Estimate the probable Threat Event Frequency (TEF):* The probable frequency (random, regular or even intentional) of any given timeframe that a threat will act against any given asset need to be estimated.
  4. *Estimate the Threat Capability (T Cap):* This is the probable amount of force that any threat is capable of impacting on any given asset.
  5. *Estimate Control strength (CS):* This is the probable level of control against any given threat or risk that an asset has in place.
  6. *Derive Vulnerability (Vuln):* This is the identification of the weakness (vulnerability) of an asset which any threat might exploit.
  7. *Derive Loss Event Frequency (LEF):* This is the identification of the probable frequency (random or regular) that a loss due to any risk could have on an asset.
- *Stage 3: "Evaluate Probable Loss Magnitude" (PLM)*
  8. Estimate worst-case loss: This is where decision makers have to determine the impact of any threat or risk in order to determine the risk management technique to adopt (avoid, accept, reduce or transfer).
  9. Estimate probable loss: This is almost the same as estimating worse case loss, because decision makers need to estimate the effect of any loss before making any decision with regards to managing the risk.
- *Stage 4: "Derive and articulate Risk"*
  10. Derive and articulate Risk: This is the point where decisions are made about the identified risk on how they can be controlled and managed.

Mohd *et al.* (Mohd, Banwet, & Ravi, 2007, p. 679) in their work defined information risk as "the probability of loss arising because of incorrect, incomplete, or illegal access to information" and information risk management as "the management of information risks in supply chain through coordination or collaboration among the supply chain partners so as to ensure profitability and

continuity." They also classified information risk based on the type of impact they have on the supply chain, and these classifications are:

- *Information security/breakdown risks:* This occurs when there is a breakdown in the information system that aids information sharing within supply chain.
- *Forecast risks:* This kind of risk occurs when there is a mismatch between an organization's actual demand and projections. Information distortion of any kind within a supply chain usually leads to forecast risk.
- *Intellectual property rights risks:* Ganguli (Ganguli 2000) as cited in Mohd *et al.* (Mohd, Banwet, & Ravi, 2007, p. 681) explained that "intellectual property rights risk in a supply chain context is the ownership of knowledge and its legal use in cooperative development activities."
- *IT/IS outsourcing risks:* These are the risks that occur as a result of a company contracting out its IT assets, activities, and people to a third party company.

5.3 Discussion

In the questionnaire, respondent were asked questions pertaining to information within supply chain. The survey aimed at extracting respondents' opinion on the importance of information and the storage of information within supply chains. It also aimed at sourcing respondents' view on the readiness of trading partners to share information completely and accurately without any hold-backs. Fig 5.3 clearly shows that information is generally accepted to be important in the performance of any supply chain. An interview respondent also clearly stated that, "if our supply chain wants to compete in this present global market, we must capitalize on information within our supply chain," (Nuru, 2009). In related supply chain study, researchers have also stated the benefits of information within supply chain. An example is Davies (Davies, 1993) who in his work, showed that information should be seen as a vital component of any supply chain in the present competitive market.

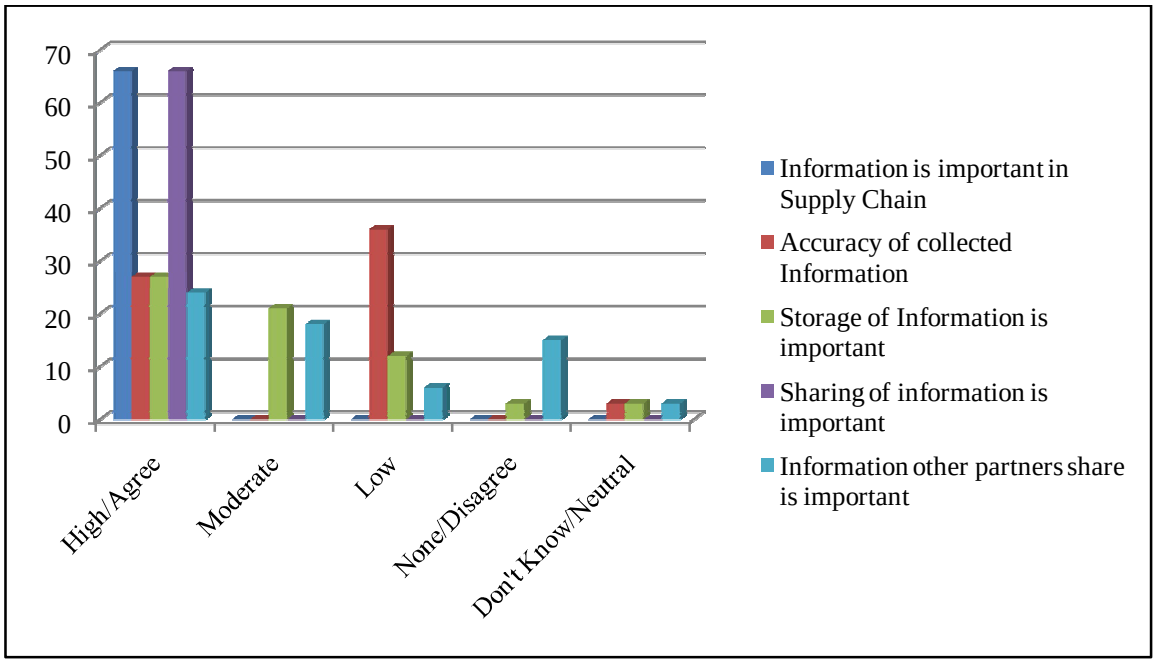

Figure 5.3 Information responses from questionnaire

The survey response indicated that storage of information within supply chain is as important as the information itself. An interview respondent from the IT unit of one of the FMCG companies that was used as case study, stated that, "We have to keep the information we get from our customers and trading partners, because these information help us in performing business analysis and forecast, which in turn facilitates production," (Ajayi, 2009). It was also gathered from some business planning personnel that, "stored data eventually forms the bulk of our historical and current information, and it enables us to plan our production," (Planning, 2009). The importance of storing information has also been shown in the literature. Osmar (Osmar, 1999) for example categorized different types of information and how their storage is essential. It was also evident from the responses of the survey that information sharing is an imperative function/activity of trading partners in any supply chain.

A business planning team leader stated that, "We can't perform our operation vis-à-vis sourcing, production, distribution etc, if we don't get and share information from and with our customers and trading partners respectively," (Planning, 2009). As explained in an interview with a supply chain consultant that, any supply chain will only be able to satisfy its customer demand and still make profit only when the supply chain partners share information about their product. He further added that, however, this information will only be very relevant when it is shared timely and accurately. As shown in the literature by authors like Simatupang and Sridharan, (Simatupang &

Sridharan, 2005) when information is captured and disseminated accurately, decision makers are able to coordinate supply chain operations. It was shown in the literature that coordination with regards to sharing information is very important.

The survey response showed that the completeness and accuracy of information collected within the supply chain is usually low. This has been linked to the unwillingness of trading partners to share information about themselves, as they believe that this information could be used against them for competitive advantage, which may eventually lead to possible rivalry. A marketing person that was interviewed stated that, "We always have problem getting information like, point-of-sale (P.O.S) information from the retailers and this is because they think it will affect the inventory we give them. For example, if we have their P.O.S information, it will be difficult for them to inflate the order they place," (Abimbola, 2009). The literature reveals that some obstacles which include; fear of leakage of information, fear of lesser bargaining power etc, are reasons why organizations feel reluctant to share more than the very minimal information.

The questionnaire also helped in capturing supply chain practitioners view about risk, especially information risk within the supply chain. Fig 5.4 shows that most of the survey respondent believes that there are high threats to information within supply chain. The response also shows that the business impact of the threats to information is very severe, if these threats are not properly managed. An interviewed supply chain executive stated that, "the paradigm shift from the traditional supply chain to modern supply chain comes a lot of complexities and issues like threats, vulnerabilities and risk to deal with," (Nuru, 2009). This supply chain executive's statement is also in accordance with Clemons (Clemons, 2000) view, when he stated in his study that, "in the past, when companies sourced and manufactured locally, there was less threats and these threats could easily be managed, but the advent of supply chain which brought about partnerships, globalization and integrated networks have generated a lot of threats which managers need to identify and manage."

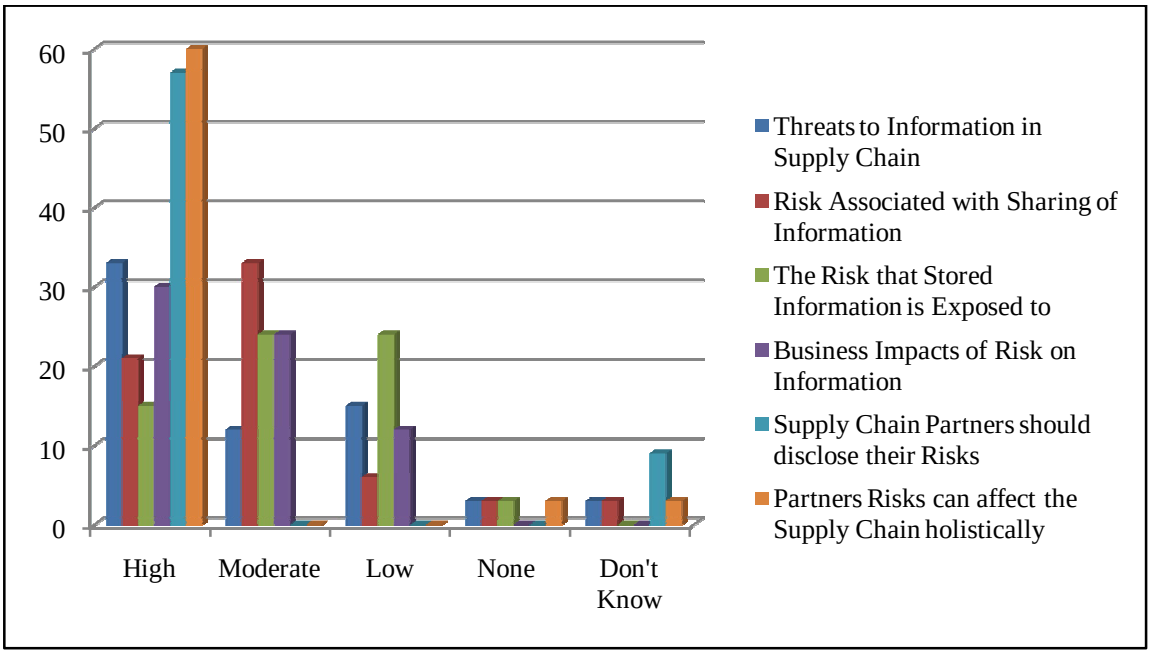

Figure 5.4 Risk responses from questionnaire

Respondents' response to the survey also showed that the risk that is associated with the sharing of information is moderate and controllable. A Chief Information Officer (CIO) who was interviewed stated that, "we use IT infrastructures and systems that facilitates the smooth sharing of information within our organization and also with our trading partners. These systems have been built using standard formats, so any information that is to be shared and that does not comply with this standard will not be shared. This standard helps reduce the risk that information sharing could come with. However, it should be noted that these standards does not reduce the physical or manmade risk like someone intentionally sharing false information," (Ajayi, 2009). Some studies as indicated by Helper (Helper, 1991) in his work shows that, buyer-supplier relationships are becoming more dependent on factors like information sharing and commitment to working together as opposed to the traditional relationships like cost, because this enables trading partners to manage other inherent supply chain components like information risk.

The survey also shows that the risk with stored information is moderate and in other cases low, depending on the storage structure put in place by the companies. This may also be linked with the fact that most organizations today use structured database management systems (DBMS) and also have backup systems for their stored data and information. An interview respondent from an IT unit stated that, "we can't afford to lose any bit of the organization's information, because information is the backbone of our operation, so, to avoid this we have to install an Oracle database management system which helps to facilitate the backup and recovery of stored

information in cases of disaster. Providing this functionality, I can say that, the oracle DBMS have helped us in managing most risk that stored information could be exposed to," (Nuru, 2009). The literature review also shows that by using DBMS and human skills, organizations have been able to support their individual performance within the supply chain, and they have been able to also manage the risk that stored information could be exposed to.

One other finding that manifested through the survey was that, the risk that affects a partner within a supply chain, may affect the entire supply chain operations. Hence, most of the survey respondent believes that trading partners should disclose their risk to other trading partners. In an interview conducted with a production manager, he stated that, "I have witnessed a situation where one of our major suppliers had their computer system attacked by virus; the supplier knew about it but did not inform us. We kept on sending inventory request to them through the EDI system, but unknown to us; it was not received by them. At the point when we needed their product, they could not deliver, and at this point, it was too late and it affected our production terribly that year. If we had been informed, we would have used an alternative means to get the inventory information to them, or better still make an alternative arrangement," (Nuru, 2009). A similar situation have been emphasized in the literature, when authors showed that, withholding of information and risk that affects any member of a supply chain may lead to dysfunctional behavior of other members in the supply chain.

5.4 Findings

Information risk within the supply chain has been identified as being a major factor in the performance of a company. A critical content analysis of the interviews conducted in the two FMCG companies used as case-study in this research yielded responses that showed and identified types of supply chain information risk (the first major step in the risk management process). The responses also showed and identified practical means of how the identified supply chain information risk could be managed (the last major step in the risk management process). This section explains information risk types and their means of management that were identified from the conducted interviews.

5.4.1 Information Risk Types within Supply Chains

According to the information risk framework and the risk management framework that was outlined in the early section of this chapter, the first major step in the risk management process is

the identification of the type of risk that could affect or impact on information. From the interview, the information risk types that were identified are:

- Malwares
- System Hackers
- Organizational scam
- Information Inconsistency
- System Breakdown
- Environmental Disaster

5.4.1.1 Malwares:

This is actually a short form for malicious software. Malware are software that is designed to secretly gain access to computer systems without the consent of the system owner, and in most cases are harmful to the computer system they gain access to. They destroy the files (also known as data or preferably information) on a hard-disk or corrupt the file system of the hard-disk by writing and adding invalid data to them. Examples of malware are Spyware, Trojans, Computer Viruses, Worms, Crimeware, Rootkits etc. Malware's most common means of access to systems is through the internet, primarily by the web and e-mail messages. However of all these forms of malware, virus, worms and spyware are the most known. In the interviews conducted, the first major types of information risk that were identified are viruses, worms and spyware. In an interview with an IT manager, it was stated that, "viruses, worms and spyware are common information risk that cannot be overlooked because the damages they cause are so severe. They could make any organization lose lots of information within minutes if not properly managed," (Nuru, 2009).

In agreement to this, Mohd *et al.* (Mohd, Banwet, & Ravi, 2007, p. 680) stated that, "Viruses, Worms and Trojans are common menace to information systems." They further went on to explain that, in supply chain, these various types of malware pose a threat of illegal transfer of the trading partners proprietary information, and this is a serious risk that will affect the overall operation of the supply chain. As extracted from the literature, viruses, worms and spywares have different mode of operation. These modes of operation are:

- *Computer Virus*: These are programs that affect executable files of a system of executable software. When these executables are run, these viruses spread to other executables and after a while affects a reasonable percentage of the system's executable.

This action alters the normal operation of the system and eventually leads to lose of information. Most supply chain IT personnel that were interviewed also agreed to this mode of virus attack.

- *Worms*: This type of malware performs its operation over the network. This is a program that has been developed to infect other computers by actively transmitting itself automatically (without user intervention to spread) over the network that the computers share.
- *Spyware*: These are programs that gather information about computer users. They are usually produced commercially. Spyware show pop-up ads or alter web-browser behavior in order to perform its operation. For example, a spyware program could redirect a search engine to an address where the spyware creator would have access to the user's information. Kucera *et al.* (Kucera *et al* 2005) cited in Mohd *et al.* (Mohd, Banwet, & Ravi, 2007) explained that spyware "is a program that resides on computers linked to the Internet and surreptitiously collects various types of personal information."

5.4.1.2 System Hacking:

System hacking is done by "hackers". These are people who are committed to getting around computer security in order to access the information on the computer system. These people carry out unauthorized remote computer system break-ins via communication networks like the Internet and the web. Although in some cases, hackers could perform legitimate operations such as fixing security problems and debugging computer codes. In the course of this study, a supply chain consultant that was interviewed narrated an incident where the information repository of a company within a supply chain was bridged by a system hacker. This hacker altered the information (which contains customers and suppliers order) in this repository, hence the company could not meet up with their supply orders, and this affected the overall operation of the supply chain as their trading partners were adversely affected by this. According to Ford and Ray (Ford & Ray, 2004) cited in Mohd *et al.*, (Mohd, Banwet, & Ravi, 2007) "technology has made web an integral and necessary part of a business operation, hackers are using this technique to find confidential information which they use as backdoor entry into a company's innermost secrets."

Hacking has been identified as a supply chain information risk. In an interview with the IT unit of one of the FMCG companies used, it was stated that, "one of the major information risk that we have to continuously deal with is system hacking, because when it happens (hacking) the financial information of our trading partners will be compromised and information such as credit

card numbers, banking details etc will be exposed," (Nuru, 2009). Another recent and most common way that hackers operate is through website defacement. "Web defacement occurs when an intruder maliciously alters a Web page by inserting or substituting provocative and frequently offending data. The defacement of an organization's Web site exposes visitors to misleading information until the unauthorized change is discovered and corrected," (Hollander, 2000, p. 2). Website defacement has also been identified as not only posing a threat to an organization's information system, but as also damaging to the reputation and credibility of an organization as a whole.

5.4.1.3 Organizational Scam:

There was a consensus in the interviews that organizational scam is also one of the most severe information risk within supply chain, because it is deliberately carried out by employee in an organization. Similarly, it was also agreed that, this is one of the most difficult information risk to manage, because it comes/happens from within an organization or a trading partner within the supply chain. An interviewee stated that, "this is an act that is perpetuated by our own staff, so an issue of trust plays an important role here. It is difficult for us to think any of our employees will want to divulge any of the organization's information to a rivalry company, but this happens. So, it is a kind of risk that we really need to be cautious of while we continuously think of ways to manage it," (Nuru, 2009). Interviewees agreed that the two most common forms of organizational scams are; service attack and employee scam.

- *Service Attack:* The responses from the interviews showed that the most common type of service attack happens through the network. An example is when an employee accesses the information repository or servers of the organization through the network and deliberately alters its normal operation, for selfish purposes. Some other example include, illegal bandwidth consumption, resource exploitation etc. These attacks interfere with the authentic access to the network, and this may result in the interruption of information flow within the supply chain.
- *Employee Scam:* As indentified by Mohd *et al.*, (Mohd, Banwet, & Ravi, 2007, p. 680) "some of the common reasons for this are employee attrition, intentional/unintentional disclosure of proprietary information or in some cases personal vendetta against the company." In this case employee would deliberately share information with their rival company, for personal benefits. This in-turn affects the performance of the affected company.

5.4.1.4 Information Inconsistency:

From the interviews, information inconsistency was sometimes also referred to as information distortion. Information distortion or information inconsistency as the case may be, is different from employee scam explained above. In employee scam, employees deliberately share their company's information, and this information in most cases is usually shared with their rival company. While in the case of information distortion or inconsistency, employees do not share information with their rival company, but makes mistakes that affects the effectiveness of their company within its supply chain network. Information inconsistency usually happens as a result of human error such as capturing of wrong information into the information system of a company, oversight in capturing of information or negligence on the part of the employee.

This inconsistency in information always causes serious misunderstanding within the supply chain. In some of the interviews, it was pointed out that when an employee from a call center makes a mistake and enters wrong information into the ERP system, this mistake affect the production planning unit, as that information is what they depend on to determine the production of the company. However, this does not stop at the production planning unit, it goes on to affect the procurement and production units, as they also rely on this information to determine the quantity of goods or services to procure and produce respectively. This simple and single mistake could impact on the company's financial budget or their customer satisfaction (when they do not meet their customer demands). This type of information risk also happens when information within supply chain is being processed manually, as any human error will affect the outcome of the processed information.

5.4.1.5 System Breakdown:

Most organizations today employ I.T systems such as the "Enterprise Resource Planning" (ERP) System in the enhancement of their function, as this reduces the risk of human error in capturing, processing and reporting of information. Interviewees agreed that one of the most important components that enhance information flow within supply chain is the I.T system in place. It was also realized from the interviews that the strength of a supply chain in today's global market depends so much I.T system an organization uses to achieve efficient information flow. However, the breakdown of these systems is always severe because they hold the information that the company needs to perform their operation. The breakdown of these systems reduces the reliability of information and also impact on the information flow within supply chain. An example is when the database system (information repository) of a company that serves as a major supplier within

a supply chain crashes, this affects the information stored by the company. If this crashed database system is not attended to in a very short while, the supply chain operation could be negatively affected.

5.4.1.6 Environmental Disaster:

According to Stephan and Christoph, (Stephan & Christoph, 2006, p. 305) this is a type of risk that, "subsumes supply chain disruptions, that when they materialize, have a severe impact in terms of magnitude in the area of their occurrence." These types of risk include natural disasters; socio-political instability, economic disruptions and civil unrest. The effects of environmental hazards have been emphasized by both interviewees and the literature. In the literature, authors have stressed the significance of not only data backup but also the importance of mirror sites as a means of making sure that the flow of information is uninterrupted in a supply chain. In an interview, a procurement officer explained how their main supplier's office was caught by fire and the impact that had on their supply chain network. Halchin (Halchin, 2004) cited in Mohd *et al*. (Mohd, Banwet, & Ravi, 2007) also explained that "the omnipresent internet technology could be leveraged by the terrorists to sieve contents of web sites and find potential targets, identify or exploit weaknesses, obtain and integrate disparate information."

The global supply chain remains subjected to environmental disaster like economic, social and political risk because multiple companies and countries are involved in the production of commodities and services. Environmental disaster when they occur affects the three major components (information, material and money) of any supply chain. In the case of information, most types of environmental disasters damages whatever information infrastructure an organization has in place. One of the examples that were spotted during the interviews was, if an organization that serves as an information hub (e.g. information service provider {ISP} or telecommunication company) in the supply chain, gets caught by fire, the flow of information within the supply chain will come to a standstill and this in-turn disrupts the supply chain functionality.

5.4.2 Management of Information Risk within Supply Chains

From the interviews conducted, ways in which the information risk types could be managed was also identified. There was a general consensus in the interviews that while a means of managing information risk could apply directly to an information risk type, another means of managing

information risk could also apply to more than one information risk type. The information risk management means that have been identified are:

- Usage of System Security Software
- Information Management
- Optimized usage of I.T Infrastructure
- Integration of Supply Chain Systems
- Regular Audit of the Supply Chain
- Information Redundancy

5.4.2.1 Usage of System Security Software

The use of security software will help reduce or prevent information and its property from theft, corruption or any other form of information loss and risk. The objectives of this software will be not only to manage information risk, but also to allow the information and its property to remain accessible, operational and productive to its intended end users. In the interviews, one of the first major agreed means of managing the risk that information is liable to is through the use of security software and techniques such as; anti-virus software (Made up of computer programs that helps in identifying and eliminating computer viruses and forms of malware), firewalls (helps to protect the system from unauthorized online intrusion), Cryptography (used to protect information in transit between systems, thus reducing the probability of information interception or modification), Authentication (used to ensure that end-point communicators are who they state they are).

One of the I.T personnel that were interviewed stated that, "one of the daily information threats that we have to continuously deal with within our supply chain network is a virus attack. This is because we receive information from other trading partners, and no matter how hard we try, some viruses still find their way into our own network through the information we receive. Also, some of our internal employees plug their infected storage devices (e.g. memory stick, external hard-drive etc) into the organization's network; this affects the network and in some cases have a ripple effect that affects the supply chain operation," (Ajayi, 2009). In managing information risk, security software such as an anti-virus will help in identifying potential virus attack on the systems and the network. Also, in the case where the virus has already attacked the system, this software could also be used in removing the virus, and as such, preventing whatever disruption or harm that could have been caused by the virus.

5.4.2.2 Information Management

It was clearly pointed out by the supply chain practitioners interviewed that in order to manage information risk, information that is acquired and shared within supply chain must be properly managed. The primary step towards information management as pointed out by some IT personnel is that "individuals with the appropriate skills and qualifications must be hired to create, manage, and support an information structure and system that will produce the right information that is supportive of the information supply chain." Another interviewee explained that, "the use of information technology (IT) facilitates information management, and in-turn help reduces information risk." "Information management refers to the use of management principles in acquiring, organizing, controlling, disseminating, and using information in order to achieve value, quality, and optimal use of information in pursuing organizational performance," (Angeles, 2009, p. 228). Apart from hiring individuals with the appropriate skills and also using information technology, some other information management strategies that were highlighted in the interviews were:

- *Virtual Supply Chain:* A Virtual supply chain is based on information rather than inventories. Here, information serves as the hub that other supply chain activities depend on. This allows for information management because in this type of environment, the trading partners in the supply chain treats information with caution. Therefore information risk is usually minimized.
- *Process Integration:* The creation of process integration between trading partners has been identified as a means of managing information. This is a situation where there is an efficient, effective and standard collaboration between buyers and suppliers i.e. suppliers, manufacturers and consumers. This also extends to a joint product development between supply chain partners. This helps facilitate information management because there will be a common understanding of the shared information in this circumstance.
- *Supply Networks:* Association of suppliers forming a partner network in which they function together as an entity as against a standalone company. This reduces information risk because companies can rely on each other and also function as backup for each other in case there is any form of disappointment from any member in the network.

If information in supply chain is not well managed, disruptions may arise, thus endangering the overall activities of a supply chain. According to Hugo, (Hugos, 2003, p. 16) "When information is well managed, accurate, timely, and complete, the companies in a supply chain will each be

able to make good decisions for their own operation, and also maximize the profitability of the supply chain as a whole." Gunasekaran *et al.* (Gunasekaran, Lai, & Cheng, 2008, p. 555) explained that "information management is the ability of an enterprise to manage distributed data, information, and knowledge as the decisive enablers of core enterprise business processes." In one of the interviews conducted, it was established that standardized sharing of information (i.e. where there is an agreed format of sharing information between trading partners e.g. the use of the Electronic Data Interchange {EDI}) improves information management within the supply chain, and this consequently reduces information risk and improves the management of the overall supply chain in areas which include:

- Standardization of Supply Chain processes
- Improvement in the level of system integration
- Improvement in the quality of material and information flow

5.4.2.3 Optimized usage of I.T Systems

The development of Information Technology (I.T) systems has produced several opportunities for companies. For instance, Chizzo (Chizzo, 1998) explained how the breakthroughs in IT systems have contributed to the movement towards business process integration. Bender (Bender, 2000) also showed that information risks could be reduced by a reliable IT system. An information technologist that was interviewed stated that, "the ability of companies to share information in real-time and still reduce information risk, lies in the optimized usage of I.T systems such as the Enterprise Resource Planning(ERP) systems," (Nuru, 2009). The interviews also reveals that most I.T systems used within supply chains are usually used as modules rather than as a complete package, and this definitely impacts on the standard operation of the system, and this could also be a risk to the information supply chain.

Lee and Wolfe (Lee & Wolfe, 2003) illustrated examples of certain IT systems and technologies, and how if well optimized can be used to reduce information vulnerabilities and risk within supply chains. Some of these technologies include the "Database Management Systems" (DBMS), "Electronic Data Interchange" (EDI), "Enterprise Resource Planning" (ERP) etc. These systems facilitate the management of information within supply chain and this invariably enables them to manage information risk within supply chain. For instance, a DBMS which performs the storage and retrieval of information will reduce the risk of information loss within supply chain. The findings from the literature as well as from the interviews also showed that the optimized

usage of DBMS has helped to reduce information risk within supply chain through the storage of information.

5.4.2.4 Integration of Supply Chain Systems

There was unanimity in the interviews that integrating supply chain activities and systems would facilitate the management of information risk within supply chains. Supply chain systems as pointed out in the interviews include transportation systems, logistic systems, information systems etc. "An integrated system should be an intelligent sensing and decision-making system that is capable of automatically performing many tasks traditionally executed by human beings," (Gunasekaran, Lai, & Cheng, 2008, p. 555) therefore reducing any information risk that could be caused by human. One of the major characteristics of an integrated system is that it combines different records that relate to the same subject into one related record. Also, with an integrated system, information belonging to more than one application can also be updated simultaneously. For example, a sales transaction may update both account receivable and inventory records.

Where information systems are integrated, the consecutive processing steps and activities within the supply chain will be executed by separate subsystems in a logical order, and the processed information will be progressively transferred from one program to the next; this facilitates the management of information, thereby reducing the information risk within supply chain. An example of an integrated system is the Electronic Data Interchange (EDI) system that is usually needed for inventory, procurement, etc., as pointed out by a procurement manager. In this system, information will be entered once, and the system will provide consistency across the entire procurement operation, thereby exposing any potential loss, distortion or risk to information as it moves within the system. From the interviews it was deduced that integrating supply chain systems also supports the following functions:

- Easier access to accurate, reliable and timely information
- Elimination of redundant data and the rationalization of processes, which result in substantial cost savings
- Enabling decision-makers to have an enterprise-wide view of the information they need in a timely, reliable and consistent fashion
- Providing the backbone for an enterprise-wide information system
- Enhancing workflow, increasing efficiency, and reducing reliance on paper
- Streamlines processes and eases adoption of best business practices
- Establishing a foundation for new systems while integrating existing systems

5.4.2.5 Regular Audit of Supply Chain

Regular audit also means the systematic checking or assessment of the supply chain. It provides for an efficiency check on the three major components (material, information and cash) of a supply chain. Here, a regular audit of the supply chain means, the auditing of the overall activities (procurement, logistics, management, information collection, information sharing etc) and components (material, information and cash) of a supply chain and not the auditing of trading partner or supply chain's financial account. A logistics consultant stated that "Regular audit is needed to determine the effectiveness and efficiency of the activities in supply chain. When it is done, it helps to identify the losses and the potential losses in the supply chain," (Nuru, 2009). A procurement manager also pointed out that "regular audit enhances supply chain integration, as companies can trust the supply chain enough to become a trading partner," (Nuru, 2009).

With regards to the information supply chain, regular audits reduce the intentional and unintentional distortion of information by a company's employee, hence reducing the overall information risk. A supply chain consultant explained that, when employees in a company are aware that there is an auditing system in place and that this system checks for all forms of information distortion, and also checks for the sources of these distortions, they become really conscious of what type of mistake they make. Especially when the sources of the information distortion or risk identified is traced to the employee who is responsible, and the employee is made to face the consequences (particularly when it is an avoidable distortion) of his or her actions. There was a consensus from the interview that, in order to audit information within supply chain, the information sharing technique and the supply chain information systems need to be audited. Auditing of the information systems also help in identifying information systems that are obsolete, malfunctioning, misused or not functioning.

5.4.2.6 Information Redundancy

Information redundancy could also mean information backup. It is a situation where information is stored twice or a situation where any particular information can be retrieved from another source. Information redundancy simply refers to making of copies of information such that in the case of any information loss, these additional copy(s) can be used to restore the original. An interview respondent explained that there are some types of information risk sources that nothing can be done to prevent, such as a natural disaster. He further stated that the only way information risk may be managed or information loss recovered is when a backup of the information is available to the operation. Mitigating the impact of supply chain information risk, disruption, or

loss through the use of backup has proven to be one of the most efficient means to manage information loss or risk, this is so because in some cases, employees could accidentally delete operational information, or files could get corrupt by virus. In situation such as this, information can easily be restored by using the backup information.

The series of natural disasters such as the tsunami, hurricanes (e.g. Katrina and Rita) that "have happened in the past have brought forth the importance of not only data backup but have made organizations to seriously think of mirror sites to keep the flow of information uninterrupted in a supply chain," (Mohd, Banwet, & Ravi, 2007, p. 680). The interviews revealed that most organizations are today making use of data recovery centers (sometimes referred to as a "mirror sites" center) as a means of backing up their information. A data recovery center is usually an organization that serves as a backup center to other organization. This organization accepts other organizations information and keeps it as backup. However, for a data recovery center to perform its operation efficiently, some features (such as storage space, efficient network bandwidth, security of information, etc.) must be ensured.

5.5 SCIRM Framework

The SCIRM framework is a framework that has been developed to help identify the vulnerability of the different point/means (Nodes) of information exchange within the supply chain. The framework also identifies the different types/sources of risk that each of these nodes can be exposed to. Finally, the framework proposes how to identify the severity of information risk within supply chains. By adopting the supply chain information risk management means stated earlier (section 5.4.2) these severities can be reasonably managed.

The SCIRM framework is a proposed framework that takes into consideration the fact that in some situations information risk cannot be regarded as being generic, hence, information risk could be relative to the company's supply chain scenario (i.e. the information risk of supply chain A might not be the information risk of supply chain B). An example of a filled-in matrix is presented below.

Nodes	risk severity (0 – no risk, 1 – mild, 2- moderate, 3- high)						
	Malwares	System Hackers	Organizational Scam	Information Inconsistency	System Breakdown	Environmental Disaster	Total
H-H	0	0	2	3	0	1	R_{HH} =6
H-S	1	2	2	3	1	1	R_{HS} = 10
S-S	2	1	0	0	2	1	R_{SS} =6
S-H	0	0	0	1	1	1	R_{SH} = 3

Table 5.3 Filled-in Matrix

The above table represents the vulnerability points (Nodes) and the risk severity arising from various sources as it applies to information within the supply chain. The meanings of the notations used in the table are presented below:

H: Represents Human. This means using an employee as a means of capturing, processing, reporting and sharing information within the supply chain.

S: Represents System. This means using systems (e.g. ERP, EDI) as a means of capturing, processing, reporting and sharing information within the supply chain.

Hence:

H-H: refers to a situation where information is shared by human to human. This could also be referred to as "Manual" information sharing.

H-S: refers to a situation where information is shared by human to system. This could also be referred to as "Semi-Automated" information sharing.

S-S: refers to a situation where information is shared from system to system. This could also be referred to as "Automated" information sharing.

S-H: refers to a situation where information is shared from system to human. This is also another type of "Semi-Automated" information sharing. Note that the risk table is not symmetric in that R_{SH} is not the same as R_{HS}. As an illustration, consider that a human may pass a computer virus to

a computer (via a memory stick, through bad browsing habits) but a computer cannot pass a computer virus to a human.

The 3's in the above table indicates that there is a high risk, while the 0's indicates that there is no risk. So in the example presented, it may be seen that the greatest risk to the supply chain is that arising from Human-System interface which scored 10 (higher numbers represent higher risk).

The SCIRM framework proposes that, the total Risk (R) to information within a supply chain is the sum of the individual risks (R_i), where

$$R_i = \alpha_{ik} r_{ki}.$$

This equation may be written in full as:

$$R_1 = \alpha_{1k} r_{k1} = \alpha_{11} r_{11} + \alpha_{12} r_{21} + \alpha_{13} r_{31} + \alpha_{14} r_{41}$$

$$R_2 = \alpha_{2k} r_{k2} = \alpha_{21} r_{12} + \alpha_{22} r_{22} + \alpha_{23} r_{32} + \alpha_{24} r_{42}$$

$$R_3 = \alpha_{3k} r_{k3} = \alpha_{31} r_{13} + \alpha_{32} r_{23} + \alpha_{33} r_{33} + \alpha_{34} r_{43}$$

$$R_4 = \alpha_{4k} r_{k4} = \alpha_{41} r_{14} + \alpha_{42} r_{24} + \alpha_{43} r_{34} + \alpha_{44} r_{44}$$

Thus

$$R = R_1 + R_2 + R_3 + R_4$$

Note that the r_{kj} are values that range from 0 to 3 and the α_{1k} are weights that will scale the relative importance of the particular risk vector for the supply chain in question. For example for a supply chain that that has to span the Indian Ocean during the Monsoon, the coefficient of environmental disaster vector will be elevated. It is proposed that these coefficients range from 1 – standard contribution, 2 – heightened contribution, 3 – significant (severe) contribution.

As with other risk models, the SCIRM framework proposes that a risk tolerance point be agreed upon and accepted by the organization for each of its supply chains. When the supply chain information risk is below the tolerance point, "Risk Acceptance" as a risk management strategy (as explained in section 5.2.2) can still be applied, but when the supply chain information risk exceeds the tolerance point, then "Risk Avoidance or Mitigation" as a risk management strategy (as explained in section 5.2.2) should be considered.

5.6 Conclusion

In this chapter, findings from the analysis of the responses obtained from the questionnaire and interviews conducted were discussed. Findings from the interviews have shown that information risk has an adverse impact on the overall operation of a supply chain, as information is one of the major components that flow in any supply chain. Supply chain personnel were able to identify various types and sources of supply chain information loss, distortion and risk. Clearly, the understanding of supply chain information vulnerabilities assists managers in assessing the vulnerability of their supply chains, and in comparing the efficiency and effectiveness of the different information risk management strategies, (Stephan & Nikrouz, 2009). There was a consensus from the interviews that, the only way to counteract information risk within a supply chain was to implement a standard information risk management strategy. Supply chain information risk management like any other management approach is dependent on an efficient and effective quality management strategy. This strategy should include a combination of actions, processes and individuals with the appropriate knowledge, experience and skills. This chapter also presents the SCIRM framework that was developed to help identify the vulnerability of the different nodes of information exchange within a supply chain. The framework also identifies the different types of risk that each of these nodes can be exposed to. Finally, the framework proposes how to identify the severity of information risk within supply chains. The next chapter presents the conclusion of the thesis.

Chapter 6

CONCLUSIONS

6.1 Introduction

In the previous chapter, the research findings were presented. From these findings, it may be concluded that the function of information in the success of any supply chain cannot be over-emphasized. Therefore, for information to perform its function within supply chains, information when gathered must be shared between partners. Information needs to be well managed so that "the companies in a supply chain will each be able to make good decisions for their own operation, and also maximize the profitability of the supply chain as a whole," (Hugos, 2003, p. 16). The literature and the findings from this research show that the impact of information loss or disruption within supply chain is severe, and it also affects the other two major components (material and cash) of a supply chain. Hence, to ensure and achieve a fully functional, productive and optimized supply chain, the management of information loss, disruption or risk is of paramount importance. The research findings identified the following information risk types:

- Malwares
- System Hackers
- Organizational scam
- Information Inconsistency
- System Breakdown
- Environmental Disaster

The findings also identified the following means of managing information risk within the supply chain:

- Usage of System Security Software
- Information Management
- Optimized usage of I.T Infrastructure
- Integration of Supply Chain Systems
- Regular Audit of the Supply Chain
- Information Redundancy

The research also helped in the development of the SCIRM framework that helps in the identifying of information vulnerability points within the supply chain. The framework also helps in identifying the risk that these points may be exposed to, and the severity of this risk. The SCIRM framework proposes that a risk tolerance point be agreed upon and accepted by an organization for each of its supply chains. When the supply chain information risk is below the tolerance point, "Risk Acceptance" as a risk management strategy should be applied, but when the supply chain information risk exceeds the tolerance point, then "Risk Avoidance or Mitigation" as a risk management strategy should be considered. However, if the risk can be easily identified by the framework, then one or more means of managing information risk (as identified by the research findings) can be applied.

6.2 Dissertation Conclusions

From the first chapter of this dissertation, it may be concluded that consumer demand for diversity, the company's drive to reduce cost and still meet consumer demand has lead to the formation of supply chain, and this supply chain has become a key area that every company should examine. In this chapter, it was also revealed that the supply chain has evolved from various concepts such as "procurement management" and "logistics". The chapter also gave a brief understanding of how supply chain companies have evolved from being a functional or departmental unit to being an integrated company, and how they have also finally evolved into today's value network company. It can be further concluded from this chapter that supply chain practitioners and researchers have shown much concern and interest in understanding the geometric development of the supply chain phenomenon.

The second chapter of this dissertation examines literature on supply chains, information within supply chains, and risk and risk management within supply chains. From the review of the literature, it may be concluded that information within supply chains is usually compiled in response to a specific need and often with the purpose of revealing trends or patterns, (Bothma, 2006) and this makes information generation and management in any supply chain imperative. The literature further showed that, information and information sharing should not be concentrated on the internal environment, but rather should be made to set a foundation for companies across the supply chain. It may also be concluded from the literature that the interest of dealing with supply chain (by trading partners) as an integrated entity has steadily increased.

The second chapter also reveals that information sharing within supply chains has a great effect on the overall cost of running a successful supply chain, and it also improves the holistic

management of supply chain activities. Today's supply chain has been globalized, and hence become more complex. This can be deduced from the fact that the usage of global sourcing strategies has stretched the supply chain geographically. Supply chain complexity could also be linked to the fact that the number of the supply partners are increasing and spreading across the globe; thus, causing the supply chain to become longer. The chapter also reveals that the globalization of supply chain ultimately means more threats to information, cash and material, (Stephan & Christoph, 2006) thereby exposing the supply chain to various risks.

The third chapter of this dissertation reviews various literature on the information systems (IS) that support supply chain operations, and how these systems, especially information technology (IT) helps to enhance the collection, management and sharing of information between the supply chain trading partners. The interviews conducted for this study show that "customer demands for products and services are becoming increasingly volatile and uncertain in terms of volume, mix, timing, and place," but this chapter shows that "IT is changing the level of customer intimacy within the supply chain and hence increasing customer expectations," (Suhong & Binshan, 2006). It can also be inferred from this chapter that when companies within the supply chain exploit modern technologies such as the ERP, EDI, VMI, etc, they will have full control of their operations and also be able to make decisions that improve their performance within the supply chain network. These technologies also create transparency across the overall supply chain network.

In the fourth chapter, the method used for gathering the necessary information relevant to the understanding of this study was presented. The chapter started by presenting the criterion that was considered in the selection of the companies that was used for this research. The chapter also explains why a case study methodology was chosen as the best form of exploring the role of information, information risk and information risk management within supply chains. The reason for the sample type and the analysis method, which are purposive sampling and content analysis respectively, was also explained. From the methodology used in this research, it may be concluded that one of the best ways to understand information and information flow, information risk and ways to manage information risk within supply chain is by exploring and understudying the perspectives of supply chain personnel.

From the fifth chapter, it was evident that companies are striving to enhance their overall performance by using different supply chain initiatives such as the identification and monitoring of various supply chain risk (including supply chain information risk), the adoption and

implementation of various risk management strategies, etc. These initiatives enhance information acquisition, sharing and management and reduce information loss, distortion or disruption within supply chains. These initiatives also increase revenue and reduce cost. However, it was also pointed out in this chapter that, these initiatives can only be achieved in a stable environment. The chapter listed and explained the various supply chain information risk types and sources that were identifies from the interviews. The chapter also listed and explained the various information risk management strategies that were identified from the interviews.

From the fifth chapter it may be deduced that potential disruptions and risks can occur within the supply chain (e.g. employees scam, system breakdown etc) or outside the supply chain (e.g. environmental disaster, hackers etc). Hence, a deeper knowledge of how the inherent undesirable supply chain information characteristics such as distortion, disruption, risk, etc, can increase or decrease supply chain information performance was discovered and presented. Also, there was an understanding of how the exposure to supply chain risk will help improve the performance and optimization of the holistic supply chain. This knowledge and exposure would help supply chain managers in making decisions on their supply chain planning and design. It was also discovered from the interviews that managing supply chain information risk will help in areas which include:

- Supply Chain Decision Making
- Supply Chain Problem Solving
- Enlightenment of the Supply Chain Information System

6.3 Future Research Works

The literature and the findings from this research work show that some areas within supply chain needs to be explored. These areas include:

- Future research on how the information technology (I.T) infrastructures and business processes may be used to further enhance the acquisition, sharing and management of information within supply chain, is envisaged.
- Future research on how the understanding of supply chain network as a complex adaptive system enables supply chain optimization and collaboration.
- The investigation of risk impact on different organizational network structures and hence, developing tools for identifying network related risks.

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APPENDIX

Ethical Clearance Letter

UNIVERSITY OF
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02 February 2010

Mr. N Ajayi
Faculty of Management Studies
School of Information Systems & Technology
Westville Campus

Dear Mr. Ajayi

PROTOCOL: "Information Risk Management within Supply Chain"
ETHICAL APPROVAL NUMBER: HSS/0050/10M

In response to your application dated 27 January 2010, Student Number: **209510551** the Humanities & Social Sciences Ethics Committee has considered the abovementioned application and the protocol has been given **FULL APPROVAL.**

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

Professor Steve Collings (Chair)
HUMANITIES & SOCIAL SCIENCES ETHICS COMMITTEE

cc: Supervisor (Prof. M Maharaj)
cc: Mrs. C Haddon

Interview Schedule

Topic: Information Risk Management within Supply Chains

M Com Research Project

School of Information Systems & Technology

Faculty of Management Studies

University of KwaZulu-Natal

Researcher: Nurudeen Ajayi (0793147203)

Supervisor: Prof. Manoj Maharaj (031-2608003)

Introduction

My name is Nurudeen Ajayi. I am a Masters student at the School of Information Systems & Technology, University of KwaZulu-Natal. I would like to ask you some questions about your background, your job, and your experience. Particularly the experience you have gained in the course of working within your company's supply chain. This is to enable me gain an insight into what information flows within the supply chain, and how information flows within the supply chain. It is also to enable me understand the relationship between information and material flow within supply chain, and to also understand information vulnerability and the business risks associated with these vulnerabilities.

I hope to use the gathered information to provide a framework for information risk management within supply chains, which risk and information officers within supply chains can adapt to their respective companies, thereby increasing value for their company and stakeholders. In this interview, the following keywords are used: Information, Risk and Supply Chain. As used in the research, each can be briefly described as:

Information: Data that has been processed, manipulated and organized in a way suitable for human interpretation, and that adds to the knowledge of the person receiving it.

Risk: The state of uncertainty, threat or probability that an action or event will adversely or beneficially affect the ability to achieve desired objectives.

Supply Chain: An integrated process wherein various business entities (suppliers, manufacturers, distributors, and retailers) work together in an effort to: Acquire raw materials, Convert these raw materials into specified final products, and Deliver these final products to consumers.

Note: As used in this interview, Supply chain partners also mean other Business entities.

The interview should take about 30 minutes.

Job & Experience

Job & Job role

a) How long have you worked in this company?
b) What position do you hold in this company?
c) How long have you worked in this position?
d) What are your main responsibilities?
e) Have you worked in any company before joining this company? If yes, was your job role/responsibility the same it is now?
f) Would you consider yourself a decision maker in this company? If yes, please explain your involvement in decision making process of this company.
g) Would you consider yourself a policy maker in this company? If yes, please explain your involvement in the policy making process of this company.

Experience in Supply chain & Risk management

a) Prior to joining this company, did you work within the:
    i. Supply chain network of an organization?
    ii. Risk management unit of an organization?
b) Does your present job position/responsibility involve the:
    i. Supply chain of this company?
    ii. Risk management of this company?
c) Have you had any training in:
    i. Supply chain?
    ii. Risk management?

Supply Chain

Information within supply chain.

a) What is the importance of information in the performance of your company's supply chain (e.g. Supply chain optimization, Return on Investment etc)?

b) What kind of information does your company collect within the supply chain (e.g. information that aids/determines production, distribution, forecast etc)?
c) How accurate is the collected information within the supply chain (free of error) (this also explains how accurately information is shared within the supply chain)?
d) Could you please explain the process of collecting information within the supply chain?
e) Could you please explain:
    i. How information that is collected within the supply chain is stored?
    ii. Where information that is collected within the supply chain is stored (database)?

Sharing of Information within supply chain.

a) What is the importance of sharing information within the supply chain?
b) How openly is information shared within the supply chain?
c) How promptly is information shared within the supply chain?
d) Could you please explain the quality of the process of sharing information within the supply chain?
e) Could you please explain the process of sharing information within the supply chain?

Relationship with supply chain partners.

a) What are the business entities that your company collects information from?
b) What are the business entities that your company shares information with?
c) Do other business entities within the supply chain need to share information about:
    i. Themselves (e.g. organogram, staff strength etc)?
    ii. Their business processes, or just their activities that involves the supply chain?
    If yes to any or both, please explain why?

Risk management

Information Risk within supply chain

a) What are the threats to information within the supply chain?
b) What are the risks associated with storage of information (risk considered before and when storing information e.g. carelessness of people, process of storage etc)?
c) What are the risk information is exposed to when stored (e.g. Virus, disasters etc)
d) Are there measures put in place to mitigate/prevent risk:

i. Associated with storage of information (e.g. check on people, process etc)?
ii. Stored information (e.g. redundancy)?

If there are, could you please explain them?

Risk of sharing information within supply chain

a) What are the risks associated with sharing of information within the supply chain?
b) What is the business impacts of risk associated with sharing of information within the supply chain?
c) Would you say sharing information outweighs the risk involved in sharing information?
d) Are there measures put in place to mitigate/prevent risk associated with sharing of information within the supply chain? If there are, could you please explain them?

Risk with supply chain partners

a) Do other business entities within the supply chain need to disclose the risk that affects their supply chain activity? If yes, please explain why?
b) Does the risk that affects other business entities within your company's supply chain affect the supply chain activity holistically? If yes, please explain how it does.
c) Are there measures put in place to mitigate/prevent risk that affects other business entity within the supply chain from:
    i. Affecting your company's supply chain activities
    ii. Affecting the supply chain activity holistically?

    If there are, could you please explain them?

Finally, is there anything you would like to add?

Thank you for your time – it is highly appreciated!!!

Questionnaire

Topic: Information Risk Management within Supply Chains

M Com Research Project

School of Information Systems & Technology

Faculty of Management Studies

University of KwaZulu-Natal

Researcher: Nurudeen Ajayi (0793147203)

Supervisor: Prof. Manoj Maharaj (031-2608003)

Introduction

The purpose of this questionnaire is to gather information from you on "what information flows, and how information flows within the supply chain of your company". Its purpose is also to get information from you on "information vulnerability and the business risks associated with these vulnerabilities within the supply chain of your company".

The information gathered from you will be used to provide a framework for information risk management within supply chains, which risk and information officers within supply chains can adapt to their respective companies, thereby increasing value for their company and stakeholders.

In this questionnaire, the following keywords are used: Information, Risk and Supply Chain. As used in this research, each keyword can be briefly described as:

Information: Data that has been processed, manipulated and organized in a way suitable for human interpretation, and that adds to the knowledge of the person receiving it.

Risk: The state of uncertainty, threat or probability that an action or event will adversely or beneficially affect the ability to achieve desired objectives.

Supply Chain: An integrated process wherein various business entities (suppliers, manufacturers, distributors, and retailers) work together in an effort to: Acquire raw materials, Convert these raw materials into specified final products, and Deliver these final products to consumers.

Note: As used in this questionnaire, Supply chain partners also mean other Business entities.

- *Please sign the letter of informed consent, giving me permission to use your response for this research project.*
- *Please rate the statements in each section by placing a check in the appropriate box.*
- *The questionnaire should take about 20mins.*

Your response to this questionnaire will be treated with confidentiality.

Name: _____

Company: _____

Telephone: _____

Section A: Background

This section of the questionnaire refers to your background information. The information will allow me compare groups of respondents. Once again, I assure you that your response will remain confidential.

1. Gender?
   - ☐ Male
   - ☐ Female
2. Age
   - ☐ Less than 22 years old
   - ☐ Older than 22 but younger than 25
   - ☐ Older than 25 but younger than 30
   - ☐ Older than 30 but younger than 50
   - ☐ Older than 50
   - ☐ I do not wish to answer
3. Race?
   - ☐ African
   - ☐ Coloured
   - ☐ Indian
   - ☐ White
   - ☐ Another-Group (specify): _____
   - ☐ I do not wish to answer
4. Your educational qualifications?
   - ☐ No formal qualification
   - ☐ School leaving certificate
   - ☐ Technical Diploma
   - ☐ Graduate

- ☐ Post Graduate
- ☐ Industry specific certification
- ☐ Still studying (Please specify) _____
- ☐ Other (Specify):_____
- ☐ I do not wish to answer

Section B: Job & Experience

This section of the questionnaire explores your past and present job, job role/responsibility and experience. The information will allow me make correlation between questions and responses.

5. How long have you worked in this company?
   - ☐ Less than 6 months
   - ☐ More than 6 months but less than 1 year
   - ☐ More than 1 year but less than 2 years
   - ☐ Over 2 years
6. Which of the following describes your position in your organization?
   - ☐ Director
   - ☐ Manager
   - ☐ Supervisor
   - ☐ Team leader
   - ☐ None of the above (please specify): _____
7. How long have you worked in this position?
   - ☐ Less than 6 months
   - ☐ More than 6 months but less than 1 year
   - ☐ More than 1 year but less than 2 years
   - ☐ Over 2 years
8. Your responsibility in this company involves (tick all that apply)?
   - ☐ Decision making
   - ☐ Policy making
   - ☐ Supply chain
   - ☐ Risk management
   - ☐ None of the above (please specify): _____
9. Have you worked in any other company before joining this company?

- ☐ Yes
- ☐ No

➢ If yes, did your responsibility involve any of the following (tick all that apply)?

- ☐ Supply chain
- ☐ Risk management
- ☐ Decision making
- ☐ Policy making
- ☐ None of the above (please specify): _____

10. Have you had training in any of the following (tick all that apply)?

- ☐ Supply chain
- ☐ Risk management
- ☐ Other training (please specify): _____
- ☐ None

Section C: Supply chain

This section of the questionnaire explores information within your company's supply chain. It also explores the sharing of information between your company and other business entities within the supply chain network.

11. Information is important in optimizing the performance of your company's supply chain?

- ☐ Agree
- ☐ Disagree
- ☐ Neutral

12. Which business entity does your company collect information from (tick all that apply)?

- ☐ Supplier
- ☐ Manufacturer
- ☐ Distributor
- ☐ Retailer
- ☐ None of the above

13. How would you describe the process of collecting information within the supply chain?

- ☐ Efficient and Effective
- ☐ Efficient but not Effective
- ☐ Not Efficient but Effective

- ☐ Neither Efficient nor Effective

14. How would you describe the information that is collected within the supply chain?
    - ☐ Accurate
    - ☐ Not so Accurate
    - ☐ Not Accurate
15. How would you rate the quality of information that is collected within the supply chain?
    - ☐ Satisfactory and Effective
    - ☐ Satisfactory but not Effective
    - ☐ Not Satisfactory
16. How would you describe the storage of information collected within the supply chain?
    - ☐ Efficient and Effective
    - ☐ Efficient but not Effective
    - ☐ Not Efficient but Effective
    - ☐ Not Efficient or Effective
17. Sharing of information within the supply chain is important to improve performance?
    - ☐ Agree
    - ☐ Disagree
    - ☐ Neutral
18. How would you describe sharing of information within the supply chain?
    - ☐ Openly and Promptly
    - ☐ Openly but not Promptly
    - ☐ Not Openly but Promptly
    - ☐ Neither Openly nor Promptly
19. How would you describe the information other supply chain partners share about their supply chain activity?
    - ☐ Promptly and Satisfactory
    - ☐ Promptly but not Satisfactory
    - ☐ Not Promptly but Satisfactory
    - ☐ Not Promptly or Satisfactory

Section D: Risk and Risk Management

This section of the questionnaire explores risk and the measure put in place to mitigate/prevent risk to information, and risk associated with sharing of information between your company and other business entities within the supply chain.

20. How would you rate the threats to information within the supply chain?
    - ☐ High
    - ☐ Moderate
    - ☐ Low
    - ☐ None
    - ☐ Don't know
21. How would you rate the risk associated with sharing of information within supply chain?
    - ☐ High
    - ☐ Moderate
    - ☐ Low
    - ☐ None
    - ☐ Don't know
22. How would you rate the risk that stored information is exposed to?
    - ☐ High
    - ☐ Moderate
    - ☐ Low
    - ☐ None
    - ☐ Don't know
23. The business impacts of risk on information and information flow within supply chain is:
    - ☐ High
    - ☐ Moderate
    - ☐ Low
    - ☐ None
    - ☐ Don't know
24. It is important that supply chain partners disclose the risks that affect their supply chain operation?
    - ☐ Agree
    - ☐ Disagree
    - ☐ Neutral

25. The risk that affects supply chain partners can affect the supply chain holistically?

- ☐ Agree
- ☐ Disagree
- ☐ Neutral

26. Measures are in place to mitigate/prevent (tick all that apply)?

- ☐ Risk to information within the supply chain
- ☐ Risk that affect stored information
- ☐ Risk associated with sharing of information within the supply chain
- ☐ Risk that affects other supply chain partners from affecting the supply chain
- ☐ Not sure
- ☐ None of the above

Date: _____

Thank you for your time - it is highly appreciated!!!