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Building a resilient supply chain model in the Middle East Region: an empirical study on Fast Moving Consumer Goods industry

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Building a resilient supply chain model in the Middle East Region: an empirical study on Fast Moving Consumer Goods industry

by

Karim Soliman

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Copyright statement

Dedication

To my mother, Eman and my father, Mohamed

To my wonderful wife, Rania

To my brother, Ahmed and my sister, Nadine

To my supervisors: Prof. Shaofeng and Prof. Dongping Song, and all my teachers

To Prof. Ismael Abdelghafar Ismael, President of Arab academy for Science, technology, and Maritime Transport.

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Last but not least, my thanks and praise are to Allah for his grace upon me in all my life.

Author’s declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Sub-Committee.

Work submitted for this research degree at the Plymouth University has not formed part of any other degree either at Plymouth University or at another establishment.

Papers have been published and presented by the author based on the PhD work, and the full list of publications has been included in the next page.

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Signed **Date**

Karim Soliman *23-7-2017*

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Conference papers

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2. Soliman, K., Liu, S and Song, D. (2013). Building Resilient Supply Chain in the Fast Moving Consumer Goods Industry in the Middle East Region. The British Academy for Management Conference (BAM 2013).
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Abstract

Fast Moving Consumer Goods (FMCG) supply chains (SCs) are becoming more and more vulnerable to different types of risks due to the increasing complexity of markets, uncertainties, and turbulence, especially in the Middle East Region (MER). The main reason behind this is the political and economic instabilities resulting from the Arab Spring revolutions which affected all SC entities. There is an urgent need to investigate how to build resilient SCs that can help all partners in the chain to proactively identify and sidestep risks, and bounce back more quickly in the case of disruptions. For this reason, this research focuses on the creation of effective SC resilience model that could help companies to avoid SC risks to reduce vulnerability instead of being reactive toward disruptions. A conceptual model for SC resilience has been developed which identified three main constructs of SC resilience: risks, capabilities, and key performance indicators (KPIs). The links between the three constructs have been established.

The empirical study has been conducted in two stages. In stage one, semi-structured interviews were conducted to collect data from 30 companies in FMCG SCs operating in the MER. A combination of thematic and comparative analysis has been used to analyse the qualitative data collected from the interviews in order to identify the main themes (types of risks and their causes, capabilities, and relevant KPIs), and to find the relations between themes. In stage 2, Analytical Hierarchy Process (AHP) was used to prioritize and rank the risks, capabilities, and KPIs using pairwise comparisons by taking into account opinions and preferences from SC managers in the FMCG industry in the MER. Preceding the analysis, a second round of structured interviews according to AHP process were conducted with the same 30 companies used in stage one.

The thesis adds to the SC resilience literature by empirically explore the main causes of SC vulnerabilities that the FMCG SCs face in the MER and how companies can increase their

capabilities to improve the resilience performance of the entire chain. An important contribution of this thesis is the development of the model for SC resilience in FMCG industry in MER context, that provides a useful reference model to assist managers in build a resilient SC, specifically, by identifying the main types of risks and their sources, by defining relevant capabilities that can help anticipate and overcome risks, and by recommending appropriate KPIs that can act as a sensor to market dynamics in the FMCG industry in MER. The model with the matrices (of risks-capabilities-KPIs) developed in this research established the links and interactions among the risks, capabilities, and KPIs which have great potential in guiding decision makers through the SC management (SCM) process, so that more informed decisions can be made and implemented for important risks to be avoided and to create more resilient FMCG SCs.

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List of abbreviations

ABC: Activity-Based Costing

AHP: Analytic Hierarchy Process

BSC: Balanced Scorecard

CCP framework: Content, Context and Process framework

CI: Consistency Index

CR: Consistency Ratio

DEA: Data envelopment analysis

DEMATEL: Decision Making Trial and Evaluation Laboratory

EC: Expert Choice

FBMS: Function-based measurement system

FMCG: Fast Moving Consuming Goods

FREAC: Faculty Research Ethical Approval Committee

GSCF: Global Supply Chain Forum

KPIs: Keep Performance Indicators

LARG: Lean, agile, resilient and green

MER: Middle East Region

SC: Supply Chain

SCs: Supply Chains

SCIMAM: Supply Chain Integrated Management Analysis Method

SCM: Supply Chain Management

SCOR model: Supply Chain Operations Reference model

SCPMS: Supply chain performance measurement system

SCRM: Supply Chain Risk Management

PPVC framework: Performance Value Planning Value Chain framework

RI: Random Index

VAR: Value at Risk

Chapter one: Introduction

1.1 Background and motivation

The contemporary tendency of increased interconnections between companies and globalisation has shown that competition has changed to be between supply chains (SCs) instead of being between companies (Christopher, 1998; Cabral et al., 2012). Furthermore, the changing in the business environments from mass production to customization, and from technology and product-driven to market and customer-driven have increased the vulnerabilities of SCs (Pettit, 2008; Kim et al., 2015). This implies that companies can no longer act as an isolated and independent entity in competition, but a fully-integrated SC can provide competitive advantages in the market.

Modern SCs are very complex, because managers optimized their supply chain (SC) strategies by reducing stock levels, outsourcing non-core activities, reducing the number of suppliers and sourcing globally, on the assumption that, the world is a relatively stable and predictable place (Maertens et al., 2012). However, this does not exist, as the complexity of global networks and the low stock levels expose companies to unexpected disruptions (Mentzer et al., 2001; Sheffi and Rice 2005)

For this reason, managing SC disruptions gained a significant interest in the supply chain management (SCM) context between academia and practitioners (Kim et al., 2015; Hohenstein et al., 2015; Diehl and Spinler, 2013). Recent studies have highlighted the importance of SC risk management aiming at developing methods to identify, assess and manage causes of SC threats (Lavastre et al., 2012). Nevertheless, several disruptions that are beyond the company's scope of control takes place even after taking all the necessary mitigation strategies (Agigi et al., 2016). Consequently, researches accentuated the importance of SC resilience to diminish the damage, recover fast and rapidly get back to the normal operations (McDonald, 2006). SC resilience is referred to as the SC capabilities to recover from any disruption to its novel state or to a more desirable condition after being threatened (Christopher and Peck, 2004). However, the SC resilience literature has not reached a standard definition to the concept (Christopher and Peck, 2004; Kim et al., 2015; Scholten et al., 2014), most of the studies asserted that SC resilience is concerned with the ability to read, respond, and recover to a better performance level (Carvalho et al., 2012).

The need for further exploration of SC resilience concept has been highlighted in the literature (Scholten and Schilder, 2015; Christopher and Peck, 2004). However, few empirical researches exploring the SC resilience constructs and their interactions are found in the literature (Scholten and Schilder, 2015; Tukamuhabwa Rwakira et al., 2015). Moreover, the empirical studies from previous studies were focused on the developed countries (Scholten and Schilder, 2015; Tukamuhabwa Rwakira et al., 2015; Zsidisin and Wagner, 2010; Agigi et al., 2016) without giving attention to the developing countries particularly in the Middle East Region (MER) where the resiliency of the SC has not kept pace with the continually rising level of logistical complexity (Soliman et al., 2013).

The growing importance of the field of SC resilience is the motivation for this research especially in the SCs of Fast Moving Consumer Goods (FMCG). In FMCG, the complexity of markets, uncertainty, and turbulence had led that SC has become vulnerable to different kinds of risks (Agigi et al., 2016). Thus, to stay ahead of competition in today's dynamic business environment, there will be a need to turn resilience into a distinctive competitive advantage through enhancing resilience between all SC partners. This could be achieved by focusing on the capabilities that enable SCs to anticipate and overcome disruptions (Pettit, 2008).

FMCG industry is one of the largest industries in the world since it includes several variants of products (Kärkkäinen, 2003), such as: food, beverages, dairy products, cosmetics, and cleaning products. Those products are characterized by having high turnover rates accompanied with short shelf life because of increasing demand or because the product deteriorates quickly (Bilgen and Günther, 2010). Furthermore, the complex nature of the products itself leads to a magnificent increase of uncertainties that will in turn make SC being vulnerable to the complex economic, political, and social conditions in the MER. Moreover, the MER falls in the middle of the way between Europe and America and the Far East where any transported goods pass from Suez Canal located in Egypt instead of passing from the Cape of Good Hope route. We must then consider that any threat elsewhere in the world will cause failure to the companies operating in the developing countries (Diabat et al., 2012; Kim et al., 2015).

Likewise, several capabilities and strategies to enhance SC resilience such as visibility, flexibility, etc., have been proposed in the literature. Nonetheless, the literature lacked investigating the interrelations between various capabilities and the SC risks empirically. Some researchers indicated that these capabilities are in-dependent (Zsidisin and Wagner, 2010; Sheffi, 2005; Sheffi and Rice, 2005), while other researchers claimed that they are interrelated (e.g. Scholten and Schilder, 2015; Tang, 2006; Jüttner and Maklan, 2011). This recommends that the interrelations between the SC resilience constructs and their implementations should be investigated.

1.2 Research justification

Managing SC disruptions gained a significant interest in the SCM context (Pettit et al., 2010; Sheffi, 2005; Christopher and Peck, 2004). However, several disruptions are beyond the company's control even after taking all the necessary mitigation strategies. Thus, researches emphasized the importance of SC resilience to diminish the damage, recover fast and rapidly get back to the normal operations (Jüttner and Maklan, 2011). Furthermore, latest statistics show that almost 80% of companies across globe are keen to build resilience into SCs (World Economic Forum, 2013).

The MER has a significant role in the global economy and in sequence has a role in the global SCs. Though, these SCs similarly face vulnerabilities with severe outcomes like the developed countries' SCs when they fail (Chika et al., 2011). However, the current problems explain that SC managers in the MER have a narrow vision regarding the global economy in terms of SC strategies (Soliman et al., 2014). This misleads them to missing the broad vision to the risks that are internal to their SC network, but external to their organisations (Christopher and Peck, 2003). For example, the sudden political changes such as the Arab Spring revolution has affected adversely the entire SC network causing significant increase in the prices of goods and services for all stakeholders such as customers (Soliman et al., 2014). This would not have happened if SC managers had a strategic long term view within the context of the network risks. In this research, the FMCG Industry has been selected because this industry is characterized by high market dynamics and competition within their SCs (Bala and Kumar, 2011). Some of the issues, such as the bullwhip effect (relatively small variability in end-customer demand expands to successively high variability in the upstream the SC), and higher returns, machine equipment breakdown, and transit losses, are widely evident in these SCs (Bala and Kumar, 2011). Moreover, FMCG industry SCs generate innovative ideas and act as benchmarking frameworks for other industries because of their high volume of product flows, close interaction with their customers, and less complex manufacturing processes (Mosquera, 2009). Another aspect that characterizes this industry is that different entities in a similar SC operate according to different sets of constraints and objectives and their performance is dependent on the performance of the entire chain (Swaminathan et al, 1998). Moreover, any disruption can have very different implications depending on how SCs are designed and planned for such an event. Thus, to stay ahead of competition in today's dynamic business environment, there will be a need to turn resilience into a distinctive competitive advantage through enhancing resilience between all SC partners.

1.3 Research aim, objectives and research questions

As discussed in the previous sections, more empirical investigations on SC resilience in the MER context is the clear motivation for this research. It has been clear that existing differences; such as, economic, political, cultural, and other differences between the developing countries and developed countries recommend that the response to any risk will differ. Furthermore, other differences in the level of political, economic, and cultural maturity, besides the poor infrastructure in the MER will make SCs more vulnerable. Especially after Arab Spring revolutions have affected all the SC network causing increase in the prices of goods and services for important stakeholders such as customers (Soliman et al., 2014). Thus, it is important to explore the SC resilience constructs and the interrelations between them empirically. In addition, these interrelations should be investigated from the SC performance context.

Thus, this research aims to develop a model of a resilient SC in the FMCG industry in the MER that gives more empirical investigations on SC resilience constructs. This would be achieved by investigating all the risks that face FMCG companies in the MER and rank them. Moreover, important capabilities will also be investigated and ranked. Finally, KPIs that can be used to measure FMCG SC resilience will be investigated.

The main objectives of this study are:

1. To identify risks types that cause vulnerabilities to the FMCG SCs and their classification.
2. To investigate the capabilities that SC managers employ to manage risks.
3. To investigate different KPIs that companies adopt.
4. To construct a SC resilience model for FMCG industry.
5. To validate and evaluate the model in the MER.
6. To draw recommendations for SCM in MER FMCG.

The following research questions were formulated:

1. **1.** What are the MER types of risks that causes vulnerabilities and the ranking of risks to the FMCG industry?
2. **2.** What are the capabilities that companies can develop to manage risks and their relative importance to the SC managers in FMCG?
3. **3.** What are the possible KPIs for SC performance to manage resilience in the FMCG?

1.4 Key contributions

This research discovered findings which were empirically evidenced based on the analysis of SC risks, capabilities, and KPIs from a holistic overview of the entire chain. There were five new risks identified from these findings. They are: corruption, lower consumer spending, rising labour cost, tacit knowledge risks, and dis-honest supplier. There is also a new capability category emerged from the findings called learning and innovation. Furthermore, the sub-capabilities identified are considered to be a novel contribution, not because they are new to the literature, but because they were identified either as main capabilities required to be resilient, or they were identified in different contexts other than SC resilience.

The key findings of this study have made several theoretical contributions:

1. Developing a SC resilience model which enumerate all the risk factors causing vulnerabilities, the capabilities required to be resilient, and the SC KPIs that would ensure SC resilience. This enumeration of all risk factors, capabilities, and SC KPIs would help SC managers to have control on their SC processes with a proactive manner towards any uncertainties that causes disruptions to the entire network.
2. Ranking SC risks that affects the entire chain to assist SC managers in taking proactive decisions towards the most important risks rather than focusing on the least important.
3. Ranking capabilities that enhance SC resilience by identifying which capabilities should a company focuses on attaining first based on their importance to mitigate risks that

causes SC vulnerabilities and in return, enhance SC overall performance for the entire chain.

4. Ranking SC KPIs in the SC resilience context that involves SC managers in creating a through reflection of the interdependencies while exerting efforts to enhance resilience and SC performance.
5. Developing three matrices (risks versus KPIs, risks versus KPIs, and capabilities versus KPIs) based on the empirical findings. These matrices will enable SC managers to understand which capability attempts to improve which risk factor, which risk factor affect specifically which KPI, and, which KPI can be used to measure which risk factor, and finally, which capability can be employed to enhance which KPI.
6. Discovered new links between SCOR SC performance attributes and level one KPIs. These links would enable SC managers to focus on the new contribution to improve the standard metrics adopted from the SCOR model. For example: to improve responsiveness, SC managers should monitor and improve "Perfect Order Fulfilment" (new contribution) beside "Order Fulfilment Cycle Time" (the main matric by SCOR model) to enhance the SC performance of the entire chain.

Besides theoretical contributions, this study has several managerial implications concerning understanding risks, capabilities, and KPIs. Findings of the empirical study have made a number of contributions to SC managers, such as:

1. Classifying the risk factors under four main risk categories to enhance the understanding of them based on empirical evidence from the industry and context where they operate.
2. Proposing sub-capabilities under each of the five main capabilities groups to present a clear road map for practitioners to cope with different risk factors, and in return, maintain a competitive advantage over SCs that are less resilient, so as to enlighten SC

managers with the most important capabilities that should be employed to enhance resilience in their SCs.

3. Proposing a SC resilience model for FMCG in the MER which is not only considered to be the first model devoted to resilience context in the MER operating in a specified industry, but also provides the interrelations between risks, capabilities, and KPIs based on the matrices developed (risks versus capabilities; risks versus KPIs; KPIs versus capabilities) rather than focusing on risks or capabilities only.

1.5 Structure of the thesis

Figure 1.1 illustrates the organisation of the thesis

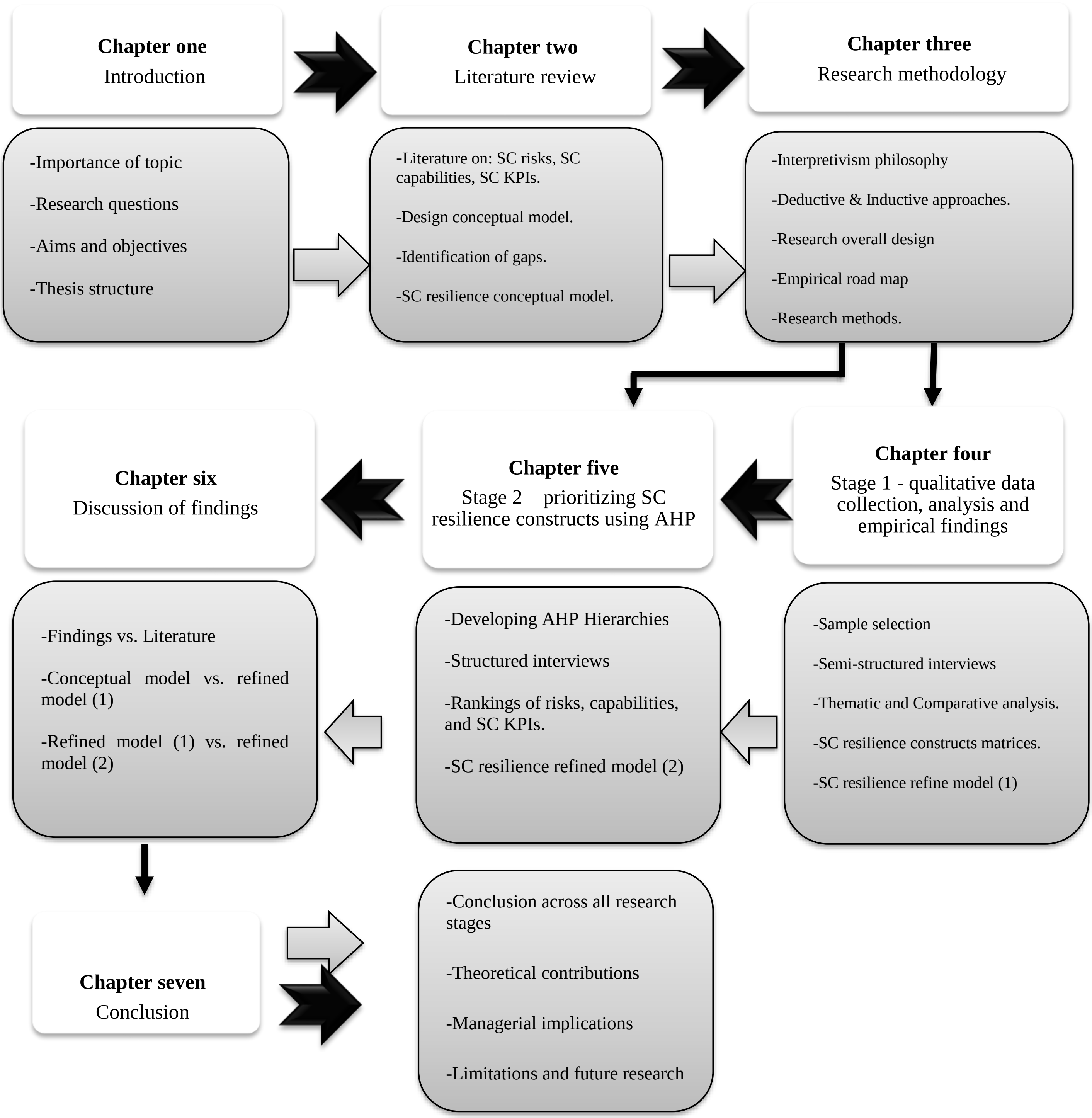

Figure 1.1: Thesis structure

The thesis consists of seven chapters as outlined below:

Chapter one starts with a brief background and motivation of this research. Research aim, objectives and research questions are the presented. In addition, a summary of the key theoretical contributions and managerial implications is also discussed. Finally, the chapter outlines the structure of the whole thesis.

In **Chapter 2**, broad related concepts such as: supply chain management (SCM), SC risk management, SC uncertainty, and SC vulnerability are reviewed. This chapter further analyses the literature on various definitions and concepts of SC resilience. Then, SC capabilities are unfolded to the previously summarized relevant researches. After that, different SC performance measurement systems are investigated; and the SCOR model is presented and justified as the appropriate measurement system to standardize the SC KPIs across all SC network. Finally, the research gaps are addressed with the conceptual model developed as a base to guide the empirical study.

In **Chapter 3**, the research methodological is discussed. Further, the chapter describes the choice of using qualitative methods for data collection and analysis for both stages of the empirical study.

Chapter four presents stage one of the empirical study. In this chapter, the semi-structured interview process for data collection, and the data analysis approach (thematic analysis and comparative analysis) are presented. Furthermore, a refined SC resilience model is developed based on the findings from the stage one of empirical study. Finally, matrices are developed to highlight the interrelations between the three SC resilience constructs based on the empirical findings.

Chapter five extends the findings of chapter four. It starts with developing the AHP hierarchies for the three SC resilience constructs to perform pair-wise. The data for the AHP was collected using structured interviews. Finally, the results are discussed and the refined SC resilience model (2) is developed based on the empirical findings.

Chapter six discusses the evolution of the model from the conceptual phase to stage one in the empirical study, then to stage two in the empirical study. Finally, chapter six also examines whether the findings conformed or contradicted to the literature.

Finally, **chapter seven** draws conclusions to the thesis, which includes theoretical contributions and managerial implications of the findings. Moreover, limitations are identified and future research directions are recommended.

1.6 Summary

This chapter presents the research topic; what is SC resilience and what are the main constructs to design a resilient SC in FMCG in the MER. Three research questions were presented that need to be answered in order to achieve the defined research objectives. Moreover, it highlighted the main theoretical and managerial contributions from the research findings. Finally, an overview of the whole thesis is provided.

Chapter two: Literature review

2.1 Introduction

This chapter attempts to explore the related work in the literature to identify potential gaps that need further investigation. Both the concepts of supply chain risk management (SCRM) and SC resilience evolved from the SCM field. However, this research focusses on the SC resilience concepts that need investigation to achieve enhancements in overall entire SC network performance.

Thus, a comprehensive literature review is important to gain deep understanding of the topic. For this reason, this research adopted a systematic process to retrieve and choose the articles, following Denyer and Tranfield (2009) that includes three steps; sourcing articles, articles screening process, and analysis and coding. In step one, Primo search engine – provided by University of Plymouth – was used the main search engine, which facilitated the access to a variety of major business and management databases, including EBSCOhost, Emerald, ScienceDirect, and IEEE. The main key words used in searching are: supply chain management, supply chain risk management, supply chain resilience, and supply chain performance measurement systems. While the screening step in the systematic review process of the literature included three stages; a cross-checking of the articles took place to make sure that there is no duplication, checking the relevance of the articles, and finally, cross-checking the references of the chosen articles to make sure that no important articles are missing. At the end, comes the analysis and coding step that included extracting and keeping a record of the information from all the relevant sources.

Based on the above defined steps, the review of the literature included four main areas, which are critical to this research. The first part of this chapter is to explore the definition and concepts of SC to understand the complexities that companies face. Following this, risk management literature is examined to understand the different definitions and views of risk, and how these views are included into the SCM context. Consequently, SCRM literature is explored to investigate different definitions of risk management from SC context, and to identify risks affecting SCs and their classifications. Further, concepts related to SC resilience such as: SC vulnerability, disruptions, and uncertainties are explained. Then moving forward to define and analyse the SC resilience literature, in addition, the SC resilience capabilities that enable SC managers to incorporate resilience to prepare for unexpected events, respond to disruptions, and gain a recovery to more desirable condition are studied. At last, SC performance KPIs literature is explored to identify several SC KPIs that could be further investigated and related to SC resilience constructs (risks, and capabilities).

This chapter concludes with a discussion of gaps emerged from the literature findings. Moreover, a conceptual model for FMCG SC resilience in the MER that is based on the relevant literature is proposed aiming at filling the emerged gaps in the area of study.

2.2 Supply chain management

2.2.1 The concept of SCM and its evolution

The concept of SCM has been discussed between practitioners and researchers since the early 1980s (Houlihan, 1985; Jones and Riley, 1987) as a separate area from operations management, and recently companies has also started to work according to SCM concepts and principles. The term SCM first appeared in 1982, according to a study by Cooper et al. (1997). Since the early 1990s, SCM has been distinguished in researches from logistics management as focus has shifted from reducing inventory in the single company to the entire network inventory optimization. Throughout the literature there are two distinctive views on defining SCM.

The first view is considered an extension of the logistics management traditional definition with original focus on material movement. This view on SCM, found in many early logistics management textbooks, emphasises that operational effectiveness is the key to competitive advantage (Bowersox et al., 1996). This means that SCM is concerned with procurement, manufacturing, and movement of materials to the end users (Swaminathan et al., 1996; Sauer and Seuring, 2017). On the other hand, the second view of SCM is from the broader perspective of integrated strategic management of the entire network processes and activities (Schaltegger and Burritt, 2014). This means, that value is created by maintaining appropriate control on information and related activities to optimize the total cost for multiple activities of chain members rather than optimizing logistics cost of a single entity in the chain (Varsei et al., 2014). Accordingly, there is an economic gain to the integration of processes through the entire chain (Håkansson and Persson, 2004) creating a high level of competitive advantage which will accordingly result in increasing performance of the entire chain activities (Mentzer et al., 2001).

In the next section, articulation of the concepts and definitions of SC will be discussed.

2.2.2 Various definitions of supply chain management

SC is defined as a network of linked and mutually dependent entities that works together to manage the flow of raw materials, work-in-process, finished goods, information, and money flow from point of origin (suppliers) to point of destination (end-users) with an ultimate goal of reducing overall total cost of SC activities (Christopher, 1998; Varsei et al., 2014). Christopher and Holweg (2011) defined SCM as integrated strategic aligned entities that focus on how to gain market opportunities based on mutual benefit which requires co-operation and Collaboration among partners. Consistent with Christopher and Holweg (2011) definition, SCM was seen as a strategic tool to increase customers' satisfaction which will in turn increase the company's profitability and competitiveness (Giunipero et al., 2008). Accordingly, SCM can be viewed as the management of both upstream and downstream relations between all entities from suppliers to the final customers to provide the required value at a lower cost to the SC

(Christopher, 1998). Figure 2.1 illustrates the different types of channel relationships within the SC.

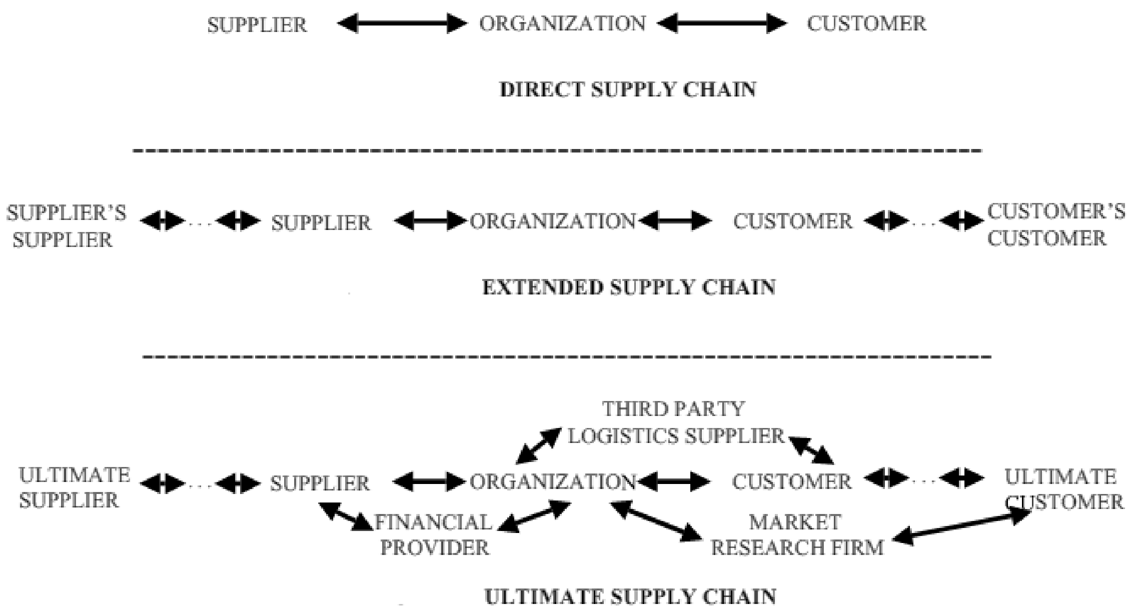

Figure 2.1: Channel relationships within SC

Source: (Mentzer et al., 2001)

As shown in Figure 2.1, Mentzer et al. (2001) identified three degrees of complexities (direct SC, extended SC, and ultimate SC) within SC based on the parties involved within each channel.

Furthermore, SCM is considered to have a managerial and strategic perspective. Managerial perspectives in the essence have specific managerial objectives that need to be met through the appropriate management of various SC processes (Cousins et al., 2006). Furthermore, management encompasses responsibilities on both levels; company level to manage flow of materials and information, and SC level in managing relations with different SC entities within the chain (Lambert and Cooper, 2000; Mentzer et al., 2001; Laurence, 2011). On the other hand, SCM involves decision making involving decision on sources of supply, how to meet customers' expectations, etc. (Storey et al., 2006). By the same token, SCM was defined as the systematic strategic management of the ordinary business functions and strategies for any company in the chain to be extended to improve the long-term performance of the entire SC (Mentzer et al., 2001). Thus, SCM can be defined as the management of material, information and money flows through a network of organisations (i.e. suppliers, manufacturers, logistics providers, wholesalers, distributors, retailers) aiming at producing and delivering the desired products or services to the customers with the lowest SC overall cost (Tang, 2006). This includes coordination and Collaboration of SC processes between all function such as marketing, sales, production, product design, procurement, logistics, finance, and information technology within the network of organisations (Tang, 2006; Laari et al., 2017). Table 2.1 shows the relevant definitions of SCM found in the literature.

Table 2.1: Summary of SCM definitions

Author	Definition
Jones and Riley (1987)	SCM deals with the total flow of materials from suppliers through end users
Monczka et al., (1998)	The objective of SCM is to integrate and manage the sourcing, flow, and control of materials using a total systems perspective across multiple functions and multiple tiers of suppliers.
Christopher and Peck (2004)	Describes the SCs as being a network of entities that are involved, performing different activities through upstream and downstream relationships, aiming at creating value in the form of products and services to satisfy customers' needs.
Cooper et al. (1997)	Defines SCM as collaborative thinking to manage the flows in distribution channels from supplier to the end-users.
Christopher and Holweg (2011. 2017)	Integrated group of strategically aligned organisations in the supply chain, focused on specific market opportunities. This idea of extended enterprise is based on mutual benefit which requires co-operation and Collaboration among partners.
Christopher (1998) Varsei et al. (2014)	The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at lower cost to the supply chain as a whole.
Mentzer et al. (2001)	The systemic, strategic coordination of the traditional business functions different strategies across these functions in a specific company and across different functions within the entire SC, for the purposes of improving the SC performance of the individual companies and the SC as a whole.
Stock and Lambert (2001)	The integration of different business functions from end user to the suppliers of suppliers that provides products, services and information to add value for customers and different stakeholders.
Stevenson (2005)	The goal is to link all components of the supply chain so that the market demand is met as efficiently and as effectively as possible across the entire chain. This requires matching supply and demand at each stage of the chain. Organisations in a supply chain are both customers and suppliers.
Tang (2006)	Managing the three main flows in the entire chain between a network of organisations with the ultimate aim of producing and delivery of products and services for the end-users. This includes integration and Collaboration of different business functions (i.e. marketing, sales, production, product design, procurement, logistics, finance, and IT across the network.

Peck (2006)	Includes effective planning and management of all activities undertaken in purchasing, production, and the logistics management activities. Moreover, it also includes coordination and Collaboration with different partners in the chain, which can be suppliers, outsourcing companies, third-party service providers and customers to integrate supply and demand within and across companies.
Stock and Boyer (2009)	SCM deals with the total flow of materials from suppliers through end users aiming at achieving a balance in the trade-off off between high customer-service and low inventory levels
Sheffi (2007)	Focuses on the flow of products through the global web of suppliers, manufacturers, distributors, transportation carriers and retailers, from raw materials to finished goods in consumers' hands and the recycling and disposal of these products.
Pienaar (2009)	Consists of integrated processes performed by companies to transfer raw materials to final products and delivering them to their destinations.
Giunipero et al. (2008)	Defined SCM thus: 'in its broadest contest SCM is a Strategic management tool used to enhance customers' satisfaction that in turn improve the company's competitiveness and profitability.
Cohen and Kunreuther (2007)	Matching both supply and demand with the lowest cost possible to satisfy customer needs with high quality products
Laari et al., 2017	Integrating different entities in the chain with the ultimate aim of enhancing the overall competitiveness of the entire chain
Lu (2011)	SC consists of several connected parties that add value to all inputs from the source to destination to satisfy customers' demand

As shown in Table 2.1, there are several definitions for SCM covering different aspects, however, the majority of definitions highlighted the importance of the end-to-end integration with effective planning of the logistics activities as the heart of SCM concept. Nevertheless, there had been long arguments whether if logistics management is part of the SCM, or vice-versa. However, SCM from its broader perspective, is reviewed to involve logistics management under its umbrella as it performs the movement of material among the supply chain network (Larson et al., 2007).

As the market environment changed and became more competitive, SCs became more challenging and complex (Griffiths et al., 2000). These changes took place due to the changing demands of the marketplace, constant changes in product specifications, together with numerous initiatives which managers employ inside the organisations and the whole SC entities that implied that SCs never actually reach a stable steady state (Haywood and Peck, 2004).

2.2.3 Supply chain management challenges

Literature clearly highlight that SCs are characterised by crises and shocks. For example, Christopher and Holweg (2011) argued that prior the global financial crisis of 2008, SCs were increasingly being disrupted due to changes in oil prices, environmental disasters and many others disruptions. The emerging connections between the global SCs led to more risks becoming more relevant to many countries around the globe (Harland et al., 2003).

Hence, managing SCs in a competitive, high uncertainty and strong industry is very complicated, since it is very difficult to manage SCs in isolation. Also, SC strategies should be aligned with the specific objectives of the organisation, such as increasing business, increasing profit, or reducing total program extensive costs at the time maintaining program extensive service levels (Chopra and Meindl, 2007; Turker and Altuntas, 2014). However, the frequent incident of mishaps, work conflicts, unclear supply and demand, provider bankruptcy, governmental changes, war and terrorism have led to further concerns about risk management for the SC (Christopher and Lee, 2004; Hohenstein et al.,2015).

Thus, the challenge in SCs is handling and mitigating the risks that are natural in every business situation, however, it is complicated to design SC strategies in isolation as SCs are directly affected by other entities in the chain (Chopra and Meindl, 2007; Tummala and Schoenherr, 2011). The reason behind this is that different entities in the SC frequently have different and conflicting objectives. For example, suppliers always ask manufacturing companies to make their purchasing in bulk with fixed quantities with flexible delivery dates. Unlikely, although most manufacturing companies would like to have long production runs, they need to be flexible in fulfilling customers' needs bearing in mind changing demands. Thus, the suppliers' goals are in direct conflict with manufacturing companies' need for flexibility. Likewise, manufacturing companies' objective of mass production is in conflict with the objectives of both warehouses and distribution centres to reduce the level of inventory (Tang, 2006). However, the objective of reducing inventory levels requires an increase in transportation costs, which will accordingly lead to a substantial increase in the overall SC cost (Kleindorfer and Saad, 2005; Crona and Parker, 2012).

The SC is a dynamic system that evolves over time. Indeed, not only customer demand and supplier capabilities change over time, but SCs relationships also evolve over time. For this reason, uncertainty and risk are inherent in every SC, which results in getting the SC more complex due to uncertainty in forecasting customer demand, transportation time, capacity, machines and vehicles breakdowns, manufacturing time and missing information (Lee et al, 1997; Lee and Whang, 1999; Taylor and Brunt, 2001; Arns et al, 2002; Geary et al, 2002, Kouvelis and Milner, 2002; Kogg, 2009; Seuring and Muller, 2008).

Recently, what makes SCM more challenging are new industry trends, including outsourcing, lean manufacturing processes, as well as, the complexity driven globalisation, high transportation costs, poor infrastructure, weather-related disasters, and terrorist threats, managing the SC have become even more challenging (Pilbeam et al., 2012).

Tsiakkouri (2010) recognized that SC challenges occur because a lot of organisations have extended their functions outside the regional limitations of nations, and even major regions. By working worldwide, organisations try to decrease price through financial systems of scale in purchasing, manufacturing, seeking and through focused manufacturing and set up functions. Although this trend has coming back advantages for organisations which help organisations improve their aggressive position and website, but on the other hand this may force organisations to get involved in longer provide stores, thus leads to working and organizing with more parties. Consequently, the variety of organisations accountable for providing the item to the final customer has significantly increased (Kleindorfer and Van Wassenhove., 2004; Wiengarten et al., 2016). This makes sequence connections and functions more complicated.

Consequently, organisations are dealing with a variety of challenges to be able to react to these global changes and competitors. In addition, dealing with the different nature of various issues regarding ecological, technical, governmental, social, cost-effective, national, and international security has become a most crucial challenge for the current SC of a company (Sheffi, 2005). For this reason, SC managers are seeking to reduce risk and enhance competitive performance by integrating internal functions within an organisation and effectively linking them with the external operations of supply members and final customers (Simangunsong et al., 2016; Giunipero and Eltantawy, 2004).

Consistent with existing literature, SC challenges will keep on improving more and more through the future years. It is noteworthy to mention that the world is becoming global and organisations are also seeking to globalize, at the same time attempting to constantly reduce SC expenses from item idea to distribution, through the adopting of lean manufacturing and outsourcing from the low manufacturing price nations, thus will increase the complexity of the SCs.

The next stage of this literature review is devoted to investigative the concept of risk, identifying different SC risks, as well as introducing the concept of SC resilience as the building block for mitigation SC disruptions.

2.3 Supply chain risks and related concepts

Having identified the increasing significance of risk in SCM, this section of the literature review is devoted to explore risk as a concept and to explain different risks affecting SCs. Section 2.3.1 introduces the risk concept in itself. Then, section 2.3.2 provides an overview of the work carried out to identify risks from the SCM context. It also investigates related concepts to SC risks such as: SC uncertainty, SC vulnerability, and SCRM respectively. Main categories and classifications of risks affecting SCs are highlighted and summarized as it is not possible to identify all SC risks; on the contrary, it is necessary to focus on the most significant ones.

2.3.1 Risk definition and perceptions

The term risk is a common concept, but the meaning of the word risk is very variant (Diehl and Spliner, 2013; Manuj and Mentzer, 2008; Frosdick, 1997). Risk was first studied as a mathematical construct in the 1600s through probabilities, a field of mathematics developed by both Fermat and Pascal. This definition was known as the outcome of multiplication of how likely an event happens by the severity of this event (Barbosa-Povoa, 2014; Rao and Goldsby, 2009). The objective based risk definition was expressly used in the financial and insurance risk management fields in the 18th and 19th century (Khan and Zsidisin, 2012; Spekman and Davis, 2004). The argument started when risk was defined from a subjective point of view as being the outcome of risk taking process by decision makers after considering the benefit that they will gain by taking such decisions (Bailey, 2016). Based on this view, the concept of risk was used in management and psychology context emphasizing that risk taking is the main attribute for decision makers (Manuj and Mentzer, 2008).

Later, from this essence, authors defined risk from different perspectives. However, Ritchie and Marshall (1993) argued that there are unlimited definitions related to the term risk according to different views and perceptions. While Sitkin and Pablo (1992) indicated that risk is concerned with the assessment of effect of the uncertainty that may be caused once a decision is taken. On the other hand, Deloach (2000) defined risk as the extent of losses, the chance of loss, and the potential exposure to loss, while Brindle et al. (2006) divided risk into three dimensions: likelihood of occurrence of a particular event or outcome, consequences of the particular event or outcome occurring, and causal pathway leading to the event. Moreover, Tummala and Schoenherr (2011) viewed risk as a multi-dimensional concept that has different implication depending on the difference in business functions. Furthermore, Blos et al. (2009) stated that risks must be viewed only from managers' point of view based on the different parameters; such as, the downside of risk, the degree of expected losses, and the use of skills, judgment and control.

Finally, the issue of whether risk can be measured objectively or whether it is based on a subjective viewpoint will have a significant impact on how the various parties in a network perceive and attempt to manage risk (Khan and Burnes, 2007). Table 2.2 summarizes different definitions of risks.

Table 2.2: Summary of risk definitions

Author	Definition
MacCrimmon and Wehrung (1986)	Classified risk into three components: the extent of losses, the chance of loss, and the potential exposure to loss
Dickson and Hastings (1989)	The systematic process of identifying, analysing and controlling any disruptions, which can threaten the assets, or earning capacity of an enterprise.
Sitkin and Pablo (1992)	Stated that the risk is measuring whether the uncertainty is about potentially significant or disappointing outcomes of decisions
Ritchie and Marshall (1993)	Identify that there is an infinite number of definitions related to the term risk according to specific decision contexts and types
Blos et al. (2009)	Found that small number of managers defined risk into four terms 1.The downside of risk 2.Its magnitude of possible losses, 3.The act of risk taking involving the use of skills, judgment and control 4.Risk as a concept that cannot be captured with a single number
Cheese and Cheese (2016)	a loss, the greater the probability of this loss, the greater the risk thought to exist for an individual.
Christopher (2004)	Mentioned that the goal of risk management is the protection of the business from adverse events and their effects
Ritchie and Brindle (2007)	Divided risk into three dimensions: Likelihood of occurrence, the consequences that may occur, and the pathway of to mitigate such consequences.
Tummala and Schoenherr (2011)	The process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence.
Diehl and Spinler (2013)	The process of identifying, analysing and controlling any disruptions, which can threaten the assets, or capacity of a company.
Zsidisin et al. (2005)	Refers to any variations in the results or outputs
Rao and Goldsby (2009)	Refers to any risk exposure that results in uncertainty of the expected outcomes
Juttner (2005)	Refers to the subjective values that results due to any variations in the outcomes
Tang and Musa (2011)	Any financial or performance losses occurs associated with any risky event
Khan and Burnes (2007)	The negative consequences of any hazard and extent of these consequences

The literature can be broadly split into those that view risk as a loss (Manuj and Mentzer, 2008; Tang and Musa, 2011) or risk as a variance (Rao and Goldsby, 2009; Colicchia and Strozzi, 2012). While, Tang and Musa (2011) argued that risk is associated only with the negative outcomes and impacts. However, losses appear in terms of financial, performance or efficiency related outcomes. This includes losses of customer service levels, product quality and time (Towill, 2005; Christopher and Lee, 2004).

To conclude with a general definition of risk after reviewing several definitions adopted in the literature, it can be argued that risk is the probability of being exposed to any uncertainties that can lead to hazard taking place (Deloach, 2000; Norrman et al., 2004). However, some definitions tinted some positive features of risks, in the essence of being the hope of gain (Khan and Burnes, 2007; Olson and Wu, 2008; Cheese and Cheese, 2016) by capitalizing on risks that competitors cannot mitigate to gain a competitive advantage (Simchi-Levi et al., 2002; Sheffi, 2001)

As stated earlier in the section 2.2, SCs are constantly changing and becoming more complex, which in turn, had to adjust to their environment to remain be able to compete in the market (Stolte, 2014). In fact, literature suggested several SC trends adopted, such as: outsourcing, globalisation, reduction of the supplier base, etc. These trends have intensified risks in SCs, thus, there is an urgent need for the study of risks that threaten SCs (Norrman, et al., 2004; Khan and Burnes, 2007; Manuj and Mentzer, 2008; Christopher and Holweg, 2011; Giannakis and Louis, 2011).

Having reviewed risk as a concept, the most commonly cited definitions and perceptions of risks, as well as the role of SC complexity, the next section focuses on the identifying risks from a SCM perspective.

2.3.2 Risks in supply chains

SC risks definitions and interpretations are diverse and can be seen from different perspectives depending on the context (Tang and Musa, 2011, Sodhi et al., 2012). Apparently, previous studies can be divided into those that see risk as a loss (Manuj and Mentzer, 2008; Tang and Musa, 2011) or risk as a variance (Rao and Goldsby, 2009; Colicchia and Strozzi, 2012). On the other hand, it was argued that risk is only related with the undesirable outcomes and impacts (Tang and Musa, 2011).

Furthermore, there is a significant body of researches that focuses on risks affecting SC business functions and processes (Khan and Burnes, 2007; Manuj and Mentzer, 2008; Christopher and Holweg, 2011; Simangunsong et al., 2016; Gualandris and Kalchschmidt, 2015). Nevertheless, SCRM as a research area is considered in its beginning (Sodhi et al., 2012), though it began to receive bigger attention from researches due to the increasing level of uncertainty (Rao and Goldsby, 2009; Colicchia and Strozzi, 2012). This uncertainty has been in several high-profile threats and disruptions, such as 9/11, hurricane Katrina (Chopra and Sodhi, 2004; Manuj and Mentzer, 2008), and the Arab Spring in the MER (Soliman et al., 2013). The increase in these phenomena has underlined the need to consider low probability and potentially unknown risks that could affect the normal processes of any SC adversely. However, the literature review indicated that it is impossible to identify all possible risks that may cause vulnerabilities to SCs. Although, the known risks in SCs only present a certain proportion of all risks to a supply chain (Khan and Zsidisin, 2012).

Definitions of SC risk have been explained by several authors from their areas of origin. In the SC, the primary driver of risk centers on the disruption of the flow of information, materials, products and capital. These flows are interdependent and by definition extend beyond the boundaries of a single firm (Norrman and Jansson, 2004). Christopher and Peck (2004) defined supply chain risk following the first notion of definition of risk, Harland et al (2003) defined

SC risk as associated with the chance of undesired consequence such as danger, damage, injury and loss. Also, Juttner (2005) stated that, a number of factors have increased the level of SC risk that includes: (1) a focus on efficiency rather than effectiveness; (2) the globalisation of SCs; (3) focused factories and centralized distribution; (4) the trend to outsourcing; and (5) the reduction of the supplier base. All these arise from areas internally controlled by the organisation and that the risk management initiatives including the identification of the risk drivers are necessary to build a resilient supply chain. They discussed managing various trade-off decisions as an essential part of SC while Zsidisin and Ellram in (2003) suggested that risk in a SC context can be defined as the potential occurrence of an incidence associated with inbound supply in which the result is the inability of the purchasing organisation to meet customer demand, which in turns results in a financial loss for the firm.

Owing to the above, managing risks is SCs is one of the greatest challenges to attain business continuity (Trkman and McCormack, 2009; Riley et al., 2016). However, there are closely related concepts related to each other that need to be highlighted in order to understand the difference between them. Those concepts are: SC uncertainty, SC vulnerability, and SCRM. The three concepts are relatively explained in the literature, and sometimes can be used interchangeably, which seems to be confusing (Ekwall, 2010).

2.3.3 Supply chain uncertainty

Literature attempted to show the difference between uncertainty and risks (Simangunsong et al., 2012). While some authors did not consider showing the difference between the two terminologies assuming that it is difficult to do so (Jüttner et al., 2003; Tang and Musa, 2011; Vilko et al., 2014). Moreover, it was argued that both terminologies can be used interchangeably (Ritchie and Brindley, 2007).

SC uncertainty was claimed to be a broader concept including the risky event that may have uncertain negative or positive consequences unlike risk that only has negative consequences

(Simangunsong et al., 2012; Christopher and Holweg, 2017). Nevertheless, some authors (Ritchie and Brindley, 2007; Rao and Goldsby, 2009) highlighted that risk consequences can be also positive in the essence of how to convert the threat into an opportunity to gain. Eventually, it is clear that the sources causing SC risks are the same sourcing causing SC uncertainty (Lavastre et al., 2012; Simangunsong et al., 2012). Thus, the distinction between both concepts is indefinable.

Thus, for the purpose of this research and to be consistent with previous studies (Jüttner, 2005; Waters, 2011; Rao and Goldsby, 2009; Christopher and Holweg, 2011; Tummala and Schoenherr, 2011; Tukamuhabwa Rwakira, 2015; Tukamuhabwa Rwakira et al., 2015) both SC risk and uncertainty have negative effects causing vulnerability to SCs. Accordingly, a need of creating resilience in SCs is urgent to overcome uncertainties causing vulnerabilities (Cardoso et al., 2015; Zhang et al., 2011; Yang and Xu, 2015).

2.3.4 Supply Chain vulnerability

The concept of SC vulnerability started to get attention from academics due to the increasing interest in SCRM and SC resilience (Schlegel and Trent, 2012). However, both the concepts of SC vulnerability and SC risk are used interchangeably in most times (Peck, 2006; Lavastre et al., 2012), but the concept of vulnerability is concerned with the condition of the SC after any exposure to risks (Juttner, 2005; Svensson, 2002; Christopher and Peck, 2004; Agigi et al., 2016). A similar perspective is that vulnerability can be viewed as a combination of the likelihood of an event and its potential severity (Sheffi 2005; Craighead et al., 2009).SC vulnerability has been viewed by Bernes and Oloruntoba (2005) as a function related to SC characteristics that keep the company very sensitive to any kind of threat or uncertainty, which will affect the normal SC operations. Table 2.3 shows a summary of SC vulnerabilities definitions.

Table 2.3: SC vulnerability definitions.

Definitions	Authors
SC vulnerability is about the exposure of SC operations to any disturbance that may be caused by either internal or external risks to the SC	Christopher and Peck, (2004)
The exposure or predisposition to any further loss because of any existing organisational or functional conditions.	Bernes and Oloruntoba (2005)
The exposure or predisposition to any further loss because of any existing organisational or functional conditions.	Marsh (2012)
Vulnerability is about a specific SC characteristics that increase the sensitivity of the organisation to severe disruption	Wagner and Bode (2008); Munoz and Dunbar (2015)
the tendency of threats to offset safety measures causing SC disruptions	Kurniawan et al. (2017)
SC vulnerability is defined as any unplanned deviances from the normal SC operations that causes negative consequences.	Svensson, (2000, 2002, 2004)
Is the exposure of SCs to severe threats that negatively affects the SCs' capabilities to serve their customers.	Juttner (2005); Chopra and Sodhi (2014)
SC vulnerability refers the major elements making the companies subject to any disturbance.	Pettit et al. (2010)
The exposure of SCs to any disruptions that affects SC's capabilities to satisfy the end customers.	Juttner (2005); Juttner and Maklan (2011); Pournader at al. (2016)

From the discussion, it can be seen that not all SC risks are controllable or discoverable, and this is why SCs are meant to be vulnerable (Christopher and Peck, 2004; Pournader at al., 2016). Thus, reducing SCs vulnerabilities and the probability of disruptions' occurrences with the corresponding capabilities improve SC resilience (Pettit et al., 2010; Sheffi and Rice, 2005; Scholten and Schilder, 2015). Moreover, all SC vulnerability definitions found from traditional SCRM concepts were further investigated by other authors (Zsidisin and Ellram, 2003; Svensson, 2004; Peck, 2006). Thus, a deep look will be taken in the next section to explain the SCRM concepts and how different risks are identified and categorized.

2.3.5 Supply chain risk Management

SCRM was developed at the confluence of two relatively well defined concepts i.e., SCM and risk management (Christopher and Lee, 2004). For this reason, SCRM is relatively a new concept that have been developed based on the areas of researchers' origin that began to gain attention of researchers in the early 2000s (Sodhi, et al., 2012; Juttner et al., 2003; Chen and Wu., 2013; Ritchie and Brindley, 2007; Trkman and McCormack, 2009; Tummala and Schoenherr, 2011; Ghadge et al., 2012).

The traditional SCRM concept was seen as maintaining emergency stocks as lead times are becoming less viable (Sheffi, 2007). This have to be done in line with reducing the probability of threats causing disruptions to SCs and to increase resilience through building capabilities to recover from them (Sheffi, 2007). SCRM has been described from SC performance measurement discipline in two ways; first, a link between the overall objectives of the entire chain and SC performance has to be established, second, is to have clear consent on processes, objectives, and KPIs between all SC members (Neely et al., 2002). Some researchers argue that the reason of absence of empirical studies on SCRM is that companies do not focus on having a well-established SCRM system (Christopher and Holweg, 2011; Sodhi et al., 2012; Kim et al., 2015, Wiengarten et al., 2016).

In Table 2.4 some SCRM definitions retrieved in literature are summarized. The first column presents the definitions, the second displays the considered references, the third column indicates whether the definition can be interpreted as either danger or danger and opportunity, and the fourth column presents key managerial application and capabilities in the risk management process.

Table 2.4: SCRM definitions

Definition	Focus	managerial application and capabilities	Link with performance	Author
The identification and management of risks for the SC, through a co-ordinated approach amongst SC members, to reduce SC vulnerability as a whole.	Danger	- Identification - Management - Coordination		Jütttner et al. (2003); Juttner and Maklan (2011)
SCRM applies with Collaboration with partners in a SCRM process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources.	Danger	- Collaboration		Norrman and Lindroth (2002)
SCRM is defined as the management of SC risk through coordination or Collaboration among the SC partners to ensure profitability and continuity”	Danger and opportunity	- Collaboration - Management - Coordination	Yes (profitability and continuity)	Tang (2006); Tang and Musa (2011); Sodhi et al. (2012)

The focus of SCRM is to understand, and try to avoid the devastating effects that disasters or even minor business disruptions can have in a SC.	Danger and opportunity	- Understanding - Avoidance		Norrman and Jansson (2004)
SCRM is a formal process that involves identifying potential losses, understanding the likelihood of potential losses, and assigning significance to these losses	Danger	- formal process - Identification - Understanding		Giunipero and Eltantawy (2004)
SCRM is the systematic identification, assessment and mitigation of potential disruptions in logistics networks with the objective to reduce their negative impact on the logistics network's performance	Danger	- systematic identification -	Yes (logistics network's performance)	Council (2008); Mandal et al. (2016)
Global SCRM is the identification and evaluation of risks and consequent losses in the global SC, and implementation of appropriate strategies through a coordinated approach among SC members with the objective of reducing one or more of the following: losses, probability, speed of event, speed of losses, the time for detection of the events, frequency, or exposure, for SC outcomes that in turn lead to close matching of actual cost savings and profitability with those desired.	Danger and opportunity	- Identification - evaluation - implementation	Yes (cost savings and profitability)	Manuj and Mentzer (2008)
SCRM is defined as the management of SC risks through coordination or Collaboration among the SC partners to ensure profitability and continuity.	Danger and opportunity	- Management - coordination - Collaboration	Yes (profitability and continuity)	Brindley (2004); Trkman et al. (2016)
SCRM is defined as the identification and management of risks within the supply network and externally through a co-ordinated approach amongst SC members to reduce SC vulnerability as a whole.	Danger	- Identification - management - reduction		Goh et al. (2007); Sodhi et al. (2012)
SCRM refers to risks that can modify or prevent part of the movement and efficient flow of information, materials and products between the actors of a SC within an organisation, or among actors in a global SC (from the supplier's supplier to the customer's customer). SCRM can be seen as the capacity to be agile.	Danger and opportunity	- Prevention - Agility		Lavastre et al. (2012)
SCRM process is a tool to provide management with useful and strategic information concerning the SC risk profiles associated with a given situation. This contrasts with the traditional approach based	Danger and opportunity	- managerial tool - information - strategic thinking -strategic decision making	Yes (improve SC performance)	Tummala and Schoenherr (2011); Khan and Zsidisin (2012); Zsidisin et al. (2016)

on single point estimates. The SCRMP ensures SC managers adopt strategic thinking and strategic decision making in evaluating options				
Defined that the SC risk measurement is the system of sub-set of SC performance measurement. Also, there are Two principles from the performance measurement philosophy should be considered in the SC risk measurement discipline. First, the measurement system should be linked to the specific objectives of the chain so it will be focused on the achievement. Secondly, the measurement system requires that all members agree on processes, objectives and measures across the SC.	Danger and opportunity	-System of performance measurements - agree on process and measures	Yes (link performance with objectives and aligning them between all SC members)	Neely et al. (2003); Li et al. (2017)
Find that the focus of SCRM is to understand and try to avoid the devastating ripple effects that disasters or even minor business disruptions can have in a SC	Danger and opportunity	- Understanding - Avoidance		Norrman and Jansson (2004)
Refers that classic SCRM such as maintaining buffer stocks and slack lead times are becoming less viable nowadays. Also, he showed that the aim of SCRM is to reduce the probability of risk events occurring and to increase resilience, and the capability to recover from a disruption	Danger and opportunity	- Reduce - Redundancy		Sheffi (2007)
Adopting qualitative and quantitative techniques to recognize, mitigate, and monitor any micro and macro threats that affects SC negatively	Danger	- Identification - management - reduction		Ho et al. (2015)

Table 2.4 provides the main definitions available in the previous studies. Although it was claimed that there is an absence of a general accepted definition of SCRM (Ponomarov and Holcomb, 2009; Sodhi, et al., 2012), authors indicated vital aspects in SCRM such as: identification, evaluation, mitigation, and monitoring of threats causing SC vulnerabilities (Manuj and Mentzer, 2008). Another significant fact that appears in the definitions is the Collaboration and coordination between all SC members (Jüttner et al., 2003; Tang 2006; Manuj and Mentzer, 2008; Ho et al., 2015) collaborative and coordinated participation among the chains' members, emphasizing the idea that competition occurs based on chains and not on

individual companies' level, i.e. the risk management along the chain is dependent on the relationship and integration among its members.

As most of the concepts argue, SCRM main purpose is the chain's vulnerability reduction. When the risks are recognized and examined, their impacts and occurrences can be reduced in order to avoid them. This is generally known as risk avoidance. Thus, most of the studies, which tackle the definition of reducing vulnerability, associate the concept with chain's performance, response speed and profitability. This is due to the fact that chain reduction vulnerability lessens the various effects related to the risk avoiding loss (Tang, 2006; Manuj and Mentzer, 2008; Neely et al., 2002). Accordingly, SCRM methodologies should bear in mind the management processes' performance in an array of organisations. SCRM asserts that objectives may not be supported; therefore, risk management has to comprise persuasion, negotiation, and reflection among SC partners.

There is a trend within both the researches and empirical studies to consider the consequences and outcomes of any disruption rather than the cause of this disruption (Zsidisin et al., 2005; Tang and Musa, 2011; Sodhi et al., 2012). As a result, several authors defined risk in terms of the sources of uncertainty, rather than focusing on the outcomes of this specific risk (Christopher and Peck, 2004, Juttner, 2005; Manuj and Mentzer, 2008; Christopher and Holweg, 2011). Thus, in the next section, common categories of risk sources will be addressed to highlight the differences between different categories and how risk sources are grouped under these categories.

2.3.5.1 Supply chain risks sources and categories

Literature argues that SCRM prevailed towards focusing on recognized risks with high probability of occurrence rather than exerting efforts to predict the un-expected risks that may have low probability of occurrence (Kleindorfer and Saad, 2005, Chopra and Sodhi, 2004). Moreover, great efforts are done in both literature and practice to give attention to the negative outcomes of risks and how to overcome these outcomes rather than focusing on the causes of these disruption (Zsidisin et al., 2005).

The literature showed a diversity of risks due to the increased complexities of SCs which in turn makes it very hard to explore all threats that may cause vulnerabilities to SC (Khan and Burnes, 2007). Accordingly, it is argued that the identified SC risks present a proportion of the entire risks facing SCs (Khan and Zsidisin, 2012). While reviewing previous studies that explore different types of risks affecting SCs, it appears that these studies lean towards focusing on the identification of different risks, whereas later studies focused on categorizing the sources of risks into groups. Thus, researchers believed that an appropriate SCRM approach would need risks to be identified and grouped (Habermann, 2009).

Apparently, there is no agreement on the most correct way to categorize SC risks (Tukamuhabwa Rwakira et al., 2015). Many scholars tried to group SC risks in the form of taxonomies/typologies, since different risk sources need different risk management activities, understanding the categories and nature of SC disruption is essential (Calvinato, 2004; Chopra and Sodhi, 2004; Christopher and Peck, 2004; Norrman and Lindroth, 2004; Svensson, 2000).

As shown in Table 2.4, many classifications for SC risk are found in the literature proposed by different authors. Mason-Jones and Towill (1998) and Christopher and Peck (2004) identify five risk groups: internal, SC risks, external risks, process, and control risks. On the other hand, Stecke and Kumar (2009) categorized the types of risks that may cause vulnerabilities to SC into 3 managerial levels; strategic, tactical, and operational. Another classification was proposed by Vilko and hallikas (2011) categorizing them under five groups: supply risks, security risks, operational risks, macro risks, policy risks and environmental risks. Another classification of risks was proposed by Wu et al. (2006) based on four categories: internal controllable, internally partially controllable, internal controllable, and external controllable.

Svensson (2000) classified SC risks as quantitative and qualitative, Juttner (2005) proposed three types: supply, demand, and environmental. Whereas Manuj and Mentzer (2008) highlighted eight types: supply, operational, demand, security, macro, policy, competitive, and resource. Wagner and Bode (2009) reviewed other authors' classifications and summarized that SC risk sources have five categories: demand side; supply side; regulatory, legal, and bureaucratic; infrastructure; and catastrophic. Furthermore, according to Tang and Tomlin (2009), SC risks are categorized into six types: supply risks, process risks, demand risks, intellectual property risks, behavioural risks and political/social risks. Chopra and Sodhi (2004) extend this to nine categories of risk which are: delays, systems, forecast, intellectual property, procurement, receivables, inventory, capacity and disruptions. Cousins et al. (2004) have a simpler model, suggesting that companies are exposed to two main types of SC: technological and strategic risks. Other suggested categories of risk included supply market, supplier, regulatory and supply strategy risks (Minahan, 2005). While Johnson (2001) divides SC risks into supply risks and demand risks.

Table 2.5: SC risks classifications

	Type of risk	**Definition**	**Author**
Internal risks	**Are tied to a company's internal product development, manufacturing, and distribution operations.**		
	Operations risk	Related to adverse events within the firm that affect a firm's internal ability to produce goods and services, quality and timeliness of production, and/or profitability. Such as breakdown of operations; inadequate manufacturing or processing capability; high levels of process variations; changes in technology; changes in operating exposure.	Meulbrook (2000); Manuj and Mentzer (2008); Blackhurst et al. (2008); Spekman and Davis (2004); Tummala and Schoenherr (2011)
	Asset risk	Reduces utilization of an asset and can arise when the ability of the asset to generate income is reduced	Yang and Xu (2015); Hofmann et al. (2014)
	Product characteristics	Technical complexity and value of the item are positively correlated with the degree of perceived risk	Zsidisin et al. (2016); Kaufmann and Carter (2006)

	Resource Risks	Risks associated with unanticipated differences in resource requirements in production.	Manuj and Mentzer, 2008; Hamel and Valikangas (2003); Tummala and Schoenherr (2011)
	Process	Issues that can cause fluctuations in effective capacity and quality such as total quality management and lean manufacturing.	Samvedi et al. (2013); Tang and Tomlin (2009); Mason-Jones and Towill, (1998); Peck, (2006)
	Forecast	Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, small customer base "Bullwhip effect" or information distortion due to sales promotions, incentives, lack of SC visibility and exaggeration of demand in times of product shortage.	Chopra and Sodhi, (2004); Blackhurst et al. (2008)
	Inventory	Risks that can occur due to excess inventory, rate of product obsolescence, inventory holding cost, and demand and supply uncertainty	Chopra and Sodhi (2004); Blackhurst et al. (2008); Tummala and Schoenherr (2011)
	Capacity	Building excess capacity usually becomes a strategic choice. Thus, excess capacity hurts financial performance because building cost of capacity reduces firm’s ability to be flexible.	Chopra and Sodhi, (2004); Blackhurst et al. (2008); Tummala and Schoenherr (2011)
	Risk of innovation	Risk conditions equated with conditions characterized by newness, uncertainty, and lack of information.	Rajesh and Ravi, 2015; Pettit et al., 2013
External	**Broad external forces that affect the entire business and SC.**		
	Country	Country of origin of buyer affects an individual’s risk preference	Zsidisin (2003)
	Macro Risks	Economic shifts in wage rates, interest rates, exchange rates, and prices	Manuj and Mentzer (2008); Ho et al. (2015)
	Financial	The common risks are exchange rate risk, price and cost risk.	Tang and Musa, (2011); Merna and Smith (1999); Lakovou et al. (2007)
	Policy Risks	Risks associated with unexpected actions of national governments such as like quota restrictions or sanctions.	Manuj and Mentzer, 2008

	Turbulence	Environment characterized by frequent changes in external factors beyond your control	Sevensson (2000); Sheffi (2005)
	Deliberate threats	Intentional attacks aimed at disrupting operations or causing human or financial harm	Sheffi (2005)
	Environmental	Comprise any external uncertainties arising from the SC such as disruption caused by political (e.g. fuel crisis), natural (e.g. foot and mouth outbreak, fire, earthquake) or social (e.g. terrorist attacks) uncertainties.	Juttner (2005); Mason-Jones and Towill, (1998); Merna and Smith (1999); Peck, (2006)
	Political / Social	A global SC is subjected to social/political risks when multiple countries are involved.	Tang and Tomlin (2009); Merna and Smith (1999)
	Receivables and Procurement	Refers to unanticipated increases in acquisition costs resulting from fluctuating exchange rates or supplier price hikes or through changes in taxation.	Chopra and Sodhi, (2004); Meulbrook (2000); Roberta et al. (2014)
Network	**Centre on a company's upstream and downstream supply chain partners.**		
	Demand risk	Demand risk is the distribution of outcomes related to adverse events in the outbound flows that affect the likelihood of customers placing orders with the focal firm, and/or variance in the volume and assortment desired by the customer, such as: the new product introductions; variations in demand (fads, seasonality, and new product introductions by competitors); chaos in the system (the Bullwhip Effect on demand distortion and amplification); product obsolescence.	Meulbrook (2000); Manuj and Mentzer, 2008; Tummala and Schoenherr (2011); Agigi et al. (2016)
	Strategic risk	Over-reliance on a single or limited number of suppliers.	Agigi et al. (2016); Peck (2006)
	Supply Risks	Disruption of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes	Manuj and Mentzer, 2008; Harland et al. (2001); Zsidisin et al. (2000); Meulbrook (2000); Blackhurst et al. (2008)
	Competitive Risks	Risks associated with uncertainty about competitor activities and moves in foreign markets	Manuj and Mentzer, 2008; Tukamuhabwa Rwakira et al. (2015)
	Supplier/Customer disruptions	Susceptibility of suppliers and customers to external forces or disruptions	Sevensson (2000), Sheffi (2005)

	Intellectual property	While outsourcing or off-shoring can result in lower manufacturing costs, it makes it difficult to protect Intellectual Property.	Tang and Tomlin (2009); Chopra and Sodhi (2004); Finch, (2004); Blackhurst et al. (2008)
	Behavioural	As the number of partners increases in a global supply chain, the level of visibility and control can be reduced significantly.	Tang and Tomlin (2009); Tukamuhabwa Rwakira et al. (2015)
	Delays	Delays in material flows that occurs when a supplier through high utilization or another cause of inflexibility cannot respond to changes in demand.	Chopra and Sodhi, (2004); Zsidisin et al. (2016)
	Receivables	the possibility of being unable to collect on receivables, can torpedo the performance of any company	Chopra and Sodhi, (2004); Zsidisin et al. (2016); Blackhurst et al. (2008)
	Disruption	Disruptions to material flows anywhere in the SC are unpredictable and rare but often quite damaging. Such as natural disasters, labour disputes, supplier bankruptcy, etc.	Tummala and Schoenherr (2011); Chopra and Sodhi, (2004); Tang (2006)
	Control	Risks occurs due to uncertainty arising from inter-organisational networking; such as strategic alliances. The weak control over suppliers and customers in the SC can be compounded affecting links up or down the SC.	Mason-Jones and Towill, (1998); Finch, (2004); Datta et al (2007)
	Strategic decision making	Risks such as the actions of competitors and the increased bargaining power of customers and suppliers.	Finch, (2004); Rao and Goldsby (2009)
	Material flow	Source involves inquiring physical products or services. Typical risk issues are single sourcing risk, sourcing flexibility risk, supplier selection / outsourcing, supply product monitoring/quality and supply capacity.	Tang and Musa, (2011); Svensson (2000)
Functional	**Relate to the business functions that support supply chain activities, such as finance, human resources, legal and information technology.**		
	Systems	The more a company networks its information systems, the greater the threat that a failure anywhere can cause failure everywhere.	Chopra and Sodhi, (2004); Rao and Goldsby (2009)
	Financial	Financial flow risk involves the inability to settle payments and improper investment. The common risks are price and cost risk, financial	Tang and Musa, (2011); Merna and Smith (1999); Tummala and Schoenherr (2011)

		strength of SC partners and financial handling/practice.	
	Data / information security risks	Risks that are largely under the control of the organisation, although this is not always the case such as information security and virus detection / hacking.	Finch, (2004); Blackhurst et al. (2008); Spekman and Davis (2004)
	Accidents	Risks that are to a large extent mitigated by company policies and procedures. Human error is one potential source of accidents common to all sizes of company	Finch (2004); Agigi et al. (2016); Speier et al. (2011)
	Information Risk	The probability of loss arising because of: incorrect, incomplete, or illegal access to information, and information scarcity as a key facet of uncertainty in terms of the existence of important resources and commitment duration	Tang, (2006); Zsidisin et al. (2016); Tang and Musa (2011)
	Regulatory risk, Legal and Bureaucratic risk	Refer to the legal enforceability and execution of SC relevant laws and policies (e.g., trade and transportation laws) as well as the degree and frequency of changes in these laws and policies. This includes the ability to obtain approvals necessary for SC design activities and SC operation. Exposes the firm to litigation with action arising from customers, suppliers, shareholders or employees	Agigi et al. (2016); Wagner and Bode (2009); Minhan, (2005); Meulbrook (2000); Spekman and Davis (2004)

After reviewing literature, it was found that many authors talked about the same risks or similar risks, even though they classified them differently. For example, supply and demand risks are commonly used in the classifications of risks (Meulbrook, 2000; Manuj and Mentzer, 2008; Harland et al., 2001; Zsidisin et al., 2000, 2016; Meulbrook, 2000; Blackhurst et al. 2008). However, some authors did not use the same classification but stated instead different risks that can be grouped under the same demand and supply risks such as: receivables and procurement risk, strategic risk, supplier/customer disruptions, market risks, etc. Moreover, some risks such as legal risks, environmental risks, macro risks, etc. are considered to be out of control of any entity in the SC and can be grouped under one classification, because all of them are considered out of the scope of SC activities and adversely affects all SC partners. While risks that directly affect the focal firms such as machine breakdowns, resource risks, capacity risks, etc. are all considered to be internal risks that affect the firms' normal operations. Consistent with previous research, the classification adopted by Manson-Jones and Towill (1998) and Christopher and Peck (2004) will be adopted as the basis on the assimilated classification that combines all risks. They identified three risk groups: (1) internal risks arising from the organisation, (2) SC risks that are external to the organisation but within the SC, and (3) external risks that are external to the SC and arise from the partners or the environment. Whereas a fourth type – functional risks– was added to Christopher and Peck (2004) classification adopted from a research conducted by Deloitte Development LLC (2013). Functional risks include technical risks that are linked with business functions which support SC activities, such as finance, human resources, legal, and information technology and communication (Deloitte, 2013). The rationale behind adding the functional risks to the classification is that SC encompasses several process oriented organisations that depends on the integration and communication of all business functions inside the company, or from any entity within the entire chain where the company operates (i.e. suppliers, distributors, customers). Thus, it is important to focus in the risks from functionality perspective to ensure that all expected risk factors are known and detected.

2.4 Supply Chain resilience

SC resilience is argued to have arisen from SCRM concepts (Pettit et al., 2010; Ponomarov and Holcomb, 2009). However, some studies from the literature highlighted that the aim of SCRM strategies affects the relationship between SCRM and creating resilience in SCs (Juttner and Maklan, 2011), while others demonstrated that SC resilience is enhanced by putting SCRM strategies into action (Thun et al., 2011). In the next sub-sections, different SC resilience definitions will be investigated to give a deep insight of the concept to achieve the purpose of this study.

2.4.1 What is meant by supply chain resilience?

After discussing the changes happening to the markets that caused SC complexities causing vulnerabilities to SCs, there is an urgent need to review the literature on SC resilience to understand how to build resilience into SCs even if there is no threat causing vulnerability to SCs.

As discussed earlier, SCs consisting of complex networks of companies that experience continual disturbances create potential for unknown disruptions. However, traditional risk management concepts lack the ability to assess SC complexities that in turn affects the ability of a firm to get prepared for any disruptions (Hertz and Thomas, 1983; Starr et al., 2003; Roberta Pereira et al., 2014). Many SC researchers are paying more attention to the concept of resilience. However, resilience concept is used interchangeably with risks and vulnerability in previous studies. Moreover, SC resilience term emerged because not all the SC risks can be avoided or controlled (Peck, 2006). Thus, further exploitation of the concept will be highlighted in this section to identify the main characteristics underpinning the concept.

2.4.2 Definitions of supply chain resilience

Resilience is an evolving concept and differs from traditional risk management. Since the 1970s, risk analysis techniques have played a major role in corporate decision making, especially when combined with financial models (Hertz and Thomas, 1983). To incorporate the concept of resilience into management theory, the use of the term resilience in a variety of non-business fields and discuss lessons that can be applied to the study of SC resilience must be presented. The concept of resilience is used extensively in engineering, ecological sciences and organisational research, all of which provide insights into creating a conceptual model for SC resilience. Timmerman (1981) was one of the first to define resilience of a society as the measure of a system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event. Folke et al. (2010) defined the three properties of resilience: (a) amount of change the system can undergo (and implicitly, therefore, the amount of extrinsic force the system can sustain) and still remain within the same domain of attraction (i.e., retain the same controls on structure and function); (b) The degree to which the system is capable of self-organisation, (c) The degree to which system can build and increase the capacity to learn and adapt.

A very basic definition of resilience can be found in engineering: the tendency of a material to return to its original shape after the removal of a stress that has produced elastic strain (Merriam-Webster, 2007). However, it may be beneficial for a SC not to return to its original shape following a disruption, but rather to learn from the disturbance and adapt into a new configuration. In the ecological sciences, the standard definition of resilience is the ability of an ecosystem to rebound from a disturbance while maintaining diversity, integrity and ecological processes (Folke et al., 2010). The concept of adaptability is vital to living systems, and SCs may be realized as a network of systems. Accordingly, Fiksel (2006, 2015) projected four key characteristics of resilient systems: diversity, efficiency, adaptability and cohesion. Thus, creating resilient leaders is the optimum way to ensure that any organisation will thrive in a very muddled and unpredicted future and those resilient organisations consistently survive more than their less resilient competitors (Stoltz, 2004; Scholten et al., 2014).

In business terms, resilience characterizes the company's ability to respond to an unpredicted disruption and re-establish normal operations or move to a new, more desirable state, after being disturbed (Rice and Caniato, 2003; Christopher and Peck, 2004; Peck, 2006; Tang, 2006; Li et al., 2017). Robustness and resilience are very similar concepts; robustness highlights the ability of a company to maintain the continuity of its operations and resilience, the ability of the company in recovering from a disruption to a state not worse than the previous one (Han and Shin, 2015). Thus, with resilience the company can achieve a better operational state than before the disruption. Moreover, resilience does not only measure the company's ability but also the speed at which it can return to the usual performance level after a high impact disruption (Sheffi, 2007). How quickly and effectively a company will return to its normal or desirable operations do not depend only on the processes and the infrastructure it has in place, but also on the company's speed reaction to a disruption. For this reason, resilience now has become an issue of enormous importance in relatively new fields such as risk management and SCM, disaster management.

SC resilience was defined by Ponomarov and Hollcomb (2009) as the adaptive capability of the SC to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function. While in 2005, Sheffi and Rice stated that resilience can be achieved by creating redundancy or increasing flexibility and that flexibility may create company capabilities that can detect threats and respond to them quickly.

Fiksel (2006) defined resilience as the capacity of a system to adapt, survive and grow in the face of unstable change. From Pettit (2008) point of view; resilience is a feature of complex systems such as companies, cities or ecosystems, where systems evolve through cycles of growth, accumulation, crisis and renewal, and even self-organize into new, more desirable configurations. While Perrings (2001) defined the resilience in terms of the broader concept of sustainability as the capacity to absorb stress and shocks, Bruneau et al. (2003) refer, to how a community reduces the probability of structural or system failure, and how quickly it returns to normal in the case of the last. Table 2.6 provides a summary of resilience definitions from a SC perspective.

Table 2.6: SC resilience definitions

Definition	Author
Resilience is the ability of the network of supply to respond to any unexpected threat and restoring the normal SC operations.	Rice and Caniato (2003)
Is the ability of SCs to be ready for any unknow events, responding, and quickly recovering to a more preferable condition	Hohenstein et al. (2015)
It is the SC ability to return to either get back to the normal operations, or to a more favorable condition before the disruption occurrence	Christopher and Peck (2004)
It is the company's ability to make a rapid rebound from any disruption go get back to the normal SC performance of all activities	Sheffi (2005)
Resilience is all about how far the capacity of the SC is capable to adopt, survive in any troubled circumstances.	Fiksel (2015)
Refers to the operational capabilities companies employ to maintain the operations between different tiers in the chain	Munoz and Dunbar (2015)

It is the SC capabilities that help companies to be ready for any unknown events, respond to them, and recover while keeping the normal operations at the required level of connectedness and control.	Ponomarov and Holcomb (2009)
The SC capability to restore its operations	Ambulkar et al. (2015)
It is the SC ability to last, cope, and grow in the time of turbulence.	Pettit et al. (2010)
The SC capability to get back to the required operational level after any disturbances	Khan and Zsidisin (2012)
It is the capacity of SCs to proactively plan and design networks to anticipate negative threats, and react to them adaptively while keeping all processes and functions in control, and if possible to a better condition to gain a competitive advantage.	Ponis and Koronis (2012)
It is the ability of SCs to rebound from any disruption consequences while finding a way to permanently deal to the environment dynamics.	Yao and Meurier (2012)
The capabilities of the entire chain to evade any risks	Winston (2014)
Resilience is the overall approach undertaken to manage SC risks and dealing with unexpected disruptions	Scholten et al. (2014)
It is the ability SCs to manage unplanned disruptions	Roberta Pereira et al. (2014)
It is the SC ability to manage any changes by being read, alerted and agile	Li et al. (2017)

Table 2.7 provides a summary of resilience definitions from different perspectives; engineering, organisational, and SC views.

Table 2.7: Resilience Characteristics

Characteristics	Definition	Focus	References
Engineering			
	Capability of a body to recover its size and shape after deformation	Reactive/recovery	Merriam-Webster (2007); Gunderson (2000)
Ecosystem and Social Science View			
Equilibrium seeking	Ability to rebound from a trouble while maintaining diversity, integrity, and ecological processes	Reactive/ Static	Folke et al. (2010); Ungar (2011); Murray and Zautra (2012)
Adaptability	Ability to absorb and recover from the occurrence of hazardous events	Reactive /Recovery	Timmerman (1981); Carpenter, (2001); Carvalho et al. (2012); Kent (2012); Murray and Zautra (2012)
Learning and planning for disasters	Proactive ability that accepts change and tries to create a system capable of adapting to new conditions by learning and planning	Proactive /Mitigation / static	Ungar (2011); Gunderson (2000); Murray and Zautra (2012)
Dynamic process	Ability to maintain or regain dynamically stable state	Proactive /Mitigation / dynamic	Marie at al. (2016); Hale and Heijer (2006); Klein et al (2003)
Organisational View			
Dynamic capacity	A dynamic capacity that maintains positive adjustment under challenging conditions, dynamic capacity that grows and develops with time	Dynamic	Worline et al. (2006); Sutcliffe and Vogus (2003); Ortiz-de-Mandojana and Bansal (2015); Castellacci (2015)
Flexibility	Resilience implies being flexible enough to adapt to both positive and negative influences	Proactive Recovery / coping	Rice and Caniato (2003); Pal et al (2014); Anderson (2003); Coutu (2002); Sutcliffe and Vogus (2003); Hatum and Pettigrew (2006)

Monitoring awareness	Monitoring, recording of outputs, sensing and interpreting Awareness the outputs through appropriate measures	Reactive Recovery / Mitigation	Appelbaum and Gallagher (2000); Weick and Sutcliffe (2001); Pal et al (2014)
Integration/Alignment Information Sharing	Resilient organisations are characterized by shared sense of organisational purpose	Recovery / mitigation	Weick and Sutcliffe (2001); Sheffi (2007); Castellacci (2015); Leiblein (2011); Tang and Tomlin (2008)
Collaboration, coordination, and communication	Improved communication and coordination reduces risks by increased sense making of unpredictable environments	Proactive Mitigation	Weick and Sutcliffe (2001); Sheffi (2007); Leiblein (2011); Pal et al (2014)
Redundancy	Slackness is organisational shock absorber to environment jolts and the system's capacity to absorb and recover from the occurrence of an unsafe event	Reactive Mitigation/recovery	Weick and Sutcliffe (2001); Perrings, (2001); Stoltz (2004); Rice and Caniato (2003); Sheffi (2007); Ortiz-de-Mandojana and Bansal (2015)
Avoidance	People try to be as thorough as possible to avoid exposure of risk	Reactive	Li and Zahara (2012); Smith and Prior (1995); Borekci et al. (2014); Naor et al. (2010)
Supply chain view			
Visibility and information sharing	Improving end-to-end visibility improves mitigation of risk and helps in responding faster	Mitigation / Recovery /reactive	Chopra and Sodhi (2004); Christopher and Lee (2004); Blackhurst et al. (2005); Lee (2005); Juttner and Maklan (2011); Tang (2006); Brandon-Jones et al. (2014)
Control	Having control and connectedness on all SC functions		Ponomarov and Holcomb (2009); Ponis and Koronis (2012); Ponomarov (2012)
Agility / velocity	Rapid response to changed conditions. It measures the ability and speed at which SCs can return to their normal performance level after a disruption.	Recovery	Christopher (2000); Christopher and Peck (2004); Nishat Faisal et al. (2006); Sheffi and Rice (2005); Carvalho et al. (2012); Pettit et al. (2013); Ponis and Koronis (2012); Mandal (2012); Scholten et al. (2014)
Structure /capacity	A broad element of SC resilience is knowledge and understanding of SC structures and capacities - both physical and informational that would lead SCs to self-organize into new, more desirable configurations.	Mitigation / Recovery / reactive	Samaddar et al. (2006); Pettit (2008); Fiksel (2006); Yang and Xu (2015); Scholten et al. (2014)
Flexibility	Increasing flexibility enables supply chain's ability to respond quickly and efficiently to market changes. It may be different from the original state by using the market opportunities and by tackling the external unrest.	Recovery / Coping/reactive	Barad and Sapir (2003); Das and Patel (2002); Garavelli (2003); Kleindorfer and Saad (2005); Chopra and Sodhi (2004)); Sheffi and Rice (2005); Christopher and Peck (2004); Mandal et al. (2016); Ambulkar et al. (2015)
Integration/ Collaboration	To manage risks effectively SCs should adopt collaborative partnerships within members	Mitigation / Recovery / proactive	Raj Sinha et al. (2004); Giunipero and Eltantawy (2004); Hoyt and Huq (2000); Handfield and Nichols (2004); Haywood and Peck (2003); Geary et al. (2006); Van der Vorst and Beulens (2002); Lee (2005); Scholten et al. (2014)

Redundancy	Adding some redundancies in supply chain can help to deal with unforeseen happenings	Mitigation / Recovery / proactive	Sheffi (2001, 2005); Sheffi and Rice (2005); Martha and Subbakrishna (2002); Ponis and Koronis (2012)
Diversification	Multiple sourcing, augmentation of capability by providing additional resources diffuse impacts of disaster and improves preparedness	Mitigation/ Recovery / proactive	Hendricks et al. (2008); Urciuoli et al. (2014)
Robustness	Resisting risks and recover from the disruption.	Mitigation / Recovery / proactive	Han and Shin (2016); Durach et al. (2015); Ponis and Koronis (2012); Yang and Xu (2015); Vlajic et al. (2013)

From Tables 2.6 and 2.7, it can be argued that there are several definitions of SC resilience combining different characteristics, such as: capacity, adaptive capabilities, preparations, etc. (Ponomarov, 2012; Ponis and Koronis, 2012). Moreover, most of the definitions ignored the any cost related aspects (Tukamuhabwa Rwakira, 2015; Tukamuhabwa Rwakira et al., 2015). However, it has been stated that SC resilience can be achieved in a cost-efficient way without high operations costs (Ishfaq, 2012). Another point about SC resilience that should be considered is that resilience has another point other than the ability to manage risk, which is the way any SC respond to these risks in a more cost-effective manner than its rivals to gain a competitive edge (Yao and Meurier 2012)

Furthermore, there are different focuses (mitigation, recovery, dynamic, and proactive) on the relevant research which are thoroughly identified. The literature is classified into these four broad categories to show that resilience – apart from being a dynamic phenomenon – is a combination of capabilities required to mitigate the effects of unwarranted happenings, recover from hazards after they occur and make decisions to adopt a set of capabilities in response to changes in environment. Thus, the challenge is to establish a proactive process to identify possible sources of risk, measure potential effects on the SC and then select appropriate counter measures that may prevent or mitigate the effects (Knemeyer et al., 2009). The reason behind this is that resilience is more than just recovery; it also implies a certain level of flexibility and ability to adapt to both positive and negative influences of the environment (Mitroff and Alpaslan, 2003).

Resilience is not just recovery from the setbacks, but it is a structured and integrated exploration of capabilities within the SC to resist and win against unforeseen happening. Accordingly, a resilient SC must have enough slack to recover from any disruptions, but this slack should in no way harm the normal working efficiency. Nevertheless, it should be watchful of and responsive to any faint signal of deviation or disturbances through continued monitoring of KPIs, thus concentrating on the prevention of loss of control over risks. One major drawback of this approach is that SC resilience is built on passive rescue and recovery thinking. However, the proactive resilience is considered as the inevitability of change, and creating a system that can adapt to new conditions and necessities.

Thus, it is obvious from the summary of previous researches on SC resilience and organisational resilience that the importance of SC resilience in all contexts is a dynamic characteristic and a source of sustainable competitive advantage for SCs, individuals and organisations.

In the next section, SC resilience literature will be further investigated and analysed to address the research gaps for this thesis.

2.4.3 Supply chain resilience constructs

The SCRM and resilience literature has moved on in the last five years (Bailey, 2016). It was argued that there was an urgent need to shift from the traditional risk management approaches that faced inherent difficulties in predicting some risks and their consequences due to the complex environment surrounding SCs (Pettit et al., 2013; Fiksel, 2015; Scholten et al., 2014). Accordingly, a notable number of studies; such as Pettit et al. (2013), Fiksel (2015), Vilko et al. (2014) highlighted the concept of SC resilience outlining the key constructs for building resilience into SCs.

Whereas the SC resilience as a concept was traditionally focusing only on different aspects of management risks, recent views highlighted that resilience forms an important block of having a sustainable SC. Thus, enhancing capabilities will enable in turn companies to gain a competitive edge over their rivals by performing at a higher level than other companies that does not adopt resilience into their SCs (Stoltz, 2004; Sheffi, 2005).

Consistent with (Agigi et al., 2016), previous studies on SC resilience and its constructs was originated from the influential research conducted by Christopher and Peck (2004). This research argued that to deal with SC risks, resilience capabilities; such as, 'Collaboration' and 'agility', should be considered to improve SC resilience (Christopher and Peck, 2004). Table 2.8 highlights a review of previous researches on the key SC resilience constructs adopted from Bailey (2016)

Table 2.8: Summary of literature on SC resilience constructs

Authors	Focus	Methods Used	Findings
Zsidisin et al. (2005)	vulnerabilities	Case study	- Supply risk theory using grounded theory approach
Pettit et al. (2013)	Resilience	Survey	-Vulnerability and capability factors linkage -development of a SC resilience measurement tool -linkage between increased resilience and improved supply chain performance
Svensson (2002)	Vulnerability	Survey	- inbound and outbound vulnerability evaluation between firms in supply chains
Fiksel (2015)	resilience	Discussion/Managerial implications	- the need for organisations to balance and match capabilities to vulnerabilities
Manuj and Mentzer (2008)	vulnerability	Literature review and conceptual model building	- six risk management strategies with respect to environmental conditions
Vilko et al. (2014)	Uncertainties	Literature review and conceptual model building	-conceptual separation of uncertainty and risk -typology of uncertainties
Giannakis and Louis (2011)	Disruptions	Modelling	-mitigation of risks in manufacturing supply chains - decision support system for the management disruptions
Scholten et al. (2014)	Resilience	Case study	resilience and disaster management processes' integrated framework of antecedents
Chowdhury and Quaddus (2015)	Resilience and vulnerability	Case study	-Core capabilities for mitigation -Four key vulnerabilities of Bangladeshi RMG industry

Scholten and Schilder (2015)	Resilience	Case study	- mutual dependence between parties can increase resilience -Collaboration as an antecedent of resilience
Leat and Revoredo-Giha (2013)	Resilience	Case study	-Collaboration linked to reduction in vulnerability
Hohenstein et al. (2015)	Resilience	Literature review	-Common proactive and reactive strategies -Four phases of SC RESILIENCE readiness, response, recover and growth
Johnson et al. (2013)	Resilience	Case study	-Three element of social capital: Structural, Cognitive, Relational -All could impact positively on capabilities to improve resilience
Durach et al. (2015)	Robustness	Systematic literature review	-Robustness as a intra and inter-organisational construct -Two dimensions of robustness: Resistance and avoidance -Eight traits of robustness
Vlajic et al. (2013)	Robustness and vulnerability	Model/assessment tool and case study	- Relation between impact of disturbances and specific characteristics of the supply chain -Development of vulnerability measurement tool
Chopra and Sodhi (2014)	Resilience	Supply network modelling	-Strategies to balance supply efficiency with resilience -Longer term cost benefits of resilience vs short term impact on efficiency
Kim et al. (2015)	Network resilience	Modelling	-Resilience is a structural property of a supply network -Redundancy does not necessarily lead to overall resilience and could lead to sub-optimal resilience
Wieland and Wallenburg (2013)	Resilience	Survey	-Two relational competences: Communication, co-operation and integration
Brandon-Jones et al. (2014)	Resilience and robustness	Survey	-Resource based view of resilience and robustness -Linkages between resources, capability and outcomes

Adopted from Bailey (2016)

It is clear from the foregoing table (Table 2.8) that SC resilience has become a central aspect to manage risks. However, it has been argued that there is a lack in having a consistent definition and understanding of the concept (Hohenstein et al., 2015). Moreover, most of the studies claimed that the aim of resilience is to reduce SC risks that causes vulnerabilities and to indicate the capabilities that would help SCs to anticipate and eliminate of any disruptions (Hohenstein et al., 2015; Chopra and Sodhi, 2014; Johnson et al., 2013; Chowdhury and Quaddus, 2015; Svensson, 2002).

To be able to avoid vulnerability factors caused by SC disruptions, previous studies have claimed that any SC can develop capabilities to assure sustainability by enabling SCs to anticipate and get rid of any disruptions (Pettit, 2008). This means that capabilities are considered important traits for performance or success (Merriam-Webster 2007). Much of the previous studies on SC resilience address the capabilities that they all refer to what can help in building resilience (Peck et al., 2003; Hamel and Valikangas, 2003; Rice and Caniato 2003; Fiksel 2006; Lee 2005; Peck 2006; Sheffi, 2005). For example, Sheffi (2005) addresses capabilities as a management response to SC vulnerabilities including: flexibility, redundancy, security, and Collaboration. While Tang (2006) proposed nine strategies that help any SC to highly perform the normal circumstances and to come back quickly after any disruptions: postponement, strategic stock, flexible supply base, make-and-buy, economic supply incentives, flexible transportation, revenue management, dynamic assortment planning and silent product rollover. Moreover, Lee (2005) suggested three key capabilities: agility, adaptability and alignment. While Fiksel (2006) proposed four capabilities: Diversity, cohesion, adaptability, and efficiency. However, it has been argued that SC resilience can be attained through redundancy and flexibility within the entire chain (Rice and Caniato, 2003; Sheffi and Rice 2005). Nevertheless, Pettit et al. (2010) pointed out fourteen capability factors and seventy-one sub-factors. While Jüttner and Maklan (2011) viewed SC resilience in four main characteristics only: flexibility, velocity, visibility and Collaboration.

In the following table (Table 2.9), various capabilities that have been considered in previous studies will be addressed with corresponding authors.

Table 2.9: SC capabilities

Capability	Definition	Author
Agility/Velocity	The ability to respond rapidly to unpredictable changes in demand or supply.	Christopher and Peck (2004); Tang and Tomlin (2008); Carvalho et al. (2012); Scholten et al. (2014)
Visibility	Knowledge of the status of operating assets and the environment by improving end-to-end visibility and information sharing	Chopra and Sodhi (2004); Chritopher and Lee (2004); Pettit et al. (2010)
Flexibility	Ability to quickly change quickly and efficiently to market changes	Christopher and Lee (2004); Chopra and Sodhi (2004); Kleindorfer and Saad (2005); Pettit et al. (2010); Rice and Caniato (2003); Sheffi, (2005); Sheffi and Rice (2005); Tang (2006); Pettit (2008); Zsidisin and Wagner (2010); Carvalho et al. (2012)
Collaboration	Ability to work effectively with other entities for mutual benefit	Sheffi (2005); Lee (2005); Pettit et al. (2010); Rice and Caniato (2003); Ponomarov and Holcomb (2009); Pettit et al. (2010); Scholten et al. (2014)
Avoidance	Dropping specific products, suppliers, or geographical markets.	Juttner et al. (2003)
Control	Control contingencies from various risk sources rather than passively treat uncertainties as constraints	Juttner et al. (2003)
Adaptability	Ability to modify operations in response to challenges or opportunities	Rice and Caniato (2003); Fiksel (2006); Tang (2006); Peck (2005); Pettit et al. (2010)
Efficiency	Capability to produce outputs with minimum resource requirements	Fiksel (2006), Sheffi (2005); Pettit et al. (2010)
Redundancy	it helps companies to respond to disruptions its services during the recovering period after a disruption. Companies mostly practice to protect themselves by keeping spare inventory and in some cases by maintaining production lines or facilities in excess of capacity requirements, committing to contracts for material supply (buying capacity or sub-contracting), and maintaining a dedicated transportation fleet	Rice and Caniato (2003); Juttner and Maklan (2011); Sheffi (2005); Peck (2006); Tang (2006)
Alignment	Interests of all participating firms in the supply chain on their own. As each player maximizes its own interest, it optimizes the chain's performance as well.	Lee (2005)
Cohesion	Associated to the existence of unifying relationships among entities supporting the effort to sustain the current state or to change to a new state without network rupture.	Fiksel (2006)
Decentralization	In an uncertain environment, decentralization ensures flexibility of responses in the face of unexpected events. the decentralized information structure in the supply chain implies individual members make decisions on the basis of local information available access global information as well; and use them together for making decisions	Anand and Mendelson (1997); Samaddar et al. (2006)

Anticipation	Anticipation helps a company to predict disruptions or risky events that may attack its supply chain network, which enables it to pro-actively respond and prevent if possible.	Christopher and Lee (2004); Pettit et al. (2010)
Risk management culture	A company should hire qualified and creative personnel whom have culture of risk management, know how to deal and take decisions, and are flexible enough in the occurrences of any disruption	Peck et al. (2003)
Competence and efficiency	It is related to the efficiency /redundancy trade-off. Capacity and inventory can provide slack, supporting a proper response to disturbances. However, they could hinder efficiency gains in supply chains	Christopher and Peck (2004)

Table 2.9 shows that the most cited capabilities are flexibility, visibility, redundancy, Collaboration, and agility. Although these capabilities separately would create a lot of value to the organisation, but it is noteworthy to mention that not all of them are essential, and some of them can be grouped together as one capability. Moreover, some of them can be considered as key enablers that would enhance the implementation of these strategies; such as organisation and technology. However, it has been mentioned that resilience capabilities can have proactive and reactive strategies, even though some strategies can be reactive or proactive based on when and why they are applied (Tukamuhabwa Rwakira et al., 2015). For example, Collaboration can be very useful to eliminate any probability of risk occurrence, but it can also be very vital to fasten the recovery process through enhancing information sharing between SC partners (Scholten et al., 2014). However, developing capabilities that are best linked to overcoming the SC's risks creates a balance between investment and risk (Pettit et al., 2010). For this reason, SC managers may hardly accept to execute proactive strategies for mitigation of any threat that may or may not occur (Tukamuhabwa Rwakira, 2015; Tukamuhabwa Rwakira et al., 2015).

In the next sub-section, an overall view of the empirical studies available will be investigated

2.4.4 Empirical research on supply chain resilience

As discussed earlier, resilience concept has been widely discussed in the literature covering conceptual, theoretical, and modelling efforts addressing the SC resilience building blocks (Tukamuhabwa Rwakira et al., 2015). A systematic literature review study conducted by Tukamuhabwa Rwakira et al. (2015) investigated 91 papers indicated that 39 studies addressed conceptual and theoretical efforts, while 33 studies addressed modelling efforts, only 21 studies are considered empirical research through either case studies or surveys (Tukamuhabwa Rwakira et al., 2015; Tukamuhabwa Rwakira, 2015) as shown in Table 2.10 based on the efforts conducted by Tukamuhabwa Rwakira et al. (2015).

Table 2.10: Summary of empirical studies on SC resilience.

Authors	Year	Focus and modelling approach	Country
Battezzati and Magnani	2000	Mitigation of risks in FMCG industry	Italy
Rice and Caniato	2003	Securing resilient SCs in high-tech and pharmaceutical companies against terrorist attacks	USA
Pettit et al.	2010	SC resilience by matching capabilities with vulnerabilities using case study and focus group on beauty care products retailer.	USA
Zsidisin and Wagner	2010	SC risk sources and resilience practices using Survey in construction, paper and aircraft manufacture	USA and Germany
Blackhurst et al.	2011	Enablers of supply resilience using a case study of an automobile manufacturer.	USA, China, and Korea
Jüttner and Maklan	2011	SC resilience capabilities in a global financial crisis using case study of 3 firms.	Not indicated
Bala and Kumar	2011	SCRM techniques in FMCG industry	India and South Africa
Diabat et al.	2012	Analysing SC risks in FMCG	India
Mandal	2012	Antecedents of SC resilience using Survey of IT executives	India
Golgeci and Ponomarov	2013	Firm innovativeness and SC resilience using surveys	USA and Europe
Johnson et al.	2013	Social capital and SC resilience using case study of UK rail crash.	UK
Boone et al.	2013	Strategic orientation of inventory and SC resilience using field study involving ten United States Air Force locations	USA
Azevedo et al.	2013	An assessment model based on green and resilient practices in four companies; one automaker and three first-tier suppliers.	Portugal
Fakoor et al.	2013	SC resilience through matching capabilities with vulnerabilities using survey in the automobile SC	Iran

Pettit et al.	2013	An assessment tool for SC resilience using case study of global manufacturing and service firms	USA
Wieland and Wallenburg	2013	Interactive competences and SC resilience using Survey of manufacturing firms.	Germany, Australia. And Switzerland
Leat and Revoredo	2013	Developing resilient in Agri-food SC using case study	UK
Diehl and Spinler	2013	Adopting Supply Chain Operations Reference (SCOR) model to identify risks in FMCG industry	Eastern and central Europe
Urciuoli et al.	2014	Strategies for building the SC resilience of energy SCs using case study of five oil and gas companies.	Europe
Borekci et al.	2014	Relational dynamics and resilience in buyer-supplier triads using case study from textile industry.	Turkey
Scholten et al.	2014	Mitigation processes and SC resilience using case study of the non-profit organisations	USA
Brandon- Jones et al.	2014	Antecedents of SC resilience and robustness using Survey on manufacturing companies.	UK
Scholten and Schilder	2015	Collaboration and SC resilience using case study	Netherlands
Golgeci and Ponomarov	2015	Firm innovativeness and SC resilience using survey	USA and Europe
Tukamuhabwa Rwakira et al.	2015	Investigation of risks causing threats to SCs, and strategies employed to eliminate SC disruptions in manufacturing companies	Uganda
Agigi et al.	2016	Identification of risks and appropriate solutions linked to the various risks in FMCG	South Africa

Source: Tukamuhabwa Rwakira et al. (2015); Tukamuhabwa Rwakira (2015)

Table As shown in Table 2.10, the researcher extended Tukamuhabwa Rwakira et al. (2015) efforts by adding 6 studies to the summary of empirical researches on SC resilience. Those studies are: Battezzati and Magnani (2000); Bala and Kumar (2011); Diabat et al. (2012); Diehl and Spinler (2013); Tukamuhabwa Rwakira et al. (2015); Agigi et al. (2016). Accordingly, it is obvious that the number of empirical studies is limited to 27 study. Through analysing these studies, there are several important issues that need to be highlighted.

First, most of the studies have been conducted in developed countries. However, developing countries faces most of the instabilities and SC failures. Moreover, the economic and social differences between the developed and developing countries is very significant, such as the poor transportation infrastructure, cultural differences, etc. (Tukamuhabwa Rwakira, 2015; Tukamuhabwa Rwakira et al., 2015).

Second, it is noted that SC resilience studies focus only on the company as the analysis unit without taking a holistic view of the entire chain members' risks. However, failing in detecting the risk factors affecting the entire network may inevitably affect SC performance (Gaonkar and Viswanadham, 2007). Furthermore, it has been argued that the resilience of any company is determined by the entire resilience of the network (Sheffi and Rice, 2005). Thus, it is of an urgent need to focus beyond the firm's boundaries (Klibi at al., 2010) by considering the entire SC network rather than taking a silo perspective in managing SC resilience (Soliman et al, 2016).

Third, as per a study conducted by Agigi et al. (2016) it has been argued that a few recent studies Battezzati and Magnani (2000), Diehl and Spinler (2013), Bala and Kumar (2011), Diabat et al. (2011), Tukamuhabwa Rwakira et al. (2015), and Agigi et al. (2016) have been conducted in the FMCG industries in Italy, Eastern and central Europe, India and South Africa, India, Uganda, and South Africa respectively. These studies highlighted the reasons of disruptions facing FMCG industry Battezzati and Magnani (2000) and Bala and Kumar (2011), and Diehl and Spinler (2013) argued that risks occurring from supplier side are the significant in FMCG industry. Thus, these studies primary focus is on SCRM rather than focusing on resilience concept. However, Tukamuhabwa Rwakira et al., 2015 went a step forward and analysed the supply network in manufacturing companies in Uganda to explore the SC resilience constructs in the developing countries.

Although the need to create SC resilience in FMCG industry is clear from the studies conducted in FMCG industry, yet no studies have taken place to explore the SC resilience constructs and their interactions specifically in the FMCG industry in the MER.

Last, SC resilience and risk management activities are only justified if the risks that cause vulnerabilities affect SC performance (Wagner and Bode, 2008). As far as the researcher knowledge in concerned, few studies (Hendricks and Singhal, 2003 and 2005; Ritchie and Brindley, 2007) explored the interconnection between risks causing vulnerabilities and SC performance. Although it has been argued that there is a direct relation between risk and performance (Knight, 2012; Hallikas et al., 2005; Chapman and Ward, 2003), having a standard performance measurement system to address the context of performance and risk need is still ambiguous. Thus, investigation of different performance measurement systems will be addressed in the next section to understand the different applied systems in SC context.

2.5 Supply chain performance management

Interest in measuring SC performance has increased dramatically among researchers and practitioners in the last 20 years (Elgazzar, 2013). It has been argued that measuring the performance enables SCs to evaluate their processes to determine the appropriate improvements needed (Parker, 2000). Furthermore, according to Kotler and Keller (2006), organisations reach their targets when they satisfy their customers with greater performance than their rivals, this is according to the marketing perspective.

There have been several definitions to performance measurement; for instance, Neely et al. (2002) define performance measurement as the process of quantifying the effectiveness and efficiency of action. Effectiveness is the extent to which customers' requirements are met, while efficiency measures how economically firms' resources are utilised when providing a pre-specified level of customer satisfaction through metrics which are to quantify both the efficiency and effectiveness of any action. Another definition stated by Moullin (2002) indicates that performance measurement is about how companies assess themselves in the way they manage and deliver value to all stakeholders.

In a SC context, different performance measurement systems have been recently developed using different techniques and for different purposes. The Balanced Scorecard (BSC) is the most widely applied system (Braz et al., 2011). Kaplan and Norton (2001) provided a measurement concept to integrate financial and non-financial indicators in a first generation BSC approach. Their management concept aims at evaluating business enterprise from four different perspectives: the financial perspective, the customer perspective, the internal business process and the learning and growth perspective. It gives top managers a fast and comprehensive view of their businesses, as it is a balanced presentation of both financial and operational measures.

Kaplan and Cooper (1998) discussed the use of multiple performance design, such as Activity-Based Costing (ABC) systems. They claimed that multiple designs provide visibility of the economics of their operations. The focus was on using multiple cost systems to provide more responsive, accurate and relevant information for serving companies. However, cost measures were the main measures in systems with no attention paid to non-financial measures.

Neely et al. (2002) developed a performance prism framework that comprised five integrated perspectives. The top and bottom facets are stakeholder satisfaction and stakeholder contribution, while the three other facets are strategies, processes and capabilities. The prism attempted to illustrate the complexity of performance management and measurement. However, the prism does not have consistency between its components, as the stakeholders' expectation may exceed the set level of performance.

Neely and Jarrar (2004) formulated the Performance Planning Value chain framework (PPVC). The focus is on what will add real value to the organisation by comparing the performance with other competitors. Thus, benchmarking was one of the recent methods that have been used in a performance measure evaluation system. PPVC aims to transform data into value-added information that enables organisations in their decisions.

Cuthbertson and Piotrowicz (2011) developed Content, Context and Process (CCP) framework for analysing SC performance measurement systems. The content element includes the categories and dimensions of metrics used in the assessment process. The context element aims at identify the factors that influence the SC performance, and process elements which cover the methods and frameworks used to assess the performance of the SC.

Some of the various performance measurement systems that have been proposed and used to evaluate the performance of SCs have been subjected to criticism. According to previous studies (Gunasekaran et al., 2001; I. van Hoek, 2001; Ramaa et al., 2009; Agami et al., 2012), almost no performance measurement systems are adjusted to the actual SC necessities. From the perspective of Chan and Qi (2003), SC performance is measured in oversimplified terms that are counterproductive. That is, it fundamentally focuses on costs as the means to minimize individual costs but not to maximize the value to the end customer. Pohlen and Lambert (2001) also criticized the measures used to evaluate SC performance. From their perspective, the SC performance measurement systems are focused on logistics measures (e.g. lead time, fill-rate, on-time performance), but do not provide information on how well the key business processes have been performed, or the extent to which the SC should meet customer needs. Moreover, the same authors argue that these measures do not provide information on the way by which the overall SC have performed and failed to identify opportunities in order to increase competitiveness, customer value and shareholder value for each company in the SC.

Table 2.11 shows some common performance measurement systems and frameworks applied in the SC context.

Table 2.11: SC performance measurement systems

Framework/System	Author
Performance Measurement Matrix	Keegan et al. (1989)
Performance pyramid	Lynch and Cross (1992)
Function-based measurement system (FBMS)	Christopher (1999)
Integrated framework to measure SC performance	Beamon (1999)
Time-based competition system	Azzone et al. (1991)
Determinants framework	Brignall et al. (1991)
Balanced scorecard (BSC)	Kaplan and Norton (2001)
Performance Pyramid	Lynch and Cross (1992)
Macro process model	Brown (1996)
Activity-based cost system (ABC)	Kaplan and Cooper (1997)
Performance Prism	Neely et al. (2002)
Performance Planning Value Chain	Neely and Jarrar (2004)
Content, Context and Process (CCP)	Cuthbertson and Piotrowicz (2011)
Process-based model	Chan and Qi (2003)

Supply Chain Operation Reference (SCOR) model	Council (2008, 2010)
Global Supply Chain Forum (GSCF)	Lambert and Cooper (2000)
Supply chain performance measurement system (SCPMS)	Charan et al. (2008)
Integrated multi-objective SC model	Sabri and Beamon (2000)
Data envelopment analysis (DEA) modelling	Wong and Wong (2007)
Combine SCOR and process-based model	Theeranuphattana and Tang (2007)
Lean, agile, resilient and green (LARG) practices	Azevedo et al. (2011)
Hybrid dynamic framework for SC performance improvement	Agami et al. (2012)
AHP–SCOR integrated approach	Kocao˘glu et al. (2013)

It is clear from Table 2.11 that there are several performance measurement systems in the SC context. All these systems propose different measures and metrics used to monitor SC process under different operating environments (Beamon, 1996; Neely and Jarrar, 2004; Gunasekaran et al., 2001; Chan and Qi, 2003; Azevedo et al., 2011). However, Gunasekaran et al (2001) argued that the prospective of SCM was strongly discovered by many companies from different industries although they lack the vision for the improvement of metrics and measures that will help them to attain the goal of having a fully integrated chain. Furthermore, a clear way to get insight of objectives would possibly be hard to attain without having these metrics and measures aligned with the company's strategies. Thus, effective measurements approaches, such as balanced scorecard and Supply Chain Operation Reference (SCOR) model must be used to enhance the effectiveness of the SCM. This can be achieved by considering the overall SC goals by classifying the metrics as strategic, tactical and operational.

For this reason, the research focuses on the SC performance faced major shifts from functional-based systems to process based systems (Cooper et al., 1997; Srivastava et al., 2006; Mentzer et al., 2001; Morgan, 2007; Naslund and Williamson, 2010).

Thus, Lambert et al. (2004) highlighted several frameworks that consider standard business processes between different business functions and across the entire chain entities. Nevertheless, Lambert et al. (2004) indicated that only the SCOR and GSCF frameworks were described in details in the SC performance literature, which enables clear comparisons between the two frameworks.

Choosing the most appropriate measurement system, to be employed to measure SC performance is not an easy task. Thus, for the purpose of this research, it was found that the SCOR model has provided a common process oriented language to standardize the KPIs to be communicated between SC partners.

2.5.1 Supply Chain Operation Reference (SCOR) framework

The SCOR model was first developed in 1996 by the Supply Chain Council (SCC) in USA, and it has been adopted in many researches in the SC performance context (Wang et al., 2004; Bullingery et al., 2002; Bai et al., 2012). The SCOR model offers a universal linking business processes, metrics, best practices and technological features into one that aims at improving the effectiveness of SCM (Council, 2008). Moreover, the SCOR defines five processes (plan, source, make, deliver, and return), and offers an analysis of metrics and best practices which help SC managers to measure any significant changes in any business process through the pre-defined KPIs (Camerinelli, 2009). This analysis can be done through five competitive attributes of SC performance that are divided into two categories: customer-facing metrics and the internal-facing metrics. The former includes reliability, responsiveness, and flexibility, while the later includes costs and assets. According to the Council (2008), the five attributes of SC performance are defined as shown in Table 2.12. Those SC performance attributes cannot be measured; however, they consist of a set of metrics used to measure and calculate the capability of a SC to attain these five strategic attributes.

Table 2.12: SCOR attributes and Level one KPIs description

Attributes	Level 1 KPIs	Definition
Reliability	Perfect order fulfilment	The attribute of reliability addresses the ability to perform tasks as presumed. Predictability of the outcome of a process is the reliability focus. Reliability attribute's typical metrics include: the right quantity, the right quality, on-time. The SCOR KPI (level 1 metric) is Perfect Order Fulfilment. Reliability is a customer-focused attribute.
Responsiveness	Order fulfilment cycle time	The Responsiveness attribute describes the speed at which tasks are performed. Examples include cycle-time metrics. The SCOR KPI is

		Order Fulfilment Cycle Time. Responsiveness is a customer-focused attribute.
Flexibility	Flexibility and Adaptability	The Agility attribute describes the ability to respond to external influences and the ability to change. External influences include: Non-forecasted increases or decreases in demand; suppliers or partners going out of business; natural disasters; acts of (cyber) terrorism; availability of financial tools (the economy); or labour issues. The SCOR KPIs include Flexibility and Adaptability. Agility is a customer-focused attribute.
Cost	Cost of goods sold ratio	The Cost attribute describes the cost of operating the process. It includes labour costs, material costs, and transportation costs. The SCOR KPIs include Cost of Goods Sold and Supply Chain Management Cost. These two indicators cover all supply chain spend. Cost is an internally-focused attribute.
Assets	Return on SC fixed assets	The Asset Management Efficiency ("Assets") attribute describes the ability to efficiently utilize assets. Asset management strategies in a supply chain include inventory reduction and in-sourcing vs. outsourcing. Metrics include: inventory days of supply and capacity utilization. The SCOR KPIs include: Cash-to-Cash Cycle Time and Return on Fixed Assets. Asset Management Efficiency is an internally-focused attribute

Source: adopted from SCOR model (2008)

The SCOR metrics are structured in a hierarchical conformation including level one, level two, and level 3 metrics. Consequently, a decomposition of level one metrics is found in level two metrics in to have a detailed performance gap or improvement to level one metrics. Likewise, level three metrics provides a diagnostic decomposition for level two metrics (Council, 2010). Thus, level one metrics are considered to be strategic metrics and KPIs that give an indication of the overall SC health. While level two metrics helps in detecting the causes of any performance gap for the strategic KPIs of level one.

SCOR model provides SC managers with a standard description of all SC processes and the interrelation between these processes to increase integration between channel members. Moreover, standard KPIs are provided through standard metrics that enable companies to measure the performance of the company itself, and the entire network members (Johnson and Mena, 2008; Elgazzar, 2013). Furthermore, having standard SC KPIs helps in ensuring that all processes can be measured using a unified measure and that all SC members can interpret the results similarly.

2.5.2 Prioritisation and choice of supply chain KPIs

Choice and prioritisation of the relevant KPIs have been an important aspect in the SC performance research context (Elgazzar, 2013). There have been several approaches that can be used with the hierarchical conformation of the SC KPIs complexities with the multi-criterion nature inherently found in the KPIs (Hwang et al., 2008; Askariazad and Wanous, 2009; El-Baz, 2011). Thus, several methods have been used in the literature to provide a relevant weight of each KPI on the companies' related processes and the overall performance of the entire chain. A summary of some of these methods will be summarized in table 2.13

Table 2.13: Methods used in prioritizing SC KPIs

Method used	Author(s)
Analytic Hierarchy Process (AHP)	Chan and Qi (2003)
AHP	Huan et al. (2004)
Regression	Hwang et al. (2008)
Benchmarking	Vaidya and Hudnurkar (2013)
Questionnaire based AHP	Askariazad and Wanous (2009)
Combined the AHP and Decision Making Trial and Evaluation Labouratory (DEMATEL)	Najmia and Makuia (2010)
Fuzzy set theory and AHP	El-Baz (2011)
AHP with Expert Choice (EC) software	Perera et al. (2013)
Fuzzy AHP	Elgazzar (2013)

Table 2.13 highlighted some methods adopted to rank or prioritize SC KPIs. Eventually, most of the reviewed researches considered multi-criteria decision making approaches to provide them with a weighted objective SC KPIs rankings. The AHP method was found one of the most dominant methods used for prioritisation of SC measures using multi-criteria to enable decision-makers to meet their strategic objectives (Chan and Qi, 2003; Perera et al., 2013; Elgazzar, 2013). The reason behind this choice is that the AHP method includes a pair-wise comparison between the pre-defined SC performance KPIs in order to give weights for each KPI. Thus, companies will be able to understand the influence weight of reach KPI on the overall SC performance.

2.6 Discussion of the Research Gaps

This section shows the research gaps in the SC resilience context. The literature review has clearly showed the increasing importance of designing resilience into SCs. However, there is an urgent need to recognize how these constructs interact with each other. For example, how the capabilities that SCs use increase the resilience and acts as a hedge against SC vulnerabilities. Furthermore, different industries present many risk sources and events that are different, since every industry has its own characteristics that need to be considered. Nevertheless, there is still a lack of empirical researches investigating SC risks and resilience constructs in different cultures and industries. Previous studies on SC risks facing FMCG industry are very limited to four studies (Battezzati and Magnani, 2000; Agigi et al., 2016; Bala and Kumar, 2011; Diehl and Spinler, 2013) as discussed earlier in section (2.4.4). Moreover, two recent studies conducted by (Tukamuhabwa Rwakira et al., 2015; Agigi et al., 2016) went a step forward and addressed SC resilience strategies in FMCG industry in particular. Thus, demonstrating how the findings obtained for specific industries and cultures, which can be generalized, has yet to be achieved.

Based on the literature review on related work on SC risks, vulnerability and resilience, existing work has focused mostly on minimizing the negative consequences of risks and recovering the SC operations after failure from the focal firm point of view (Soliman et al., 2014). However, when making decisions in SC it is important to focus beyond the firm's boundaries (Rosenhead et al., 1972).

Moreover, the literature seems to lack determining the KPIs that would ensure resilience and the effects of risks on the FMCG SCs performance.

Thus, Overall, there are three important gaps identified from the literature analysis:

First, there is a need for further empirical efforts mostly on the companies operating in the FMCG industry in the MER. However, the literature identified several frameworks, models, and empirical studies on SC resilience, but the applicable models in developed countries may not be applicable in developing countries; since the operational environment and risks faced in the FMCG industry vary from those in the developed countries. Till now, from the literature available, developing countries especially the MER have been clearly ignored.

Second, the literature seems to lack determining the interactions between the three main resilience constructs; risks, capabilities, and KPIs from practitioners' point of view. Furthermore, there is a need to rank the three main SC resilience constructs from an empirical perspective to assist decision makers throughout the SC decision making process. Thus, achieving more informed decisions so that proactive measures can be taken to prevent and handle potential risks.

Third, there is a need to determine a standard set of SC KPIs to ensure resilience that can be adopted by all companies operating in the FMCG in the MER. Thus, providing a common process oriented language to standardize the KPIs in order to be able to communicate between SC partners to enhance resilience for the entire chain.

Building on the above gaps, this research attempts to firstly investigate the three SC resilience constructs in FMCG industry in the MER context. This is done by exploring what companies perceive to be disrupting their SCs, what capabilities to adopt to build resilience and reduce risks exposure, and what are the effect of those risks on the SC performance of the entire chain. Secondly, there is an urgent need to rank those constructs to assist SC managers in understanding what elements need to be addressed firstly based on the conducted empirical study.

2.7 Conceptual model

This section discusses the design of the conceptual model based on the literature review conducted. The idea of the research was inspired from the external environment in the MER, from the Arab Spring to the on-going economic deterioration facing the region (Soliman et al., 2012). This idea enhanced the background towards developing the idea of resilience in the region. After analysing the literature and investigating the factors that build SC resilience – for the purpose of this research – the researcher defined SC resilience as:

> *The capability of a SC to prepare and respond **(Capability)** to changed conditions causing vulnerabilities **(Risks)** through interpreting outputs of processes of the entire chain through appropriate measures **(KPIs)** to attain a better condition than prior disruption.*

The two constructs 'capabilities' and 'risks' in the above definition was adopted from several definitions (Hohenstein et al., 2015; Tukamuhabwa Rwakira et al., 2015; Christopher and Peck, 2004; Sheffi, 2005). Eventually, the third construct is to find the appropriate measure through defining KPIs which measures performance of the processes of all chain partners to ensure SC resilience. Thus, the conceptual model proposed in Figure 2.2 shows the relationship between the three SC resilience constructs; risks, capabilities, and KPIs, to design resilience SC in FMCG industry in the MER.

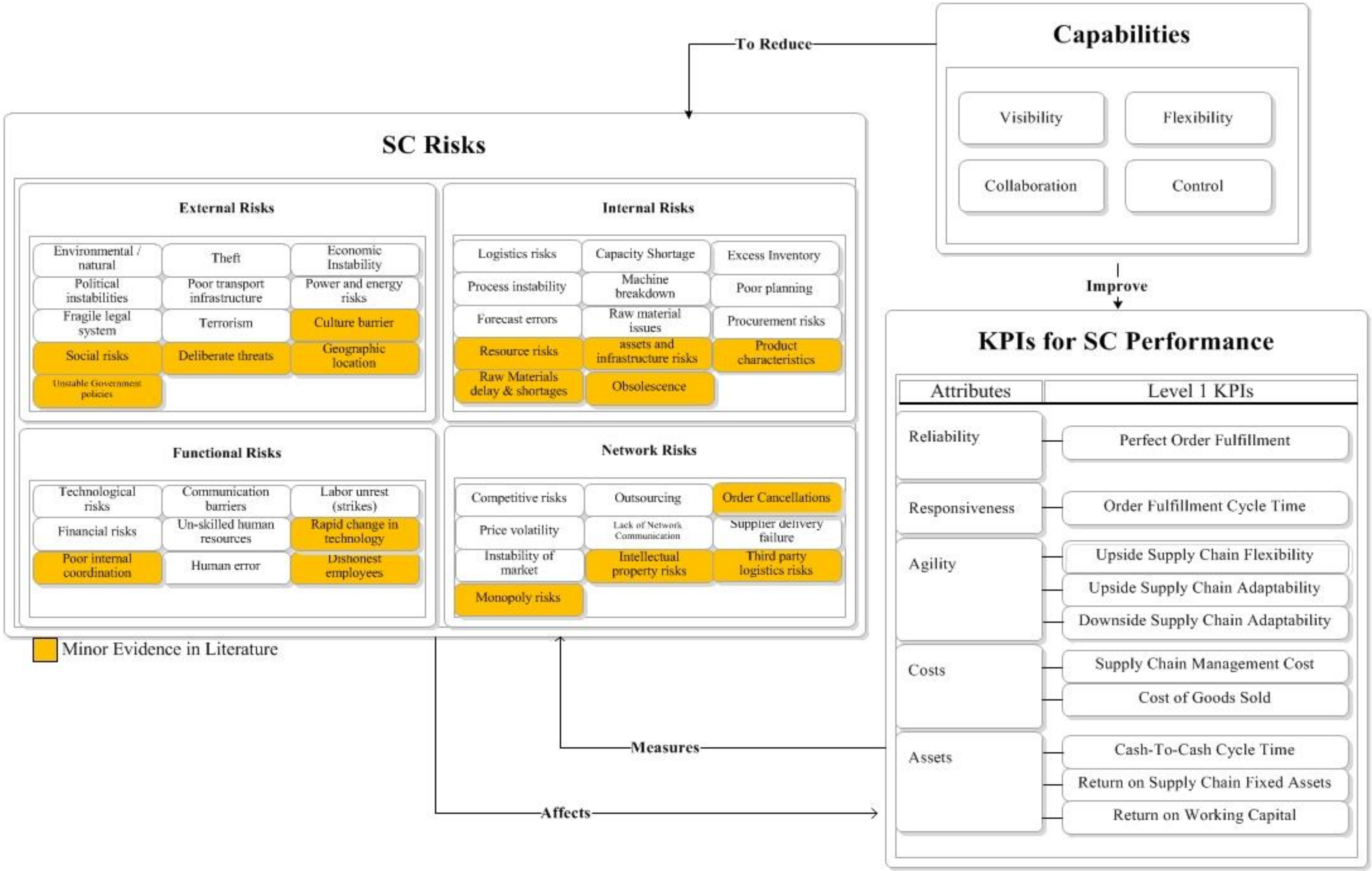

Figure 2.2: The conceptual model for SC resilience in FMCG industry in MER

As shown in figure 2.2, the conceptual model is divided into three clusters. In the SC risks cluster, the classification adopted by Manson-Jones and Towill (1998) and Christopher and Peck (2004) will be adopted to classify risks that will be divided into four types; (1) internal from the company itself, (2) network risks (external to the company but internal within the SC), (3) external from the macro environment, such as political changes, national disaster, or economic crises. The fourth type – functional risks – which was added to Christopher and Peck (2003) classification is adopted from a research conducted by Deloitte Development LLC (2013). Functional risks include technical risks that are linked with business functions which support SC activities; such as finance, human resources, legal, and information technology and communication (Deloitte, 2013) (refer to section 2.3.5.1 for more details).

Efforts to identify and mitigate SC risk have traditionally focused on operational risks and familiar sources of potential disruption that have caused trouble in the past (Sheffi, 2005). However, risks are constantly evolving and can strike from almost anywhere including sources that are new and unexpected. That's why a more holistic approach was needed to consider and address these four distinct categories of SC risk. For this reason, the model will present an assimilated model combining all SC risks from the literature to provide a one stop model, which practitioners and academics can review in order to define risks within their SCs.

However, recognizing the value of resilience as a concept is not enough. To build resilience, organisations must understand the essential components and required trade-offs that are necessary to build and improve resilience. In this respect, this research is consistent with the research of Pettit et al (2013) who acknowledged direct linkages between causes of SC vulnerability and SC capabilities. Thus, the second cluster is the capabilities that are initially chosen from the literature are: visibility, flexibility, Collaboration, and control.

The third cluster is the SC KPIs and strategic KPIs. The KPIs that would ensure SC resilience must be identified with respect to some specified standard measures to be easily adopted by all chain members. Thus, as previously stated in section (2.5.1), the SC KPIs would be adopted from the SCOR model, validated and ranked in the data collection from the SC managers as potential interviewees. Then the SC KPIs must be linked to the SC capabilities to match the SC objectives defined in the SCOR model (reliability, responsiveness, flexibility, costs and assets).

The conceptual model assumes that the SC risks affect SC performance. While the SC KPIs help to control and measure the SC risks. Whereas, SC capabilities have to be built and aligned with the SC KPIs to reduce SC vulnerabilities, which are caused from the different risks affects SCs.

Thus, SCs will be able to improve the overall performance of the entire chain. Moreover, following a clear roadmap for addressing SC vulnerability and capitalizing on opportunities would assist managers to take effective decisions leading to SC sustainability.

This research attempts to investigate the applicability of the SC constructs introduced with respect to the FMCG industry in the MER. Moreover, the model will add to the traditional risk models which consists of assessing, preparing, responding, and recovering. Another insight by identifying the KPIs that ensure resilience to measure how the risks affect performance and control the SC capabilities with a clear holistic view to all the network partners to eliminate SC risks.

2.8 Summary

This chapter discussed the relevant literature that has been carried out in SCM, SCRM, and SC resilience to achieve enhancement in overall entire SC network performance. To start with, the chapter reviewed the definition and concepts of SC to help understand the complications that companies face. In addition, the study examined risk management literature in order to highlight different definitions and views of risks, and how these views are encompassed into the SCM context. Further, the research investigated SCRM literature to understand different definitions of risk management from SC perspective, and to explore risk factors affecting SCs and their classifications. Based on the literature review conducted, it was found that there are several taxonomies adopted to classify risk factors, however, this research adopts risk categorisation into four types: internal, external, network, and functional (see Table 2.5).

Then, the research clarified some concepts related to SC resilience; such as, SC vulnerability, disruptions, and uncertainties. Consequently, the research defined and analysed the resilience literature to identify the resilience constructs in the SC context. It was found that SC resilience is built upon increasing SC capabilities to reduce vulnerabilities caused by SC risks (Pettit et al., 2010). SC capabilities that enhance resilience were underlined to enable SC managers to enhance resilience, respond to disruptions, prepare for unexpected events, and gain a recovery to more desirable condition. Another point is that SC resilience and risk management activities are only justified if the risks that causes vulnerabilities affect SC performance (Wagner and Bode, 2008). The literature review attempted to investigate the different performance measurement systems applied in SC context. However, it was recognized that SCOR model has provided a process oriented language to standardize the KPIs to be communicated between SC partners, and in turn, enhance SC resilience. For this reason, the SCOR performance attributes, level one strategic KPIs and level two operational KPIs were highlighted to be further investigated and related to SC resilience constructs risks and capabilities. Finally, research gaps were addressed and a conceptual model for SC resilience was developed to attempt to fill those gaps by contributing new knowledge to the field.

The next chapter (Chapter three) attempts to unfold the research methodology used in this research to answer the research questions by discussing how empirical data were collected and analysed, as well as the justifications for the methods choices.

Chapter three: Research design and methodology

3.1 Introduction

This chapter presents the research design and methodology applied in this research. The philosophical background of the research themes will be explored first, followed by the discussion of research approaches, design, strategy, and methods that will be adopted with justifications behind choosing them. However, this chapter will not provide details on how specific data collection and analysis methods were used in this study. These details will be fully explained in Chapters four and five, respectively.

3.2 Research philosophy

Research philosophy is concerned with the issues related to the foundations of science, formation of assumptions, use of methods, and lately, ethical implication of scientific discoveries (Kitcher, 2010). Furthermore, it discusses ways in which researchers view the nature of the world and their beliefs on what establishes acceptable knowledge. It is not essential to check how far the research is philosophically informed; however, it is crucial to have a sort of reflection on the philosophical choices and be able to defend them with respect to the alternatives that could be adopted (Saunders et al., 2012). Saunders et al. (2012) defines research philosophies as the broad term concerned about the foundation and development of a certain type of knowledge. Different paradigms are found based on researchers' perception about the knowledge under research (Johnson and Onwuegbuzie, 2004). Research paradigms are the shared perceptions that affect the different types of knowledge being researched and how they will be understood (Morgan, 2007).

Lee and Lings (2008) discuss practical issues of applied business research in terms of philosophical concepts and paradigms. According to Lee and Lings (2008), ontology refers to the study of the nature of reality. It refers to how objective or independent reality can be in reference to an observer or participant in a specific event. Thus, reality construction is considered an important issue for research ontology.

Ontology is followed by epistemology since it is the study of what we can identify about reality. While ontology is concerned with the nature of reality, epistemology studies the origin, nature and limits of knowledge identified by human (Martinich, 2010). Epistemology is the way by which we understand knowledge, how valid it is, and whether it is generalizable, or specified to a certain place and time (Lee and Lings, 2008).

After the ontology and epistemology are understood, another concept within the theoretical debate in philosophy, which is the axiology, needs to be defined. It has been argued that axiology is one of the inherent ethics of research. Moreover, in relation to ontology, the researcher should consider to explain, predict or understand reality (Lee and Lings, 2008).

There are four types of research philosophies: positivism, realism, interpretivism and pragmatism (Saunders et al., 2012). These research philosophies can be seen through the eyes of ontology, epistemology, axiology and data collection techniques. Failure to think through these concepts and other philosophies of science is not necessarily fatal, but can seriously affect the management quality of the research, because they are central to the belief of research design (Easterby-Smith et al., 2001). Table 3.1 gives a brief account on the four philosophies, then more insight will be given on the interpretivism philosophy which will be interpreted in the next sub-section.

Table 3.1: Comparison of four research philosophies

	Positivism	**Realism**	**Interpretivism**	**Pragmatism**
Ontology: *the researcher's view of the nature of reality or being*	External, objective and independent of social actors	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence (realist), but is interpreted through social conditioning (critical	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best enable answering of research question
Epistemology: *the researcher's view regarding what constitutes acceptable knowledge*	Only observable phenomena can provide credible data, facts. Focus on causality and law like generalizations, reducing phenomena to simplest elements	Observable phenomena provide credible data, facts. Insufficient data means inaccuracies in sensations (direct realism). Alternatively, phenomena create sensations which are open to misinterpretation	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help
Axiology: *the researcher's view of the role of values in research*	Research is undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; the researcher is biased by world views, cultural experiences and upbringing. These will impact on the research	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view
Data collection techniques	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

Source: Saunders et al. (2012)

3.2.1 Interpretivism

There is a continuous argument regarding which philosophy is appropriate for management research. However, the choice between the positivist and interpretivist approaches has an impact on the empirical research strategy, since the positivist paradigm assumes that the researcher takes the role of observer, whilst the interpretivist approach dictates that the researcher gains knowledge only by participating socially in the subject under study (Irani et al. 1999).

As argued by Saunders (2012), the interpretivism approach is very relevant in the business and management studies due to the great complexity and uniqueness for the business situations. That's why the interpretivism approach was chosen for this research after reviewing and analysing previous studies about risk management, SCM, and SC resilience that indicated several managerial, social, cultural, political, and operational issues that are complex and interrelated together and cannot be detached from their contexts. Thus, knowledge necessary for this research would be gained by participating in the subject of interest (Irani et al. 1999). Furthermore, this research aims to merge concepts and themes from the empirical data collected from interviews, which requires the researcher's participation in the subject. This is against the other approaches, but is well-tailored to the interpretivist paradigm.

Orlikowski and Baroudi (1991) argued that researches following interpretive approach assume that subjective understandings are created based on the interactions with the world around them. Therefore, researchers attempt to understand the phenomenon by understanding the meanings participants' assign to them. For this reason, it is necessary for the researcher to understand the differences between humans in the interpretive studies (Saunders et al., 2012). Moreover, according to Kaplan and Maxwell (1994), the interpretivistic paradigm does not attempt to predefine dependent and independent variables; rather, it focuses on the full complex picture of human sense-making as the situation emerges. This was also confirmed by Galliers (1992) who, among others, reported that the underlying interpretivistic paradigm tends to allow concepts (constructs) to emerge from field data rather than entering the field with pre-conceived theories. Therefore, interpretivism helps to study different phenomena in-depth that cannot be fully understood using qualitative methods (Venkatesh et al., 2013).

According to Remenyi and Williams (1998) and Myers (1997), the philosophical basis of interpretivistic research is rooted in the phenomenological approach. The research underlying phenomenological assumptions, as opposed to the positivist paradigm, does not consider the world to consist of an objective reality, but rather focuses on the primacy of subjective consciousness. Thus, each situation is considered as distinctive and its meaning is a function of the circumstances and the individuals involved. In addition, the phenomenologist is not independent of the subject of the research but is an intrinsic part of it. Therefore, the phenomenologist has to look beyond the details of the situation to understand the reality behind them and then constructs a meaning in terms of the situation being studied. In addition, the phenomenologist understands that the world does not consist of multiple realities, but rather, each reality is an artefact in its own right (Pather and Remenyi, 2005). Unlike positivist studies, phenomenological research is not readily conducive to generalization, other than stating that the phenomenon has been shown to exist or occur at least. Therefore – for the phenomenologist – the world is socially constructed (Pather and Remenyi, 2005).

A summary of why interpretivism has been chosen is summarized in Table 3.2

Table 3.2: Reasons of choosing interpretivism

Paradigm	**Interpretivism**	**Why it has been chosen**
Ontology: *the researcher's view of the nature of reality or being*	Socially constructed, subjective, may change, multiple	Since there is no single reality or truth about SC resilience, because it is a socially constructed issue related to a certain phenomenon
Epistemology: *the researcher's view regarding what constitutes acceptable knowledge*	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	While this research issue is very controversial. Therefore, the reality needs to be interpreted to discover and explore related meanings and social issues.
Axiology: *the researcher's view of the role of values in research*	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective	Since the researcher aims to investigate certain issue that have been explored previously, but need further investigation to gain better meaning to the phenomenon
Data collection methods most often used	Small samples, in-depth investigations, qualitative	Qualitative methods have been used, which allows the researcher to take a small sample that have experienced the research related issue. So deep investigation is needed to gain understanding and discovering of new themes, and accordingly, interpreting the findings that either confirms or dis-confirms the previous identified issues.

3.3 Research approaches

A research approach includes the process of data collection and theory development (Nogeste 2007). There are mainly two research approaches: inductive and deductive. However, using the two approaches in the same research is argued to be useful (Saunders et al., 2012). The deductive approach can be considered to be theory-driven, while the inductive approach is data-driven.

Deductive approach is a theory-testing process which begins with a well-established theory or generalization, and then seeks to examine the application of this theory to specific instances (Hyde 2000). Therefore, the deductive approach is well-suited to topics with rich literature as it can be used for defining theoretical propositions (Saunders et al. 2012). On the contrary, the inductive approach is about bottom-up approach (Saunders et al. 2012), starting with little existing literature and observation, and then the theory is developed through the collected data. Robson (1993) claimed that the inductive approach is preferable than the deductive one since it enables a full description to be made to the phenomenon under study and brings out interactions between the enquirer and the respondents. However, Patton (1991) argued that both inductive and deductive processes can be adopted by the qualitative researcher. This is because, according to Hyde (2000), the researcher begins to identify the literature and develop theoretical concepts which are then investigated in the real setting using the deductive reasoning approach.

Consistent with the above argument, this research adopted both approaches, starting with a deductive approach by developing an initial conceptual model to guide the empirical study. Thereafter, an inductive approach was adopted during the empirical study by allowing new concepts to emerge from the empirical data collected, analysed, and interpreted.

Although awareness of SC vulnerability and risk management is increasing between researcher and practitioners, the concepts are still in their early stages and there are insufficient models and empirical findings especially in the MER to give a clear sense of the phenomenon (Juttner, 2005; Manuj and Mentzer, 2008). However, the issue of creating a pre-event strategy needs to be further explored and empirically investigated, especially in the developing countries such as MER where the operational environment and risks faced in the FMCG industry from those in the developed countries.

Furthermore, SCs are a part of social systems where decisions are affected by human behaviors (Randal and Mello, 2012). This means that certain SC resilience strategies or models suggested in previous studies may need further empirical implications to be studied inductively (Rwakira, 2015).

The nature of the research problem should drive the choice of research strategy (Denzin and Linclon, 1998). For this reason, this research is considered highly exploratory to uncover possible avenues for reaching decision makers' objectives. Generally, a conversation between any researcher and the sample being studied is being used in exploratory researches. Due to the lack of literature in this area qualitative methods are mostly used in information science research to build new theoretical insight, to explore new research area by investigating and understanding a phenomenon (Walsham, 2006).

Qualitative research is used to make it possible to go in-depth into issues specific to the research and to be able to identify related distinctions to the research problem. There are several data collection methods that can be used in qualitative research such as focus groups, triads, interviews, and uninterrupted observations (Bryman, 2007). Moreover, qualitative research is used to develop an initial understanding of an issue or problem, look for a range of ideas and feelings about an issue, to understand different perspectives between groups and categories of people. The reason why qualitative is more appropriate than quantitative is that in order to get a good answer to the research questions, interviews are more suitable (Morse, 2003). Furthermore, a qualitative research method goes more in depth and answer questions such as "why" and "what". In the interviews that will be done, the respondents will be asked the same questions in order to get a fair point of view from all participants. When enough material has been gathered then the analysis will begin, to see the differences and similarities between them. This is because companies have their own way of handling their risks (Delgado-Galván, 2010). Another advantage is the ability to handle a complex phenomenon that is mainly affected by human perceptions such as risk management.

Once the philosophy of the research got clearer, the approach to research was chosen. Since the literature review identified the research themes and they were not based on any explicit theory that was apparent in the literature, deduction was ruled out as a path of research at this stage. Since the research was seen to be interpretivist and realist based, the induction approach, theory building, has been seen the most suitable approach for this the empirical study of this research.

3.4 Overall research design

The purpose of research design is to provide a plan that gives accurate evaluation of the subject being researched and to determine the scope of the study. For this reason, the research design outlined in Figure 3.1 gives a guideline to the development and evaluation of a SC resilience model with a holistic view of the entire chain exploring how the current practice managers employ for implementing SCRM to proactively anticipate disruptions and effectively make group decisions to prevent failure occurring (Soliman et al., 2014).

The overall research design outlined in Figure 3.1 consists of two phases: theoretical phase and empirical phase. The theoretical phase starts by understanding the research context and framing the research problem, aim, and objectives of the research to identify the main terms and concepts. Moving forward to the literature review, the main terms explored are: SCM, SC performance, risk management, SC risk management, and SC resilience. Having a deep look on those areas helped to identify the main gaps and perspectives and the relations between the three main resilience constructs (risks, capabilities, and KPIs). Consequently, the conceptual model has been developed based on extant literature to be refined and validated in phase two of the research. Phase two is the empirical phase that mainly aims at refining and validating the conceptual model by SC managers operating in FMCG companies in the MER. Interviews were used for data collection in the two stages of the empirical phase. However, in stage one of empirical study, semi-structured interviews were used, and in stage two, structured interviews were used. More details about the empirical phase will be highlighted in Figure 3.2.

Data analysis was conducted using thematic analysis to identify the main themes generated incorporated by comparative analysis that enables comparing themes and opinions across the different companies interviewed. Revisiting the conceptual model is very essential after data analysis to be able to refine it based on the empirical analysis. Finally, the AHP method will be used to prioritize the elements within the three main SC resilience constructs to provide recommendations to MER FMCG SC managers.

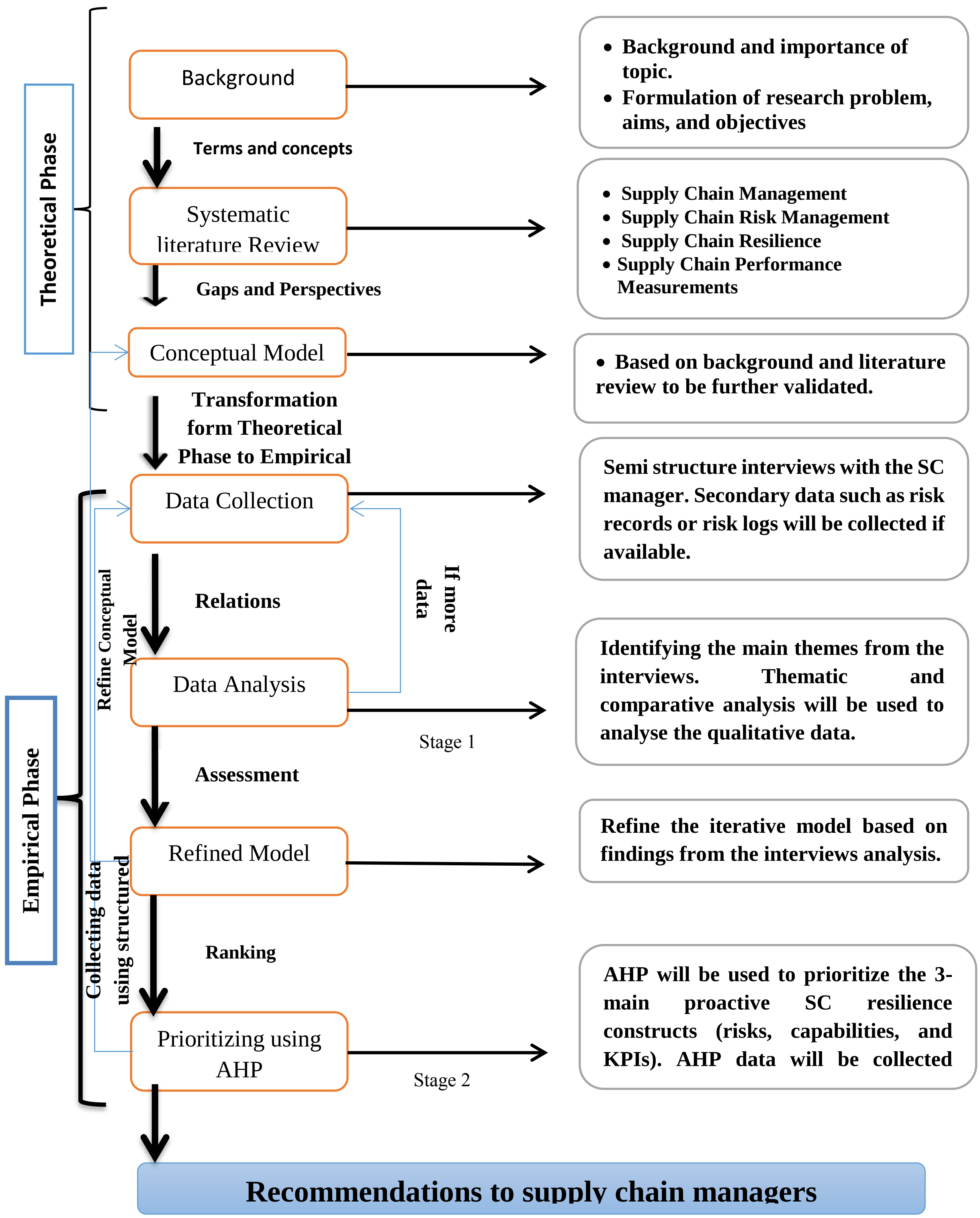

Figure 3.1: Overall Research Design

After overall design is discussed, a detailed overview has been developed in Figure 3.2 for the empirical phase to have a zoom in on what exactly has been done in the empirical phase. The empirical phase consists of two different stages. In stage one; data were collected using semi structured interviews. Then the data were analysed using a combination of thematic and comparative analysis methods. The conceptual model has been refined and improved based on the thematic and comparative analysis outcomes. Moreover, three matrices have been developed to highlight the three main resilience constructs.

The outputs of stage one of the empirical study are considered as the basis for stage two. Since the main SC resilience constructs of the FMCG in the MER have been explored in stage one, there was an emergent need to rank the elements within those constructs. For this, Analytical Hierarchy Process (AHP) was used. AHP template was constructed following formal AHP process (Saaty, 2000), and structured interviews were conducted with the same 30 FMCG companies to perform the AHP pairwise comparison and global priority calculation. The findings from stage two have provided further meanings to the findings of stage one.

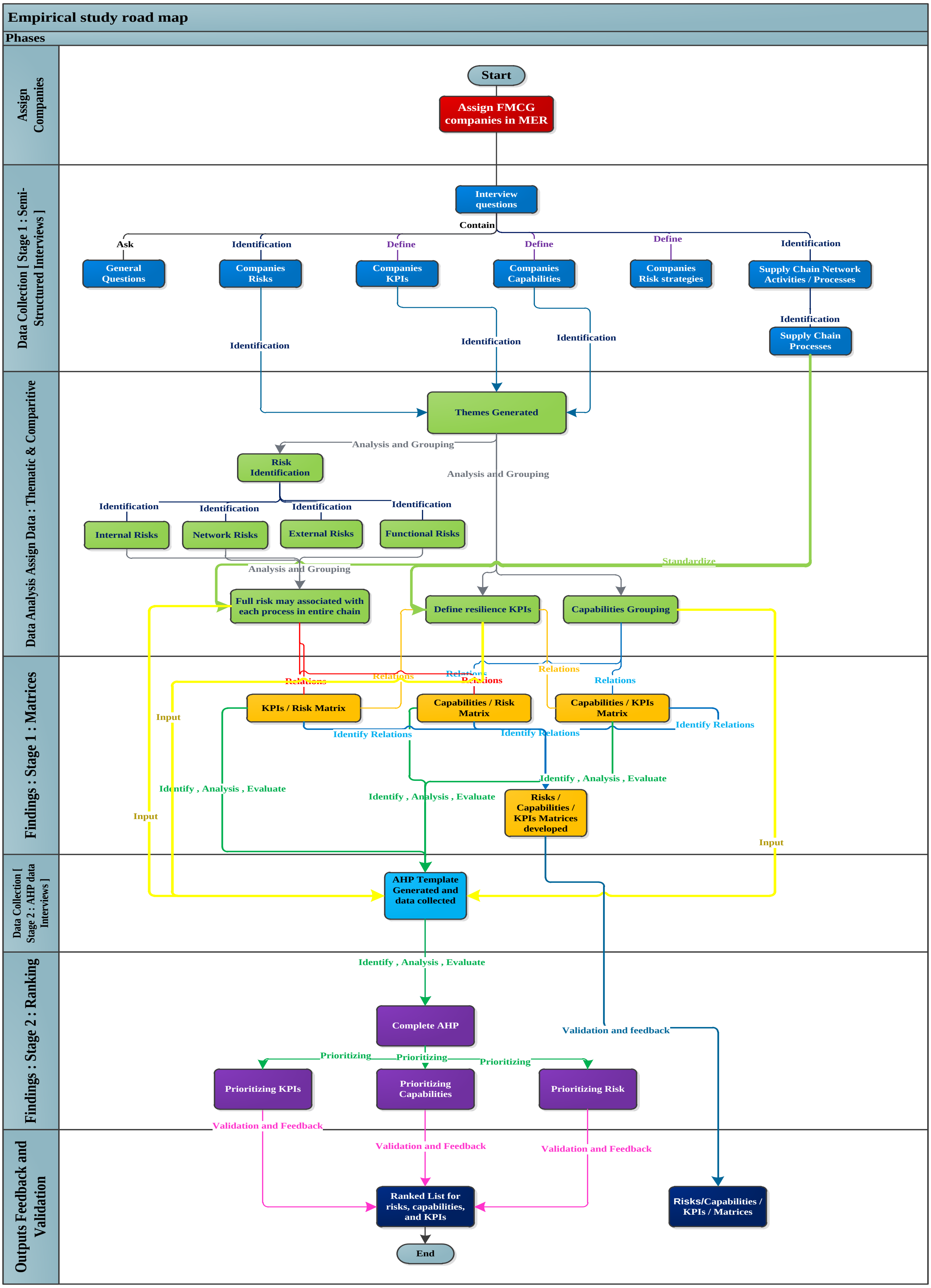

Figure 3.2: The empirical study road map

3.5 Research methods

Research methods include the set of tools used for data collection and analysis to explore a certain issue (Easterby-Smith et al. 2012; Charmaz, 2014). Thus, this section will explain the data collection and analysis methods which were adopted in this research, and why they have been selected over the other methods available. It is vital to carefully select appropriate research instruments when conducting scientific research (Morse, 2003; Tashakkori and Teddlie, 2008). The nature of the research questions and objectives demanded to use specific research methods for this study. Figure 3.3 demonstrates the research methods used in both stages of the empirical study.

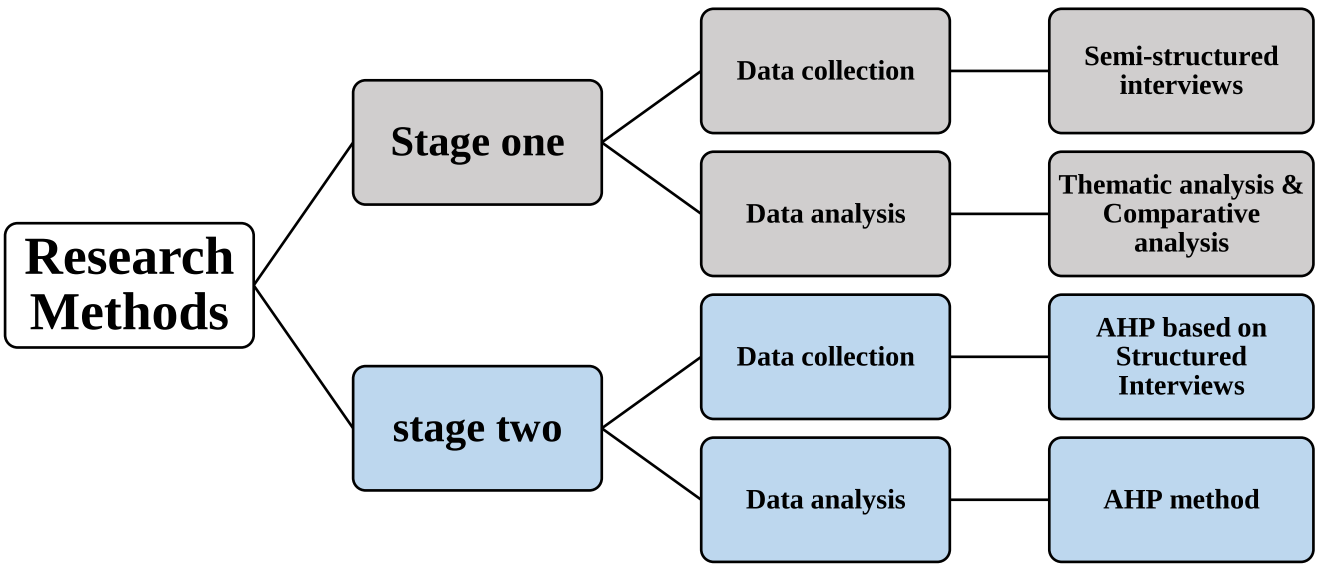

Figure 3.3: Research methods adopted

According to the literature, there are three major interview forms that can be used in research: structured, semi-structured, and unstructured (Cornford and Smithson 2006). Structured interviews are normally face-to-face or via phone using a fixed set of questions to be able to gather the required set of information that can be aggregated (Flick, 2009). While the purpose of the semi-structured interviews is to cover a list of questions; the researcher may omit or add questions depending on the circumstances and the nature of the event. The order of the questions may vary depending on the flow of the interview. On the other hand, the unstructured interviews are informal interviews used to explore a general idea which the researcher is interested in. They are in-depth interviews, and unpredicted list of questions prepared. Although a clear idea about the theme of the interview is necessary. The interviewee will have the opportunity to talk freely about the topic (Dillman, 2000). In this research, semi-structured interviews have been used for stage one and structured interviews have been used for stage two.

In stage one; data were collected using face-to-face semi-structured interviews. The benefit of conducting face-to-face interviews is that the researcher can obtain information not only from what is said by the participants but also from the visual cues and gestures made while responding to questions (Maxim, 1999). The reason for choosing semi-structured interviews is that the interview begins with a question on the part of the researcher to grab the attention of the interviewer or the participant. The researcher is then free to take the interview in another direction based on the information that provided by the subject. However, should the interview get off-track, the researcher has other prepared questions that can help re-focus the interview and bring the participant's attention back to the topic at hand (Lampard and Pole, 2002). In this way, the researcher does not have to ignore important information or feel as though he or she must keep the interview on a certain track if the participant raises important information that deserves further questioning. However, should the interviewee begin to talk about unrelated topics that are irrelevant to the larger goal of the interview, the researcher can quickly return to the prepared questions. Having prepared questions also helps the researcher in case a certain participant has little to say. The researcher is not left trying to think of questions in the middle of the interview, which can cause the participant to quickly lose interest completely in the interview (Lampard and Pole, 2002).

The interviews have been conducted with SC managers from FMCG companies operating in the MER. The focus will not be only on the focal firm, but on other parties as well as supplier, client, etc. These managers will be involved in making and executing SC activities in different firms with different sizes. The researcher had a list of themes and questions to be covered, but the interviewee had a great deal of flexibility in how to reply (Bryman, 2007; Saunders et al, 2012). Moreover, SC managers, as potential interviewees, usually use words and ideas in a precise way dealing with SCs from different cultures or countries across the globe. The opportunity to analyse these meanings through semi-structured interviews can add several implication and depth to the data acquired (Saunders et al., 2012). Additionally, more themes maybe identified that were not considered initially, but were related to the study and important for the findings.

On the other hand, structured interviews have been used for data collection in stage two. The reason behind this is that the questions are highly structured into the AHP model that has a very rigid structure. Moreover, the researcher cannot ask more flexible questions since we only need interviewees to give ranks to the elements within each SC resilience constructs (risks, capabilities, and KPIs).

A qualitative analysis process, as proposed by Creswell (2009) starts by data collection and management, then the raw data are organized to be coded and described. After that, it comes the stage of conceptualization, classifying, categorizing, and identifying themes to be connected and interrelated together. Finally, , it comes the interpretation process by creating explanatory accounts that provide meanings to the identified themes. This has led some authors, such as Braun and Clarke (2006), to argue that analysis methods are in essence thematic, but they are either claimed as being something else or are not identified as any particular method at all.

Thematic analysis and comparative analysis were used to analyse the qualitative data collected through semi-structured interviews with SC managers. These two methods were the appropriate analysis methods for the stage one of the empirical study because thematic analysis was useful for within company analysis whereas comparative analysis was useful for cross companies' analysis (Dawson, 2002; Tharenou et al., 2007; Souitaris et al., 2012).

Thematic analysis should be seen as a foundational approach for qualitative analysis and can be defined as an approach that is used for identifying, extracting, analysing and reporting patterns (themes) within the collected textual materials and then organizing and describing those themes in detail (Braun and Clarke, 2006; Wamba et al., 2015). According to Braun and Clarke (2006), one of the main benefits of thematic analysis, compared to other forms of qualitative analysis, is its flexibility. Hence, thematic analysis will be used to analyse the data.

Given the innovations in software technology, electronic techniques used for data coding are being more employed to obtain accuracy while dealing with such data. In addition, using computers provides more methodological interpretation to the data analysed (Leech and Onwuegbuzie, 2011). For this reason, Wong (2008) urged qualitative researchers to use NVIVO software since it has great advantages in reducing all the manual work conducted. Thus, giving more time to explore and discover the emerging themes. Owing to these advantages, NVIVO has been used in this research to confirm and refined the pre-discovered themes during the thematic analysis.

In stage two of the empirical study, AHP-based interviews (structured according to AHP formal process) were used to collect data from SC managers, and AHP analysis was conducted to prioritize the elements within the three main SC resilience constructs: risks, capabilities, and KPIs. The AHP proposed by Saaty (1977) is a basic approach to decision making, and a multi-criteria decision making technique which allows resolution of complex problems characterised by the existence of multiple actors, scenarios and criteria. This can be done through the developing of a ratio scale to set the priorities associated with the alternatives of the problem, by means of hierarchical modelling and pairwise comparing each decision criterion, sub-criterion, and alternative (Aguaron et al., 2000). Moreover, the AHP can be concisely summarized in terms of its three basic components: (1) modeliation (establishment of a structural hierarchy which is the simplest form used to structure a decision problem is a hierarchy consisting of three levels), (2) prioritisation (establishment of comparative judgements, and (3) valuation (synthesis of priorities and the measurement of consistency, calculation of results (Partovi, 1994; Atthirawong and MacCarthy, 2002).

Thus, the AHP is very flexible in allowing the decision-maker to structure the hierarchy to fit individual needs and preferences. The method enables the decision-maker to develop the trade-off among multiple criteria implicitly in the course of structuring and analysing a series of pairwise judgmental comparison matrices (Jayawickrama, 2015). Further, in a group decision setting, use of the AHP to structure a problem may help in achieving consensus over critical elements and/or pinpoint areas of disagreement so that more attention can then be focused on these areas to achieve consensus (Ishizaka and Lusti, 2006).

In summary, the main concepts of the AHP as defined by (Saaty and Vargas, 2012) are:

- The AHP is analytic. It assists in analysing the decision problem logically and in establishing numbers based on the decisionmaker'sintuitionand feelings which can be validated, questioned and reviewed by others.
- The AHP utilizes a hierarchy structure. This property comes naturally with the human tendency to decompose and reduce the complex problems into sub problems to be tackled one by one.
- The AHP defines a step-by-step process for decision making.

3.6 Research ethics

Ethical issues were considered when conducting the interviews. These issues included gaining informed consent and making assurances of confidentiality and anonymity. Therefore, the candidate interviewees were given enough information about the research and its purpose in order to make a decision about whether or not to participate in the study. Participants were also assured that whatever information they provided to the researcher will be securely kept, treated as highly confidential and not be divulged to anyone.

Due to the importance of ethics for conducting research that involves human participation, the University of Plymouth has adopted a specific ethical approval to be attained. An ethical approval was obtained from the Faculty Research Ethical Approval Committee (FREAC) before starting any data collection for this research (Ref. No: FoB/UPC/FREC/FREC1314.07/clc).

3.7 Summary

Research methodology denotes as the theory of how research should be undertaken in order to discover new knowledge (Saunders et al., 2012). This study follows the interprevetism philosophy with the connection of both inductive reasoning and deductive reasoning in order to answer research questions and achieve research objectives. It included a deductive approach because literature review was used as the base to develop a conceptual model to guide the empirical study. It also used the inductive approach because the research allows for new concepts to emerge from the empirical data collected. Furthermore, the research strategy adopted for this study is a qualitative strategy. The research design comprises two stages. Stage one used semi- structured interviews for data collection, and data analysis used a combination of thematic and comparative analysis. The intention of the interview was not to confirm the critical factors in the literature but rather to find which, if any, critical factors were evident in the organisations regarding building a resilient SC, as well as to discover other factors not proposed in the researcher's conceptual model. On the other hand, at stage two of the empirical study, AHP-based interviews (i.e. interviews structured according to AHP process) were used to collect data, and data analysis was done using AHP pairwise comparison and global priority calculation. The AHP technique was used in this study in order to conduct pairwise comparisons amongst the SC managers in the FMCG industry in the MER in the AHP structured interviews with the 30 companies. Ethical issues were considered when conducting the interviews. These included gaining informed consent and making assurances of confidentiality and anonymity.

This research was directed to investigate a particular subject at a specific time. Hence, the time horizon of this research is considered as cross-sectional. The areas described in this chapter construct the research methodology adopted in this study, and an overview of the same can be seen in Figure 3.4.

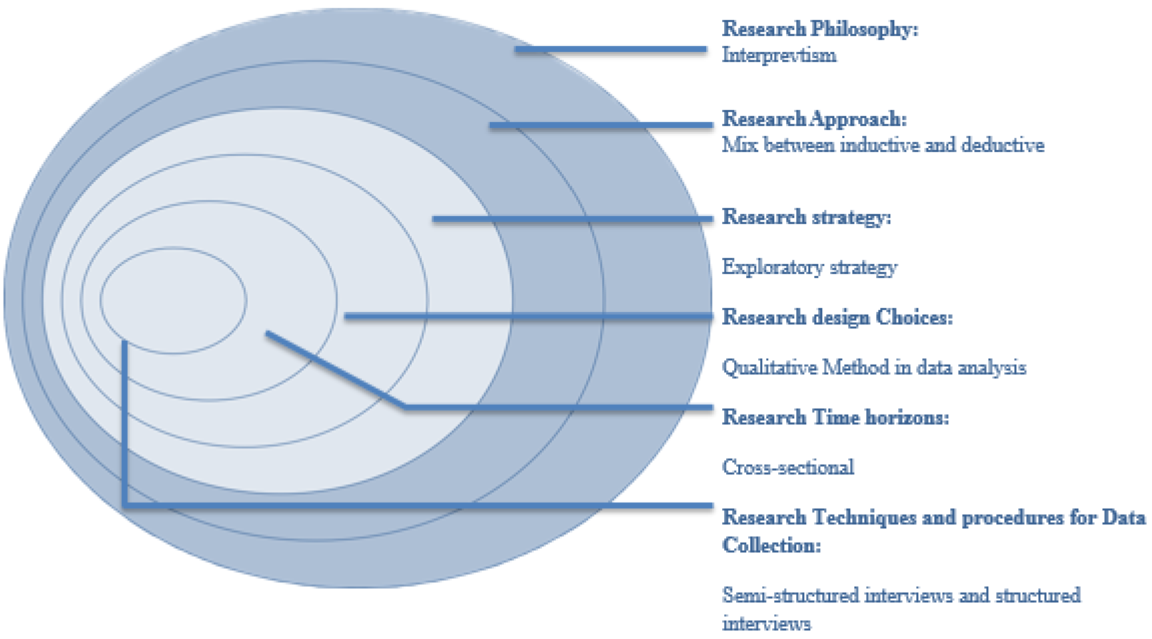

Figure 3.4: Research methodology adopted

Source: Saunders et al. (2012)

In the next chapter, stage one of the empirical phase will be presented. Findings will be under the three main resilience constructs (i.e. risks, capabilities, and KPIs). Semi-structured interviews will be used for data collection. Thematic and comparative analysis will be used for data analysis. Further in chapter five, AHP will be used to rank those constructs based on the respondents' judgments.

Chapter four: Stage 1 of empirical study - qualitative data collection, analysis and findings

4.1 Introduction

This chapter discusses the first stage of the empirical study, including the empirical data collection besides the accomplishment of the data analysis and the empirical findings. Moreover, this chapter discusses how different data collection and analysis methods were used during the research to find answers to the research questions. In particular, this chapter describes the use of semi-structured interview method to collect data for the research (next section). Sampling techniques used for the study are discussed, followed by the development of interview questions and process of conducting interviews. Then the qualitative data analysis approach will be discussed. Empirical findings of the stage one are presented and explained in detail. This chapter will also highlight the contribution to the concept of resilience. This would be achieved through incorporating empirical findings to refine the SC resilience conceptual model, which is earlier developed from the literature. Three matrices have been developed to define the interrelations between the three main constructs of SC resilience: risks, capabilities, and KPIs.

4.2 Sampling technique

The number and content of interviews were based on non-probability sampling techniques; purposive (judgmental), and snowball sampling. The initial participant sample is based on the participant's interest to participate in the research. In purposive sampling, participants were selected based on pre-selected criteria which will best enable the researcher to answer the research questions. Purposive sampling ensures adequate representation of important themes. Then each interviewee was asked towards the end of the interview who they may think would be suitable for a similar interview, and who may be knowledgeable about the phenomena (snowball sampling). Thus, recommendations will be taken from people who know that they are suitable for similar lines on questioning around the research framework.

In purposive sampling technique, the suitable interview participants were identified through industry contacts after they have been assessed based on the following criteria:

- The sample should be from the FMCG industry covering any of the FMCG categories such as (Food, Home, Personal Care, Agriculture, Retail, Medicinal Herbs, Bakery, Beverages, Dairy products, fast food)
- The company must be at least medium-sized (From 10 to 249 Employee) or large-sized (Greeter than 249 Employees).
- SC manager interviewed must have a level of experience of more than 5 years.
- Company type / function (manufacture – distributor – supplier – retailer)
- The company should provide access to its key information (primary data)

In application to this research, two informal meetings were conducted with experts from the SC Council Middle East Chapter based in Egypt. It was recommended to look for 35 companies from the FMCG that have appropriate SC activities. Accordingly, the research has emailed all the 35 companies, and got 30 responses out of the 35 that were willing to participate in the current research. From those 30 companies, 5 companies were neglected because either their SC activities are very limited or the people involved in the SC activities have less than 5 years of experience, which will subsequently give a lack of understanding of the issue of this research. After the 25 companies were chosen, snowball sampling was obtained by asking participants to suggest another suitable participant for the study. For example, Americana Olives SC manager was asked to suggest other companies which could contribute to the research. He then recommended Americana Cakes' SC manager. Nevertheless, based on the researcher knowledge and judgment, some companies were found to be not suitable for this research.

The companies were selected by taking into consideration their position in the FMCG SC (i.e. supplier/manufacturer/distributor/retailer). It is essential to have companies that are continuously managing their SC to get a deeper understanding of the risks and different problems that face the entire network. It is important to get interviews with people who have the right competence within the company to get the most insights from the interviews. Thus, to have a good sample of the research, 30 companies which meet the previously stated criteria have been chosen.

All interviewees were contacted over the phone by explaining the research topic, questions, objectives, and purpose of the interviews to obtain their consent to participate in the interviews. All interviews were conducted on-site and were audio recorded with the consent of participants for word-for-word transcribing purposes. Each interview was on average of 90 minutes to 120 minutes in duration. More information about the interviews will be discussed in the next section.

The data collection helps in generating themes and extending knowledge by collecting data and analysing them to refine the SC resilience conceptual model pre-developed based on the literature review conducted. Saunders et al. (2012) suggest to continuingly collect qualitative data by conducting additional interviews until data saturation is reached; in other words, until the additional collected data provides few new insights.

Apparently, there was an intention to involve a larger sample size since different participants might have different opinions and perceptions. However, if a large sample is used, data becomes rePettitive (Glaser and Strauss, 1967). This is called the saturation point; when the collection of new data may not add further insight to the research performed. The idea of data saturation in studies is important; nevertheless, it does not provide a practical guide when this point has been touched (Guest et al., 2006). Moreover, authors argued that analysing interview results can be one of the methods that help to figure out the point at which data saturation has been attained (Bernard and Bernard, 2012).

Thus, owing to the exploratory nature of this research, saturation was not applied on less than 30 interviewed companies since new risks, capabilities, and KPIs were explored based on the company's place in the network (i.e. supplier/manufacturer/distributor/retailer) and the category of FMCG under which the company falls.

4.3 Empirical data collection

After setting the criteria for the companies that could be part of this research, it has been assured that each participating SC manager had direct involvement with the respective SCM position in MER, and that all of them had direct work experience in SC for at least five years.

The 30 companies (shown in Table 4.1) represent manufacturing, supplier, distribution, and retail sectors in MER. The companies' category, level, size, type, and the level of experience are shown in the columns of Table (4.1). The number of employees' column provides an indication of the company's size. In other words, the sample consists of mid and large scale companies with various business natures. An interview template (see **Appendix 1**) was developed and used for this study, and there was always freedom for participants to express their ideas with respect to the context being discussed. For further details about the background of the companies see **Appendix 2**.

Table 4.1: Summary of the companies involved in the empirical phase

Category		Company level		Interview with	
Food	8	Multinational	15	SC top and middle management	5
Home and Personal Care	1	Local	15	SC top management	25
Food and Personal Care	1	**Company Size**		**Type**	
Agriculture	1	Medium-sized	2	Manufacture – Distributor	13
Retail	4	Large-sized	28	Manufacture – Distributor – Supplier	10
Agriculture and Medicinal Herbs	1	**Experience**		Manufacturer	1
Food and Bakery	1	More than 15 years	10	Retailer	4
Beverage	2	More than 10 years	9	Manufacture – Retail	2
Dairy	5	More than 20 years	3		
Medicinal Herbs	1	More than 5 years	6		
Fast Food	2	More than 25 years	2		
Dairy and Cheese	3				

4.3.1 Conducting interviews

The interviews were conducted in person over a period of 15 months from May 2015 to August 2016. Interview times ranged from 90 minutes to 120 minutes, depending on the interviewee's schedule and availability. Ethical issues have been considered as stated earlier through gaining informed consent and making confirmation that the interview data will be treated as confidential to be used only for research purpose. Thus, a permission of audio recordings of the interviews was asked for at the beginning of the interview. The audio files were highly useful to help transcribe all interviews word-for-word in order to reduce the bias and increase the reliability and validity of the research by obtaining confirmation for each transcription from respective interview participants. The main aim for recording the interviews is that taking notes during the interviews might cause the researcher to lose focus of important data. Additionally, note taking consumes time due to interview time limitation.

At first, the interview questions were reviewed by 5 professors from the SCM field. Then a pilot test was conducted with four SCM consultants and industry practitioners. The corrections and modifications were minor based on the feedback received from them. Nevertheless, most of the comments were related to the wording of the questions, so they were re-written to be easily understood to avoid any misunderstanding or confusion.

The researcher started the interview by introducing himself and giving an overall brief about the research conducted. Then, respondents were free to express themselves on any asked question. The interview template consists of nine sections (See **Appendix 1**). It starts with general questions asking about the company and the interviewee, then specific SC questions are asked to know about an overview of how the network. Then, the researcher gets more specific sections to ask about the four main SC functions; purchasing, warehousing, planning, and logistics. The last three sections are concerned with three main issues; the risks that the company faces, the risks facing the entire SC, and finally the SC resilience awareness, capabilities, and KPIs. After each question, the researcher confirmed about the meaning of the interviewees' answers to make sure that they are well understood. Moreover, asking open-ended questions gave the interviewees to incorporate more data, themes, and attitudes towards some issues that may be useful while analysing the collected data. However, the intention of the interview questions was not just to confirm the important factors in the literature but also to discover any new factors to refine the conceptual model. Thus, all the interview questions were designed to investigate the different types of risks affecting all SC processes (i.e. purchasing, warehousing, planning, and logistics), capabilities employed, and the SC KPIs with the ultimate aim of understanding the SC resilience constructs by obtain answers of what, why and how.

4.4 Data analysis process

Qualitative data analysis consists of identifying, coding, and categorizing patterns or themes found in the data. The analytical skills of the researcher highly affect the clarity and relevance of the findings. Consequently, these skills would be either a great strength or weakness for any qualitative based research. However, it is crucial that the researcher reports and documents the analytical processes and procedures fully and truthfully so that the credibility of the researcher and the findings could be evaluated (Braun and Clarke, 2006). The qualitative analysis process proposed by Creswell (2009) starts by data collection and management, then the raw data are organized to be coded and described. Afterwards, it comes the stage of conceptualization, classifying, categorizing, and identifying themes in order to be connected and interrelated together. Lastly, the interpretation process through creating explanatory accounts provide meanings to the identified themes. The data collected through semi-structured interviews were qualitative data of the participants' opinions and ideas on the subject being discussed. Each interview audio file was transcribed word- for-word in order to avoid missing any element from the responses given by the interview participant. The analysis of the data started with some prior knowledge, initial analytic interests, and thoughts. The transcription process was also an excellent way for the researcher to begin the process of familiarizing themes with the interview data and creating meanings from them. According to Bird (2005), transcription is a key phase of data analysis within an interpretative qualitative methodology. The majority of the recorded interviews were first translated from Arabic into English and then transcribed. Therefore, during this stage, the researcher had the opportunity to be immersed in the collected data in order to be familiar with the depth and breadth of the content. Afterwards, transcripts were carefully edited to clean them from irrelevant phrases which were not related to the interview topic.

A combination of two qualitative data analysis methods has been used (see Figure 4.1) to analyse the transcripts: thematic analysis (Tharenou et al., 2007; King and Horrocks, 2010) and comparative analysis (Miles and Huberman, 1994; Dawson, 2002). The thematic analysis has been used to allow new SC resilience themes (i.e. risks, capabilities, and KPIs in this case) to emerge by coding openly and to confirm existing themes from the transcripts and documents. The comparative analysis method has been used to examine the set of themes across the 30 companies to detect the strength of evidence from empirical data (Dawson, 2002; Tharenou et al., 2007). The coding step comprised identifying and confirming the themes of what, how, and why the risks, capabilities, and KPIs based on the frequency of occurrence of empirical data are supported from the 30 companies. Then the categories were derived and the findings were associated with relevant categories/topics in order to increase the understanding of integrative work of SC resilience. Finally, the initial conceptual model was refined, by integrating and summarizing the empirical findings. Since there was a high volume of interview data, NVIVO software was used in this research because it has various advantages; such as, reducing the manual tasks and giving more time to discover tendencies, recognize themes and derive conclusions (Wong, 2008).

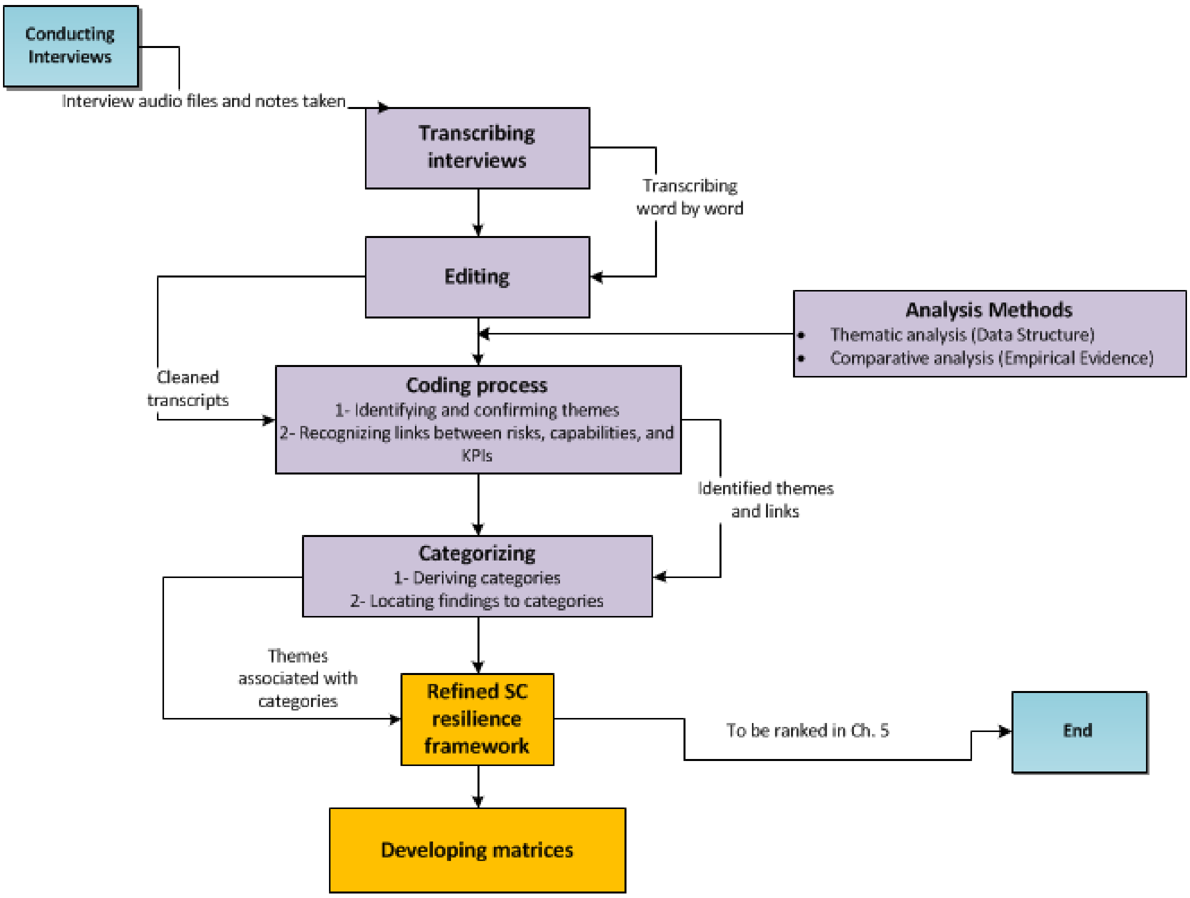

Figure 4.1: Qualitative Data Analysis steps

4.4.1 Integrating thematic and comparative analysis methods

Thematic analysis and comparative analysis were used to analyse qualitative data collected through semi-structured interviews with SC managers from the 30 FMCG companies. The themes were identified through coded data and categorized using thematic analysis. Therefore, the thematic analysis should be seen as a foundational approach for qualitative analysis. It can be defined as an approach that is used for identifying, extracting, analysing and reporting themes within the collected textual materials, and then organizing and describing those themes in detail (Braun and Clarke, 2006).

Initial coding process begins after being familiar with the data being collected after initial useful list of ideas being emerged. Furthermore, the QSR NVIVO was used to perform the second step of the data analysis. This was performed by grouping and naming selections from the text within each data item. As suggested by Braun and Clarke (2006), the researcher coded as many potential themes and patterns as possible as it is never possible to know what might become of interest later on. This step resulted in a long list of the different codes that the researcher had identified across the data. In searching for themes, there was a need to re-focus the analysis at a broader level than that which had been undertaken with the codes. This required sorting and organizing all the different relevant codes into potential themes. This step ended when a collection of possible themes and sub-themes were generated, together with related codes. A thematic map was then refined to consider whether the collated codes for each theme appeared to form a coherent pattern, whether the individual theme was valid in relation to the entire dataset, and if the thematic map accurately showed the evident meanings in the data collected as a whole (Braun and Clarke, 2006). After the step of searching for themes, the researcher came up with a set of themes.

Throughout the analysis, several themes were acknowledged following the three phases underlined by King and Horrocks (2010):

[1] Descriptive coding (first-order codes): the researcher classifies the transcribed data from the interviews that allocate descriptive codes and help in answering the research questions.

[2] Interpretative coding (second-order themes): the allocated descriptive groups which seem to carry common meanings are grouped together in order to create an interpretive code.

[3] Defining main themes (aggregate dimensions): Overarching themes that can describe the main concepts in the analysis are identified.

There are many ways to write up thematic analysis (Jayawickrama, 2015). The most popular way is to define and discuss every main theme by giving examples from the data collected and acquiring quotes from the interviews transcribed to categorize themes easily. It has been demonstrated that accumulating thematic analysis helps in developing a description to inform readers how the findings of the research emphasise and show the topic in hand, rather than giving a descriptive summary of the theme (Braun and Clarke, 2006). Moreover, these quotes should have in its content short quotes to simplify the understanding of the topic and its interpretation (Symon and Cassell, 2012). In application to this research, the second-order themes were identified using first-order codes, and categorized as aggregated dimensions to reveal the main categories of risks, capabilities, and KPIs.

On the other hand, the comparative analysis is closely connected to thematic analysis (Dawson, 2002) and used with the thematic analysis in this research. Using this method, data from different companies is compared and contrasted, then the analysis continues until the findings got saturated from the data collected. Comparative and thematic analyses are frequently used together within the same research data analysis through moving backward and forwards between transcripts, memos, notes and the literature in order to confirm the themes emerged through thematic analysis (Dawson, 2002; King and Horrocks, 2010).

Comparative analysis was used to confirm the second-order themes discovered in the empirical findings for the three main SC constructs (risks, capabilities, and KPIs) to identify the similarities, agreements, and dis-agreements across the 30 interviewed companies. The scaling structure adopted was based on how frequent the second-order themes is referred to in the empirical data. The structure adopted either a tick (√) to represent an evidence from the company interviewed or no ticks to represent no evidence supported.

This scaling approach eased the identification of the saturation point where no longer interviews were needed to be carried out.

Accordingly, in the following section, the finding of the empirical analysis will be discussed in details for the purpose of refining the conceptual model using both thematic and comparative analysis.

4.5 Empirical findings from stage one

The empirical findings are discussed in this section based on the data collected through semi-structured interviews from the 30 companies. The findings from the analysis are categorized into three main themes (aggregate dimensions) according to the conceptual model. These three dimensions are SC risks, capabilities, and KPIs. In the level of data analysis, some risks, which cause SC vulnerabilities and capabilities that companies should employ to improve SC resilience, will be identified from the data which have not been stated in the SC resilience literature. Some of those are stated in the literature but are understood in a different way in the MER context, while others are stated in the literature but did not get much support in the MER context. Furthermore, relevant companies KPIs, which ensure resilience, are collected, analysed, and converted to SCOR level two KPIs as previously stated in the literature (refer to section 2.5.1) to provide SC managers with a standard description of all SC processes and KPIs. This ensures that resilience in all SC processes can be measured using unified measures.

The empirical findings will first present the SC risks from analysing interview data, followed by the different capabilities. Finally, SC KPIs will be articulated.

4.5.1 Exploring supply chain risks

SC risks were first categorized into four main types as described in chapter two along with the conceptual model (see Figure 2.2) ; (1) ***internal*** from the company itself, (2) ***network*** risks (external to the company but internal within the SC), (3) ***external*** from the macro environment, such as political changes, national disaster, or economic crises, and (4) ***functional*** including technical risks that linked with business functions that support SC activities, such as finance, human resources, legal, and information technology and communication (see section 2.5.5.1 for more details).

At the conceptual phase of this research, 14 risk factors were identified and added to the conceptual model under the internal risk category. While there were 13 risk factors identified under the external risk category. Moreover, there were 10 risk factors identified under the network risk category, and 9 risk factors under the functional risk category. The data structure table (see **Appendix 3**) shows how the different risk factors were identified and understood based on the data collected from the interviews.

The risk factors data structure shows the different types of risks that cause vulnerabilities to the FMCG SCs operating in the MER. The first order codes are the direct quotes revealed from the interviews transcripts, while the second order codes are the risk factors that represent the first order codes (quotes). Finally, the aggregate dimension column represents the main risk categories identified earlier.

The findings show 15 risk factors under the internal risk category. These factors are raw materials delays and shortages, raw materials issues, logistics risks, capacity shortages, poor planning, procurement risks, excess inventory, machine break down, process instability, product characteristics, assets and infrastructure risks, resources risk, rising labour costs, obsolescence, and forecast errors. The findings revealed one new risk factor under the internal risks category that emerged from the data which is the significant increase in the labour cost.

Furthermore, the external risks showed 14 risk factor, which are environmental /natural, political instabilities, fragile legal system, theft, poor transport infrastructure, terrorism economic instability, power and energy risks, social risks, deliberate threats, geographic location, culture barrier, corruption, and unstable government policies. Accordingly, the findings revealed one new risk factor under this category which is the corruption threat.

Moreover, under the network risks, the findings showed 12 risk factors underneath. They are competitive risks, price volatility, instability of market, outsourcing, lack of network communication, supplier delivery failure, order cancellations, intellectual property risks, third party logistics risks, lower consumer spending, monopoly risks, and dis-honest suppliers. Thus, the findings showed two new risks; namely, lower consumer spending and dis-honest suppliers.

Finally, the functional risks showed 10 risk factors, which are technological risks, financial risks, communication barriers, un-skilled human resources, labour unrest (strikes), poor internal coordination, human error, dis-honest employees, rapid change in technology, and tacit knowledge risks. The findings revealed one new risk factor under this category named tacit knowledge risks.

Despite having most of the risk factors identified in the conceptual model, some of them did not gain much support empirically in the MER context. For this reason, in Table 4.2 the comparative analysis was used to work back and forth between the transcribed interviews from the 30 companies to establish the empirical support for the risk categories identified in risk factors data structure table (see **Appendix 3**). The first column indicates the second order codes (risk factors), and the second column indicates the aggregate dimension (main risk category), while the third column indicates the number of companies that gave evidence based on the legend stated earlier in section 4.4.1 which indicates either a tick (√) representing an evidence from the company interviewed or not ticks representing no evidence supported. Table 4.2 is considered a summary of the empirical evidence table that presents the evidence with respect to each of the 30 companies (See **Appendix 4** for the full table).

Table 4.2: Summary of empirical evidence for SC risks

Second-order codes (risk factors)	Aggregate Dimensions (risk categories)	Empirical evidence (support from the 30 companies)
Forecast errors	Internal	12
assets and infrastructure risks		12
Product characteristics		13
Resource risks		14
RM delay and shortages		14
Excess Inventory		18
Raw material issues		18

Poor planning		**19**
Capacity Shortage		**20**
Procurement risks		**21**
Rising labour costs		**21**
Machine breakdown		**22**
Obsolescence		**23**
Logistics risks		**23**
Process instability		**23**
Order Cancellations	**Network**	**12**
Intellectual property risks		**13**
Lack of Network Communication		**18**
Instability of market		**19**
Supplier delivery failure		**20**
Lower consumer spending		**20**
Price volatility		**21**
Outsourcing		**21**
Monopoly risks		**22**
Third party logistics risks		**22**
Competitive risks		**23**
Dis-honest suppliers		**24**
Culture barrier	**External**	**9**
Geographic location		**11**
Deliberate threats		**12**
Fragile legal system		**12**
Environmental /natural		**13**
Social risks		**17**
Political instabilities		**18**
Economic Instability		**19**
Unstable Government policies		**20**
Theft		**20**
Power and energy risks		**21**
Terrorism		**22**
Corruption		**23**
Poor transport infrastructure		**23**
Labour unrest (strikes)	**Functional**	**9**
Poor internal coordination		**10**
Dis-honest employees		**11**
Human error		**12**
Rapid change in technology		**12**
Communication barriers		**13**
Technological risks		**16**
Financial risks		**17**
Un-skilled human resources		**19**
Tacit Knowledge risks		**22**

As shown in Table 4.2, the logistics risks, process instability, and obsolescence are the most mentioned internal risk factors by 23 out of the 30 companies. Whereas, forecast errors, assets, and infrastructure risks got evidence only from 12 companies.

> *"we may discover that the shipment is in the port waiting for our customs department to clear it out for more than 2 weeks and he isn't aware, that's because of our lack of a tracking system indicating us where our shipments are".*

After that, under the network risks, the dis-honest suppliers were empirically evidenced by 24 companies. Though, only 12 companies perceived order cancellation risks.

> *"it often happens, we order a particular material with determined specs, when we receive the shipment, we don't find the material with the specs we ordered, why, because the supplier wants to widen his profit margin so he changed the materials…"*

Poor transport infrastructure and corruption were the most highlighted external risk factors as mentioned by 23 companies. However, the culture barrier risk is the least mentioned risk as only nine companies stated it.

> *"we may have a problem in setting the transportation schedule for our shipments, because we cannot predict or estimate how long the journey from the farm to the factory would take. The roads are unpaved…….so in most cases, the plan does not materialize".*

Finally, regarding functional risks, tacit knowledge is the most emphasised risk as twenty-two companies mentioned it. Nevertheless, labour unrest was least mention from companies as only nine companies stated it.

> *"… we keen on sharing knowledge with our employees, because if the employee doesn't know the reason behind what he is doing, he won't make it right, or he will simply ignore it…"*

4.5.1.1 Ranking the risk factors

During the interviews, an initial level ranking of the risk factors were obtained from interview participants. The aim was to understand how SC managers perceive the probability of occurrence of the risk factors. Accordingly, interviewees were expressing their opinion in a qualitative manner by rating either high, medium, or low, as shown in Table 4.3. The table summarize the risks ranking based on its probability of occurrence (See **Appendix 5** for the full table with details about which company perceive which risks as high, medium, or low)

Table 4.3: Summary of SC risks ranking based on probability of occurrences

Aggregate Dimensions	Second-order themes	High	Medium	Low	Weighted sum	Aggregate Dimensions	Second-order themes	High	Medium	Low	Weighted sum
Internal	Logistics risks	10	9	10	58	External	Environmental /natural	5	5	18	43
	Process instability	11	9	10	61		Political instabilities	6	15	7	55
	Forecast errors	6	9	15	51		Fragile legal system	2	10	17	43
	Excess Inventory	4	15	10	52		Theft	7	14	9	58
	Capacity Shortage	7	15	7	58		Poor transport infrastructure	13	9	7	64
	Machine breakdown	14	10	6	68		Terrorism	14	4	11	61
	Raw material issues	6	9	13	49		Economic Instability	10	11	9	61
	Poor planning	8	8	14	54		Power and energy risks	9	11	10	59
	Resource risks	0	10	16	36		Social risks	0	8	15	31
	assets and infrastructure risks	0	12	13	37		Deliberate threats	0	9	18	36
	Product characteristics	0	14	10	38		Geographic location	0	14	12	40
	RM delay and shortages	0	10	18	38		Culture barrier	0	14	10	38
	Rising labour costs	13	7	10	63		Corruption	14	10	5	67
	Procurement risks	8	9	13	55		Unstable Government policies	15	10	4	69
	Obsolescence	12	9	9	63						
Network	Competitive risks	10	6	14	56	Functional	Technological risks	7	3	20	47
	Price volatility	3	20	7	56		Financial risks	14	6	8	62
	Instability of market	6	6	18	48		Communication barriers	11	4	15	56

	Outsourcing	4	14	12	52		Un-skilled human resources	7	10	12	53
	Lack of Network Communication	5	13	12	53		Labour unrest (strikes)	6	12	11	53
	Supplier delivery failure	4	13	12	50		Poor internal coordination	0	10	15	35
	Order Cancellations	0	10	20	40		Human error	0	11	14	36
	Intellectual property risks	0	11	16	38		Dis-honest employees	0	11	19	41
	Third party logistics risks	3	13	12	47		Rapid change in technology	0	6	13	25
	Lower consumer spending	15	6	9	66		Tacit Knowledge risks		8	12	55
	Monopoly risks	11	9	10	61						
	Dis-honest suppliers	14	6	8	62						

The first column in Table 4.3 shows the aggregate dimension, that is, the risk categories, while the second order themes column represents the risk factors underneath every main category. Then there is a column representing the probability whether high, medium, or low. If there is a zero number, this means that this risk factor was not claimed by the company as an occurring risk. For example, social risk under the external risk was not perceived having high probability of occurrence from any company from the 30 companies interviewed. Finally, the last column represents the weighted sum, which was for better trend identification by giving more weight to risks with high probability of occurrence.

Hence, based on the empirical data provided and summarized, the following arguments can be concluded:

- In the internal risks category, the machine breakdown was perceived by 14 companies as having a high probability of occurrence, while the resources risks were perceived the lowest probability of occurrence.
- In the external risks category, the unstable government policies were perceived by 15 companies as having a high probability of occurrence, while the social risks were perceived the lowest probability of occurrence.

- In the network risks category, the lower consumer spending was perceived by 15 companies as having a high probability of occurrence, while the intellectual property risks were perceived the lowest probability of occurrence.
- Finally, in the functional risks category, the financial risks were perceived by 14 companies as having a high probability of occurrences, while the poor internal coordination was perceived the lowest probability of occurrences.

This ranking was basic and not sufficient to rank the risk factors. For this reason, in the next chapter (chapter five), the results from the first stage in the empirical data collection and analysis will be extended. Thus, a focus will be on ranking the risk categories and risk factors in order to guide SC managers which risks they should focus on reducing them. The extension of stage one to stage two will be highlighted later in the end of this chapter.

4.5.2 Exploring supply chain capabilities

The SC capabilities identified from the literature review were first categorized into four main types as described in chapter 2 along with the conceptual model (see Figure 2.2); (1) visibility, (2) flexibility, (3) Collaboration, and (4) control (see section 2.6.3 for more details). At the conceptual phase of this research, these capabilities were seen appropriate based on the analysing the literature on the capabilities that have great impact on improving SC resilience. The data structure table (see **Appendix 6**) shows different capabilities identified based in the data collected from the interviews.

In the data structure table for capabilities, the first order codes are the direct quotes revealed from the interviews transcripts, while the second order codes are the sub-capabilities that represent the first order coded (quotes). However, the aggregate dimension column represents the main capability category that represents the second order codes (sub-capabilities).

The findings revealed shows five main capabilities categories Four of which were previously presented in the conceptual model – visibility, flexibility, Collaboration, and control – while a new category emerged called learning and innovation. Furthermore, there were new elements emerged from the data under the 5 main capabilities categories which are considered to be sub-capabilities. These sub-capabilities help in extending the understanding of the main capabilities and help SCs to focus on how to implement or adopt these capabilities.

The visibility category encompasses six sub-capabilities which are: role clarity, product awareness, informal networking, risk communication channels, knowledge management, and information and communications technology. Furthermore, the flexibility category encompasses six sub-capabilities: namely, customer flexibility, adaptability, agility, outsourcing, efficiency, and velocity. Moreover, the Collaboration capability includes four sub-capabilities which are: co-opetition, group decision making, supplier relationship management, and customer relationship management. Furthermore, under the control capability there are six sub-capabilities which are: accountability, process excellence, spans of control, change management, de-centralization, and leadership. Finally, under the learning and innovation main category, which were newly identified from the findings, there are 4 sub-capabilities; namely SC risk management awareness, market intelligence, research and development, and finally the developments in human resources.

These sub-capabilities which are identified based on the empirical study are not new. For example, some of these sub-capabilities, such as, role clarity, market intelligence, and co-opetition were found in the literature but in context different than SC risk and resilience. Some of these sub-capabilities were found in the SC risk and SC resilience context, but were identified as a unique capability in their own or were considered as SC resilience antecedents (Carvalho et al. 2012; Zsidisin and Wagner, 2010; Pettit et al., 2010).

Due to this reason, it was important to work back and forth between the data collected to demonstrate the empirical support of these capabilities and sub-capabilities that will be presented in the Table 4.4.

In Table 4.4, the first column indicates the second order codes (sub-capabilities) while the second column indicates the aggregate dimension (main capability category). Finally, the third column indicates the number of companies that gave evidence based on the scaling system identified earlier in section 4.4.1. Table 4.4 is considered a summary of the empirical evidence table that presents the evidence with respect to each of the 30 companies (see **Appendix 7** for the full table).

Table 4.4: Summary of empirical evidences for SC capabilities.

Second-order codes (Sub capabilities)	Aggregate dimensions (Capability category)	Empirical evidence (support from the 30 companies)
Knowledge management	Visibility	21
Information and communication Technology		21
Role clarity		23
Product awareness		23
Informal networking		23
Risk communication channels		23
Agility	Flexibility	20
Outsourcing		22
Adaptability		22
Customers flexibility		23
Efficiency		23
Velocity		23
Group-decision making	Collaboration	19
Co-opetition		20
Customer relationship management		22
Supplier relationship management		23
spans of control	Control	19
Change management		20
Process excellence		21
De-centralization		22
Accountability		24

Leadership		**27**
SC risk management awareness	**Learning and innovation**	**19**
Developments in Human resources		**20**
Research and development		**22**
Market intelligence		**23**

As shown in Table 4.4, four sub-capabilities underneath visibility which are: role clarity, product awareness, informal networking, and risk communication channels were mostly considered by 23 out of the companies.

> "*sometimes, we recognize that there is a forgotten order than need to be prepared and delivered very soon……I have a personal relation with almost all wholesalers and retailers we deal with, so we contact the customer explaining the situation and that the order would be late and they accept the situation if they can…".*

While maintaining decent supplier relationships, was as a key capability, which enhances Collaboration, .as referred by 23 companies.

> *"…. involvement of our suppliers in the product design rarely happens…. but when we started to think about the idea we realized that we were too late……sharing knowledge and experience with them (supplier) improve Collaboration to be able to respond any sudden changes in the customers' preferences…".*

Furthermore, 27 companies argued that leadership is a fundamental capability to augment control on SCs.

> *"the company's leadership performance has a lot to do with how much the organisation can accomplish in a given amount of time"*

The market intelligence was pointed out by 23 companies as the most significant talent under the learning and innovation category.

> *"market intelligence is the all about how to understand all success factors of the business, you have to understand market changes, and try to be the first mover not the follower…"*

Even though, all the identified SC capabilities are recommended to improve SC resilience; however, they cannot work in isolation. Moreover, the relationship between these capabilities and eliminating risks is still vague. For this reason, the interrelations between the risks, capabilities, and KPIs will be investigated later in this chapter.

4.5.3 Exploring SC resilience KPIs

In order to have a common process oriented language to standardize SC KPIs that improves resilience, the SCOR model developed by SCC has been adopted as a reference model. As previously discussed in Chapter two, the SCOR KPIs are structured in a hierarchical conformation including level one, and level two metrics under five competitive attributes of SC performance. These attributes are divided into two categories: customer-facing metrics, which include reliability, responsiveness, and flexibility, and the internal-facing metrics, which include cost and assets (see section 2.7.1).

As previously mentioned in section 2.5.1, the reliability attribute measure the capability of the SC to accomplish the tasks as expected by focusing on the predictability the process output (Council, 2010). The SCOR level one KPI for reliability is the perfect order fulfilment, while the responsiveness attribute measures the speed of accomplishing of the tasks assigned for all SC processes (Council, 2010). The SCOR level one KPI for responsiveness is order fulfilment cycle. On the other hand, the agility attribute address the capability of the SC to respond to any external threats (e.g. sudden increase in demand, terrorism, etc.). The SCOR level one KPIs for agility are: upside SC flexibility, upside SC adaptability, and downside SC adaptability (Council, 2010), while the cost attribute focus in the operating cost of SC processes, including labour, materials, and transportation cost (Council, 2010). The SCOR level one KPIs for cost are SCM cost, and cost of goods sold. Finally, the assets attributes address the efficiency in utilizing the companies owned assets, such as the reduction in stocks levels, etc. The SCOR level one KPIs for assets are: cash-to-cash cycle time, return on SC fixed assets, and the return on working capital (Council, 2010).

As seen in Figure 4.2, SC KPIs were collected from the companies during the interviews. Then, the KPIs collected were refined and shortlisted based on the understanding of the interviewees to the definition of SC resilience. Since every company perceive and implement different set of SC KPIs, a need to have a standard set of KPIs emerged. For this reason, based on the knowledge of interviewees and the knowledge of the researcher about SCOR KPIs, the shortlisted resilience KPIs identified during the interviews were mapped and transformed to their most equivalent SCOR level two KPIs. Owning to the reason that level two KPIs is considered the decomposition of level one KPIs, this make it easy to settle every level two KPIs under its relevant level one KPIs and SC performance attribute.

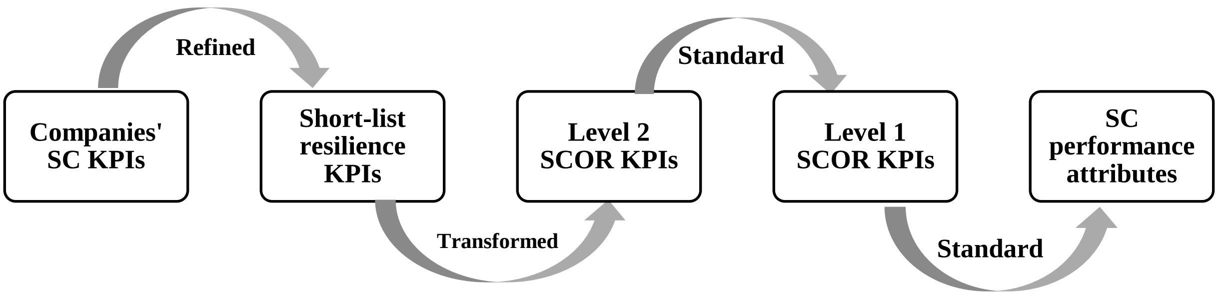

Figure 4.2: Transformation of SC KPIs to SCOR KPIs

For more elaboration, Table 4.5 shows a sample of how this transformation was performed during the data analysis process.

Table 4.5: Sample of transforming companies' KPIs to SCOR KPIs.

Companies KPIs	Resilience KPIs	SCOR level 2 equivalent KPIs	SCOR level 1 Strategic Metrics	SC Performance Attributes
Average age of order backlog	X	X	X	X
Average consignment size	X	X	X	X
Delivery Schedule Numbers of change	X	X	X	X
Average production costs of items	Average production costs of items	Cash-to-Cash Cycle Time	Supply Chain Management Cost	Costs
Cash to cash cycle time	Cash to cash cycle time	Cost to Make	Supply Chain Management Cost	Costs

Customer order cycle time	Customer order cycle time	Percentage of Orders Delivered in Full	Order Fulfilment Cycle Time	Responsiveness
Fill rate	Fill rate	Percentage of Orders Delivered in Full	Perfect Order Fulfilment	Reliability
Forecast Accuracy	Forecast Accuracy	Documentation Accuracy	Perfect Order Fulfilment	Reliability
MRO's Inventory Value	X	X	X	X
Missed Deliveries per Million	X	X	X	X
Number of active suppliers per supply employee	X	X	X	X
Percentage of problem suppliers	X	X	X	X
Material value add	X	X	X	X
Requested Time in Full	X	X	X	X

Table 4.5 shows a sample of how the SC KPIs were collected, refined based on the understanding of the definition of SC resilience, and then transformed to the equivalent SCOR level two KPI, which is decomposed under level one KPI under a certain performance attribute identified. It can be observed from the table that the companies' KPIs (in yellow colour), only five of them were shortlisted based on the understanding of SC resilience definition (in green colour). Consequently, they were transformed to their equivalent SCOR level two KPIs (in purple colour) and to level one KPIs and SC performance attribute (blue colour).

After the refinement process of the companies' KPIs to be shortlisted, the data structure table (see **Appendix 8**) shows how the transformation of the SC resilience KPIs refined from the companies SC KPIs collected during interviews. Those refined KPIs are quoted under the first column (first-order codes), while the second-order codes represent the equivalent or similar KPIs in the SCOR model level two KPIs to those refined from the data collected from interviewees. The third column represents the aggregate dimension, which is divided into two sub-columns; level one KPIs, which encompasses the decomposition of level two KPIs, and the second sub-column represents the SC performance attributes which encompasses the decomposition of level one KPI.

Based on data structure table, the findings revealed 4 level two KPIs under the perfect order fulfilment level one KPI; namely, percentage of orders delivered in full, delivery performance to customer commit date, documentation accuracy, and perfect condition. Furthermore, the order fulfilment cycle time included 4 level two KPIs; namely, source cycle time, make cycle time, delivery cycle time, and delivery retail cycle time. Moreover, the upside SC flexibility has 1 level one KPI named the upside SC flexibility. Similarly, the upside SC adaptability has 1 level two KPI named upside SC adaptability, and the downside SC adaptability has 1 level two KPI named downside SC adaptability. Further, the findings revealed 4 level two KPIs under the SCM cost level one KPI, which are cost to plan, cost to make, value at risk, and mitigation cost. While the cost of goods sold revealed 3 level two KPIs; namely, direct material cost, indirect cost related to production, and direct labour cost. Nevertheless, under the cash-to-cash cycle time, the findings showed 4 level two KPIs, which are cash-to-cash cycle time, inventory days of supply, days sales outstanding, and days of payable outstanding. The return on SC fixed assets revealed 2 level two KPIs; namely, SCM costs, and SC fixed assets. Finally, the return on working capital revealed 3 level two KPIs, which are SCM costs, inventory, and SC revenue.

The comparative analysis was used to work back and forth between the data collected to demonstrate the empirical support of these KPIs that will be presented in the next table (Table 4.6). In Table 4.6, the first column indicates the second order codes (sub-capabilities) and the second column indicates the aggregate dimension (main capability category), while the third column indicates the number of companies that gave evidence based on the scaling system identified earlier in section 4.4.1. Table 4.6 is considered a summary of the empirical evidence table that presents the evidence with respect to each of the 30 companies (see **Appendix 9** for the full table).

Table 4.6: Summary of empirical evidence for SC resilience KPIs.

Second-order codes Level 2 KPIs	Aggregate Dimensions		Empirical evidence (support from the 30 companies)
	Level 1 KPI	SC Performance attribute	
Documentation Accuracy	Perfect Order Fulfilment	Reliability	19
Perfect Condition			20
Delivery Performance to Customer Commit Date			22
Percentage of Orders Delivered in Full			23
Make Cycle Time	Order Fulfilment Cycle Time	Responsiveness	21
Delivery Cycle Time			21
Delivery Retail Cycle Time			21
Source Cycle Time			22
Upside Supply Chain Adaptability	Upside Supply Chain Adaptability	Agility	18
Upside Supply Chain Flexibility	Upside Supply Chain Flexibility		20
Downside Supply Chain Adaptability	Downside Supply Chain Adaptability		20
Value at Risk (VAR $, Percentage of Sales)	Supply Chain Management Cost	Costs	20
Cost to Plan			21
Cost to Make			21
Mitigation Cost (Cost to Mitigate Supply Chain Risk)			21
Indirect Cost Related to Production	Cost of Goods Sold		15
Direct Material Cost			21
Direct Labour Cost			21
Inventory Days of Supply	Cash-To-Cash Cycle Time	Assets	19
Days Sales Outstanding			19
Cash-to-Cash Cycle Time			21
Days of Payable Outstanding			22
Supply Chain Management Costs	Return on Supply Chain Fixed Assets		19
Supply Chain Fixed Assets			22
Supply Chain Revenue	Return on Working Capital		21
Supply Chain Management Costs			22
Inventory			22

Based on Table 4.6, it can be argued that the percentage of orders delivered in full KPI is perceived to be the most important resilience KPI based on the evidence from 23 companies. While the indirect cost related to production KPI was supported by 15 companies, most of the KPIs were moderately supported by companies, where the average range of evidences is from 20 to 22 companies for each KPI.

4.6 The refined SC resilience model (1) based on the stage one of empirical study

Based on the data collected, analysed, and presented in the previous sections, the conceptual model initially developed during the conceptual phase based on the literature review has been refined as illustrated in Figure 4.3.

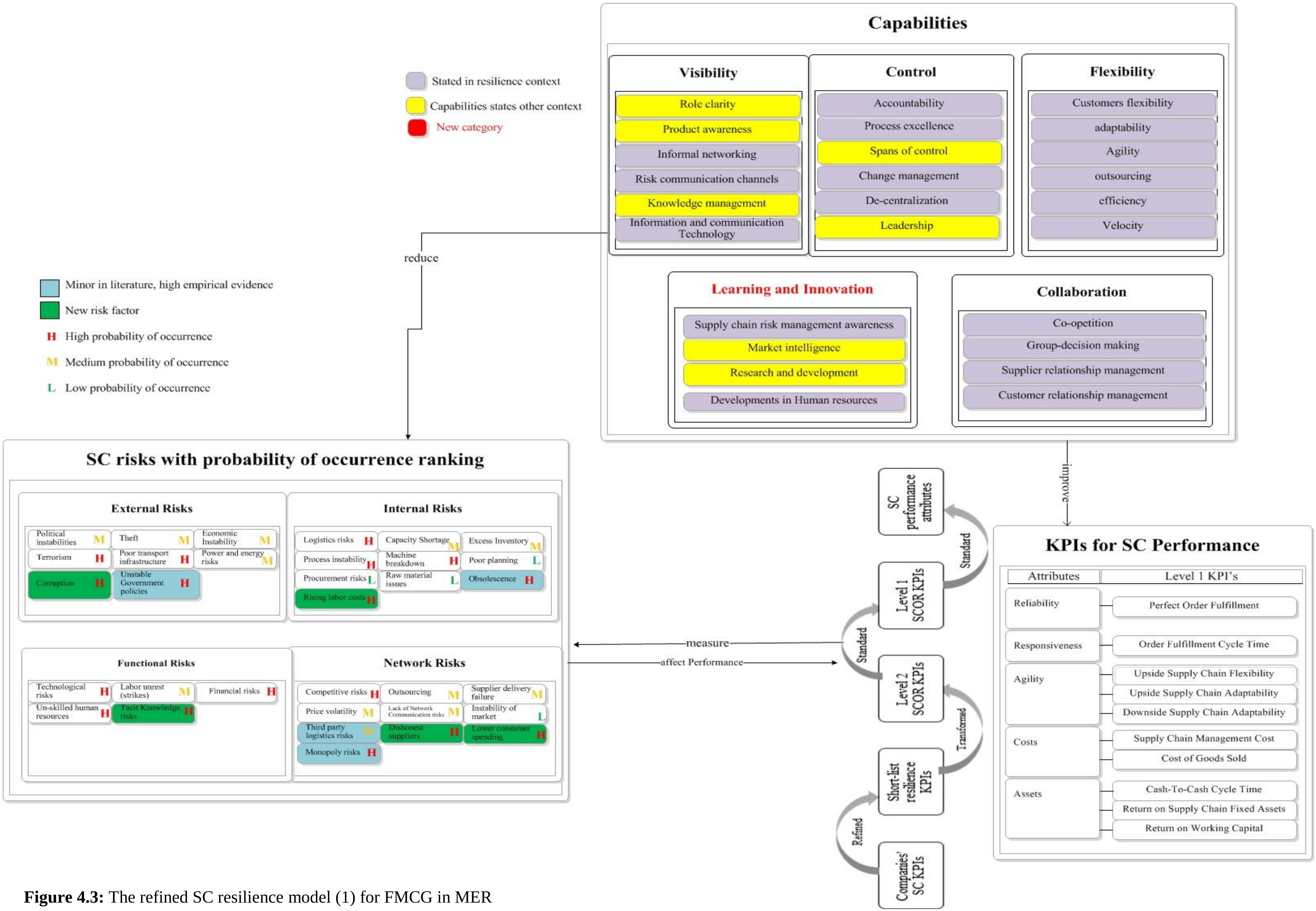

Figure 4.3: The refined SC resilience model (1) for FMCG in MER

The refined SC resilience model attempts to add more understandings to the SC resilience constructs based on the empirical findings revealed from stage one of empirical study. Tables 4.2, 4.3, 4.4, 4.5, and 4.6, in addition to Figure 2.2, are the building blocks in modelling the model. These tables investigate risks and their rankings based on their probability of occurrence, capabilities, and KPIs. Figure 2.2 demonstrates how companies' KPIs were shortlisted and transformed to a standard set of KPIs based on the resilience notion and SCOR KPIs respectively. The refined SC resilience, as shown in Figure 4.3, consists of three clusters; risks, capabilities, and KPIs. Naturally, as stated in the conceptual model, the risks affect SC performance, however, having a standard set of resilience KPIs would help SC managers to control the SC risks and measure it. Moreover, employing resilience capabilities would help SC managers to reduce SC vulnerabilities, and in turn, improve overall performance of the entire chain.

The first cluster is the risks with their rankings based on probability of occurrences. Risks were classified under four main categories as mentioned before in the literature review: (1) External risks, (2) Internal risks, (3) Network risks, (4) Functional risks. The empirical evidences added more aspects concerning risks classification which lead the research to rank risks according to the probability of occurrence. Beginning with external risks, there is a new risk factor aroused from the empirical evidences which is corruption. Corruption risks turn out to have a high probability of occurrence compared to political instabilities, theft, economic instability, or power and energy risk. Furthermore, terrorism, and poor transport infrastructure have high probability of occurrence as well as the unstable governmental policies despite it has minor evidences in literature review. The second category of risks is internal risks where rising labour costs is a new risk factor which aroused from the empirical evidences, besides it has a high probability of occurrences as well as the obsolescence risk. However, obsolescence had minor evidences in literature. On the contrary, poor planning, procurement risks, and raw material issues all have low probability of occurrences. As for capacity shortage, and excess inventory, they have a medium probability of occurrences according to the empirical evidences. While in the network risks category, there are two new risk factors discovered as a result from the empirical evidences: dis-honest suppliers and lower consumer spending. Both evidences have high probability of occurrences as well as competitive risks compared to price volatility, out sourcing, supplier delivery failure, and lack of network communication risks which all have medium probability of occurrences. Regarding instability of market, it has a low probability of occurrences. As for monopoly risks, they have a high probability of occurrences despite of having minor evidence in literature review. Third party logistics risks also had minor evidence in literature review, but it has a medium probability of occurrences. The fourth type is functional risks where the empirical evidences showed that tacit knowledge risks have a high probability of occurrences despite this was not mentioned in the literature review. Moreover, technological risks, un-skilled human resources, and financial risks also have a high probability of occurrences. On the other hand, labour unrest (strikes) has a medium probability of occurrences.

The second cluster is the capabilities. Capabilities were classified under four main categories according to the literature review which are: (1) Visibility, (2) Flexibility, (3) Collaboration, (4) control. The empirical evidences added more aspects concerning capabilities classification according to whether they are stated in resilience context or stated in other context. Beginning with visibility, informal networking, risk communication channels, and information and communication technology are capabilities stated in resilience context. However, role clarity, product awareness, and knowledge management are capabilities stated in other contexts. The second category of capabilities is control; they are capabilities stated in resilience context; such as, accountability, process excellence, change management, and de-centralization. On the other hand, spans of control, and leadership are capabilities stated in other contexts. The third category of capabilities is flexibility. All flexibility capabilities are stated in resilience context including customer flexibility, adaptability, agility, outsourcing, efficiency, and velocity. The last category mentioned in literature review was Collaboration, where co-opetition, group-decision making, supplier relationship management, and customer relationship management are all capabilities which stated in resilience context. Learning and innovation is a new category of capabilities which aroused from the empirical evidences. It includes SC risk awareness management and developments in human resources which are stated in resilience context. On the contrary, market intelligence, and research and development are capabilities stated in other context.

Finally, the third cluster is the SC KPIs. Empirical evidences attempted to collect SC KPIs from companies. Then, as short list of KPIs is created based on the definitions of SC resilience in the literature review (see Figure 2.2). After that, the process of matching the equivalent of KPIs in the short list to the level two SCOR model took place which are 27 KPIs as follows: percentage of orders delivered in full, delivery performance to customer commit date, documentation accuracy, perfect condition, source cycle time, make cycle time, delivery cycle time, delivery retail cycle time, upside SC Flexibility, upside SC Adaptability, downside SC adaptability, cost to plan, cost to make, value at risk (VAR $, percentage of sales), mitigation cost (cost to mitigate SC risk), direct material cost, indirect cost related to production, direct labour, cash-to-cash cycle time, inventory days of supply, inventory days of supply, days sales outstanding, days of payable outstanding, SCM costs, SC fixed assets, SCM costs, inventory, and SC Revenue. These level two SCOR model KPIs are decomposed from level one SCOR model KPIs which include; perfect order fulfilment, order fulfilment cycle time, upside SC Flexibility, upside SC adaptability, downside SC Adaptability, SCM cost, cost of goods sold, cash-to-cash cycle time, return on SC fixed assets, and return on working capital.

4.7 Exploring the interrelations between risks, capabilities, and KPIs

It has been obvious from the analysis of SC resilience constructs that there are complex relations between the three SC resilience constructs (Pettit et al., 2010). Although several researches focused on just highlighting different risks that provoke SC overall performance, or focused on capabilities that enhance resilience, without showing precisely which risk provoke which SC KPI. In turn, the provoked KPI will be the measuring KPI for this specific risk. In this essence, this KPI will be considered resilience KPI. On the other hand, as argued by Pettit et al. (2010) and Zsidisin and Wagner (2010), SC capabilities should be linked to the SC risks that cause vulnerabilities to SCs.

From this notion, this research attempted to demonstrate the interrelations between risks, capabilities, and KPIs by developing three matrices to elaborate the interactions between them based on the viewpoints from the 30 companies interviewed. This will be discussed in the following 3 sub-sections.

4.7.1 The risks/KPIs matrix

The risks-KPIs matrix is developed to demonstrate the interrelations between different risk factors investigated during the data collection and the SC KPIs that ensure resilience. The findings revealed that this matrix will help SC managers to indicate which risk factors largely affect which process that is measured by the pre-identified level two SC KPIs. Moreover, the affected SC resilience KPI will in turn be able to sense and measure the risk causing vulnerabilities before the consequences magnification. For example, 28 companies claimed that the third-party logistics risks affect the percentage of orders delivered in full KPI. Thus, by monitoring this KPI and comparing the results of the values within a particular time horizon, the company can trigger the third-party logistics risks that threaten the delivery process to customers.

The matrix is defined in the columns by the resilience KPIs, which are chosen from level two SCOR KPIs, the level one strategic KPI which the level one KPI decomposed from, and the SC performance attribute in which it belongs. In the rows, which were the four main risk categories and the risk factors are plotted underneath each category. Any interaction cell, which has a number, indicates that there is a relation between the row (risk factors) and the column (resilience KPI). Moreover, this number refers to the number of companies that provided evidence to this relation. Nevertheless, empty cells indicate that there is no relation between the 2 elements. For more details on all verified interactions see **Appendix 10.**

Accordingly, to give a discussion summary of the findings revealed from the matrix, Table 4.7 has been developed to summarize the number of interactions between each capability main category (which includes risk factors), and the level one strategic KPIs (which include the resilience KPIs). The discussion below will give more elaboration to Table 4.7.

Table 4.7: Summary of risks/KPIs matrix

Level 1 Strategic KPIs	**Risks**			
	Internal	**Network**	**External**	**Functional**
Perfect Order Fulfilment	7	12	10	
Order Fulfilment Cycle Time	6	11	8	5
Upside SC Flexibility	6		4	
Upside SC Adaptability		4	4	
Downside SC Adaptability	3	2		
SCM Cost	13	20	19	3
Cost of Goods Sold	5	9	4	1
Cash-To-Cash Cycle Time	5	16	8	1
Return on SC Fixed Assets	9	8	11	2
Return on Working Capital	11	25	12	1

According to Table 4.7 and the full matrix in **Appendix 10**, perfect order fulfilment is affected by six risk factors classified under internal risks including logistics risks, machine breakdown, poor planning, procurement risks, rising labour costs, and obsolescence risk. As for network risks, perfect order fulfilment is affected by eight risks which are instability of market, outsourcing, lack of network communications, supplier delivery failure, third party logistics risks, dis-honest suppliers, lower consumer spending, and monopoly risks. Regarding external risks, perfect order fulfilment is affected by five risks including political instabilities, theft, poor transport infrastructure, terrorism, and economic instability. Moreover, there are no risk factors affecting the perfect order fulfilment KPIs from the functional risk category.

On the other hand, order fulfilment cycle time is affected by five internal risks which are logistics risks, excess inventory, capacity shortage, machine break down, and poor planning risks. As for network risk, order fulfilment cycle time is affected by eight risks including price volatility, instability of market, outsourcing, supplier delivery failure, third part logistics risks, dis-honest suppliers, lower customer spending, and monopoly risks. Regarding external risks, order fulfilment cycle time is affected by six risks which are political instabilities, poor transport infrastructure, terrorism, power and energy risk, and unstable government policies. Furthermore, the order fulfilment cycle time is also affected by functional risks; such as, financial risks, unskilled human resources, and tacit knowledge risks.

Upside SC flexibility is affected by six internal risks which are process instability, excess inventory, capacity shortage, raw materials issues, poor planning, procurement risks, and rising *labour costs. External risks affect upside SC flexibility with four risks including theft, terrorism, power and energy risks, and unstable government policies. However, there are no risk factors affecting the Upside SC flexibility KPIs from the functional or network risks.

Upside SC adaptability is influenced by four network risks, which are instability of market, outsourcing, supplier delivery failure, and dis-honest suppliers. Moreover, it is also affected by external risks such as poor transport infrastructure, terrorism, power and energy risks, and unstable government policies. There are no risk factors affecting the Upside SC adaptability KPIs from the functional or network risks.

Downside SCM adaptability is affected by three internal risks including poor planning, procurement risks, and obsolescence. As for network risks, downside SCM adaptability is influenced by two risks which are competitive risks, and instability of market. On the other hand, there are no risk factors affecting the SCM adaptability KPIs from the functional or external risks.

SCM cost is influenced by seven internal risks including process instability, logistics risks, excess inventory, capacity shortage, raw materials issues, procurement risks, and obsolescence. Regarding network risks, SCM cost is affected by four risk factors, which are instability of market, outsourcing, supplier delivery failure, and dis-honest suppliers. SCM cost is also affected by five risk factors within external risks including theft, poor transport infrastructure, economic instability, power and energy risks, and corruption. Concerning functional risks, SCM cost is affected by only two risks which are technological risks, and financial risks.

While the cost of goods sold is influenced by five risk factors, including machine breakdown, raw material issues, poor planning, procurement risks, and rising labour costs. Network risks also have an impact on cost of goods sold as it is affected by six risk factors from the network risks, including competitive risks, price volatility, instability of market, third party logistics risk, lower consumer spending, and monopoly risks. Furthermore, cost of goods sold is also affected by two risks within external risks which are political instabilities and terrorism. As for functional risks, they have an impact on cost of goods sold especially from technological risks.

Cash-to-cash cycle time is affected by five risk factors from the internal risks, including machine breakdown, raw material issues, poor planning, procurement risks, and rising labour costs. It is also affected by nine risk factors categorized under network risks which are competitive risks, price volatility instability of market, outsourcing, supplier delivery failure, third party logistics risks, dis-honest suppliers, lower consumer spending, and monopoly risks.

Regarding external risks, cash-to-cash cycle time is influenced by five risk factors including political instabilities, theft, poor transport infrastructure, terrorism, and economic instability. As for functional risks, only one risk (i.e. technological risk) impacts the cash-to-cash cycle time.

The return on SC fixed assets is negatively impacted by four internal risk factors which are logistics risks, excess inventory, procurement risks, and obsolescence. Furthermore, it is also affected by six network risk factors including outsourcing, supplier delivery failure, third party logistics risks, dis-honest suppliers, lower consumer spending, and monopoly risks. Regarding external risks, return on SC fixed assets is influenced by seven risk factors including political instabilities, theft, poor transport infrastructure, terrorism, economic instability, power and energy risks, and corruption. As for functional risks, they have an impact on SC fixed assets especially from technological risks.

Finally, the return on working capital is affected by eight internal risk factors which are logistics risks, process instability, excess inventory, machine breakdown, raw material issues, poor planning, procurement risks, and rising labour costs. It is also affected by nine network risks which are competitive risks, price volatility instability of market, outsourcing, supplier delivery failure, third party logistics risks, dis-honest suppliers, lower consumer spending, and monopoly risks. Regarding external risk, return on working capital is influenced by five risk factors including, political instabilities, theft, poor transport infrastructure, terrorism, economic instability. Technological risks have a significant impact on return on working capital.

Based on preceding discussion, it was clear that perfect order fulfilment is highly affected by network risk as claimed by 16 companies. Similarly, the order fulfilment cycle time is highly affected by network risk as it has evidence from 16 companies. Concerning upside SC flexibility, it is highly affected by internal risk as it was mentioned six times by 16 companies.

However, upside SC adaptability is highly influenced by both network and external risks as 16 companies mentioned it four times. On the contrary, downside SC adaptability is affected by internal risk more than network risk as referred by 16 companies. The network risks showed the highest impact on SCM costs as acknowledged by 16 companies with twenty evidence. Likewise, the cost of goods sold and the cash-to-cash cycle time is influenced by network risks as indicated by 16 companies. On the contrary, SC fixed assets is highly affected by external risks with eleven evidences from 16 companies. Lastly, return on working capital is highly affected by network risk as sixteen companies mentioned with 25 evidences.

4.7.2 The capabilities/KPIs matrix

The capabilities-KPIs matrix is developed to demonstrate the effect of implementing the identified capabilities on enhancing performance measure by SC KPIs to ensure resilience. The findings revealed from this matrix will help SC managers to indicate which capability has to be improved to enhance a certain SC KPI that needs improvement. For example, 29 companies claimed that maintaining a good sort of group decision making will reflect significant enhancements on the percentage of orders delivered in full KPI.

The matrix is defined in the columns by the resilience KPIs, which are chosen from level two SCOR KPIs, the level one strategic KPI which the level one KPI decomposed from, and the SC performance attribute in which it belongs. In the rows, the five main capability categories and the sub-capabilities are plotted underneath each category. Any interaction cell, which has a number, indicates that there is a relation between the row (sub-capability) and the column (resilience KPI). Moreover, this number refers to the number of companies that provided an evidence to this relation. However, empty cells indicate that there is no relation between the elements. For more details on all verified interactions see **Appendix 11**.

Thus, to give a discussion summary of the findings revealed from the matrix, Table 4.8 has been developed to summarize the number of interactions between each capability main category (which include sub-capabilities), and the level one strategic KPIs (which includes the resilience KPIs). The discussion underneath will give more elaboration to Table 4.8

Table 4.8: Summary of capabilities/KPIs matrix

Level 1 Strategic KPIs	Capabilities				
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Perfect Order Fulfilment	9	6	6	7	5
Order Fulfilment Cycle Time	10	7	7	9	5
Upside Supply Chain Flexibility	1	1	1	1	1
Upside Supply Chain Adaptability	2	1	1	1	1
Downside Supply Chain Adaptability	1	1	1	1	0
Supply Chain Management Cost	12	9	5	7	7
Cost of Goods Sold	8	5	5	6	4
Cash-To-Cash Cycle Time	7	5	5	6	4
Return on Supply Chain Fixed Assets	9	6	6	7	5
Return on Working Capital	10	8	4	6	6

According to Table 4.8 and the full matrix in **Appendix 11**, the perfect order fulfilment KPIs are improved by five sub-capabilities under the visibility category including role clarity, informal networking, risk communication channels, knowledge management, information and communication technology. Furthermore, the perfect order fulfilment KPIs are improved by four sub-capabilities under flexibility category including adaptability, agility, outsourcing and efficiency. Also, they are improved by four sub-capabilities under Collaboration including co-opetition, supplier relationship management, customer relationship management, group decision making. Moreover, perfect order fulfilment KPIs are improved by five sub-capabilities under control category including accountability, process excellence, spans of control, decentralization and leadership. Finally, they are improved by three sub-capabilities under learning and innovation category including SC risk management awareness, market intelligence, research and development.

On the other hand, the order fulfilment cycle-time KPIs are improved by four sub-capabilities under visibility category, which are role clarity, informal communication, knowledge management, information and communication technology. It is also improved by three sub-capabilities under flexibility including adaptability, outsourcing and efficiency. Regarding Collaboration, the order fulfilment cycle-time KPIs are improved by three sub-capabilities which are co-opetition, customer relationship management, group decision making. Furthermore, it is also improved by four sub-capabilities under control category, including accountability, spans of control, decentralization and leadership. Finally, the order fulfilment cycle-time KPIs are improved by two sub-capabilities under learning and innovation including market intelligence, research and development.

The upside SC flexibility KPIs are enhanced by five sub-capabilities, which are risk communication channels, agility, supplier relationship management, process excellence, and SC risk management awareness. What Furthermore more, the downside SC flexibility KPIs are improved by four sub-capabilities including knowledge management, outsourcing, customer relationship management and spans of control. As for upside SC adaptability KPIs, they are enhanced by six capabilities which are role clarity, information and communication technology, efficiency, group decision making, decentralization, research and development.

While the SCM costs KPIs are reinforced by four sub-capabilities underneath visibility which are role clarity, product awareness, knowledge management, information and communication technology. It is also improved by three sub-capabilities under flexibility, including customer flexibility, efficiency and velocity. Concerning Collaboration, group decision making is the only sub-capability observed in improving SCM cost. As for control, SCM cost KPIs are improved by two sub-capabilities, decentralization and change management. Regarding learning and innovation, SCM cost KPIs are enhanced by two sub-capabilities, which are research and development, and development in human resources.

Concerning the cost of goods sold KPIs, they are highly affected by four capabilities in visibility including role clarity, informal networking, knowledge management, information and communication technology. It is also affected by three capabilities in flexibility including adaptability, outsourcing and efficiency. Regarding Collaboration, cost of goods sold is affected by three capabilities including co-opetition, customer relationship management and group-decision making. As for control, cost of goods sold is affected by four capabilities which are accountability, spans of control, decentralization and leadership. Concerning learning and innovation, cost of goods sold is affected by two capabilities including market intelligence, and research and development.

The cash-to-cash cycle time KPIs are reinforced by five sub-capabilities, which are role clarity, informal networking, knowledge management, risk communication channels, and information and communication technology. Regarding flexibility, cash-to-cash cycle time KPIs are improved by four sub-capabilities including adaptability, agility, outsourcing and efficiency. Cash-to-cash cycle time is also improved by four sub-capabilities under Collaboration including co-opetition, supplier relationship management, customer relationship management, and group decision making. Regarding control, cash-to-cash cycle time is enhanced by five sub-capabilities which are accountability, process excellence, spans of control, decentralization and leadership. Furthermore, cash-to-cash cycle time is also related to three capabilities in learning and innovation such as SC risk management awareness, market intelligence, and research and development.

Return on SC fixed assets KPIs are associated to five sub-capabilities under visibility, including role clarity, informal networking, risk communication channels, knowledge management, and information and communication technology. It is also interrelated to flexibility sub-capabilities; such as, adaptability, agility, outsourcing, and efficiency. Regarding Collaboration, return on SC fixed assets KPIs are reinforced by four sub-capabilities, which are co-opetition, supplier relationship management, customer relationship management, and group-decision making. As for control, return on SC fixed assets are allied by five sub-capabilities including accountability, process excellence, spans of control, decentralization, and leadership. Finally, return on SC fixed assets are improved by three capabilities in learning and innovation including SCM awareness, market intelligence, and research and development.

Eventually, the return on working capital KPIs relate to three sub-capabilities underneath visibility, which are role clarity, product awareness, and information and communication technology. As for flexibility, return on working capital relates to three sub-capabilities including customer flexibility, efficiency, and velocity. The return on working capital is interrelated to one capability in Collaboration which is group-decision making. Regarding control, return on working capital relate to two sub-capabilities including decentralization and change management. Finally, return on working capital KPIs are improved by two capabilities in learning and innovation which are research and development, and development in human resources.

Therefore, based on the foregoing discussion, it was obvious that perfect order fulfilment KPIs are mostly interrelated with visibility, since 16 companies stated that they related to nine sub-capabilities within visibility. Furthermore, order fulfilment cycle time is mostly related to visibility too as 16 companies believed that it is related to ten sub-capabilities within visibility. Upside SC flexibility and downside SC adaptability are equally affected by all capabilities; however, upside SC adaptability is more related with visibility than other capabilities according to 16 companies' consideration. SCM cost highly sensitive with visibility because it is related to twelve sub-capabilities as referred by 16 companies. Cost of goods sold is also highly interrelated to visibility as it is declared by 16 companies, and related with eight sub-capabilities within visibility. Regarding cash-to-cash cycle time, visibility is highly related to it, since cash-to-cash cycle time interacts with seven capabilities within visibility according to 16 companies' consideration. Return on SC fixed assets is also highly affected by visibility more than other capabilities since 16 companies believed that return on SC fixed assets is related to nine sub-capabilities. Finally, return on working capital is highly connected to visibility as sixteen companies mentioned that it is enhanced by ten sub-capabilities within visibility.

4.7.3 The capabilities/risk matrix

The capabilities-risks matrix is developed to investigate the effect of implementing the identified capabilities on eliminating risks that causes SC vulnerabilities to ensure resilience. The findings revealed from this matrix will help SC managers to indicate which capability should be improved to reduce a specific risk factor.

For example, the 30 companies claimed that outsourcing different business functions would help companies to reduce the risk of obsolescence. Thus, identifying and enhancing the outsourcing as a resilience capability would help companies to reduce SC vulnerability, and in turn, increase resilience. Furthermore, failing in identifying the adequate capabilities to overcome SC vulnerabilities would lead to magnification and migration of the risk to the entire chain (Pettit et al, 2010).

The matrix is defined in the columns by the risk factors that cause SC vulnerabilities. While in the rows, the 5 main capabilities and the sub-capabilities are identified underneath each category. Any interaction cell, which has a number, indicates that there is a relation between the row (sub-capability) and the column (risk factor). Moreover, this number refers to the number of companies that provided evidence to this relation. Nevertheless, empty cells indicate that there is no relation between the two elements. For more details on all revealed interactions see **Appendix 12**.

Accordingly, to give a discussion summary of the findings revealed from the matrix, Table 4.9 is developed to summarize the number of interactions between each capability category (which include sub-capabilities), and the risk categories (which includes risk factors). The discussion below will give more elaboration to Table 4.9

Table 4.9: Summary of capabilities/risks matrix

Level 1 Strategic KPIs	**Capabilities**				
	Visibility	**Flexibility**	**Collaboration**	**Control**	**Learning and Innovation**
Internal Risk	2	11	10	2	9
Network Risk	8	9	10	5	8
External Risk	6	4	7	4	8
Functional Risk	3	5	4	3	5

The discussion of Table 4.9 and the full matrix in **Appendix 12** will be elaborated based on the contribution of each capability on reducing the impact of the different risk factors as follow:

Visibility

Role clarity is interrelated with internal risks as it reduces the risk of excess inventory and procurement risk. It also has an influence on external risk by reducing the risk of political instabilities and poor transportation infrastructure risk. Regarding network risk, role clarity reduces the risk of market instability, outsourcing, dis-honest suppliers, and monopoly.

On the other hand, product awareness is linked to network risks as it reduces the risk of competition, and low consumer spending. Regarding external risks, the product awareness helps in overcoming the risk of terrorism. It also linked by functional risks through reducing the technological risks, and financial risks.

Information and communication technology affects the network risks by reducing the competitive risk and price volatility risk. It also has an influence on external risks as it reduces the theft risk, power and energy risks, and unstable government policies risk. Regarding functional risks, information and communication technology reduces the risk of tacit knowledge.

Flexibility

Customer flexibility has a significant influence on internal risks as it reduces the risk of logistics, process instability, capacity shortage, machine breakdown, raw material issues, poor planning, and rising labour cost. Concerning functional risks, customer flexibility reduces the threat of technological risk. It also affects network risks by reducing the threat of lack of network communication risk, supplier delivery failure risk, and third party logistics risk.

Adaptability reduces risks within functional risks; such as, un-skilled human resources risk, and labour unrest risk. It also has influence on external risk as it reduces the risk of corruption.

Agility has a great influence on internal risks as it reduces the inventory excess risk, and procurement risk. It also has an influence on external risk by reducing the risk of political instabilities and poor transportation infrastructure risk. Regarding network risk, agility reduces the risk of market instability, outsourcing, dis-honest suppliers, and monopoly.

Outsourcing reduces many risks within internal risks including rising labour cost risk, and obsolesce risk. As for external risk, it reduces the risk of terrorism. It also reduces the risk of competition and lower consumer spending within network risk. Concerning functional risks, outsourcing reduces the technological risks and financial risks.

Collaboration

CooPettition has a significant impact on internal risks, as it reduces the threat of logistics risks, process instability risks, capacity shortage, machine breakdown, raw material issues, and poor planning. It also affects network risks by reducing the threat of price volatility risk, lack of network communication, supplier delivery failure, and third party logistics risks.

Supplier relationship management reduces the risk of corruption within external risks. It also reduces the risk of un-skilled human resources and labour unrest risk within functional risks.

Customer relationship management has a great impact on network risks as it reduces the instability of market risk, outsourcing risk, dis-honest suppliers' risk, and monopoly risk. It also affects internal risks by reducing the threat of excess inventory, and procurement risks. Regarding external risks, customer relationship management reduces the threat of political instabilities, poor transport infrastructure, unstable government policies, and corruption. Customer relationship management has an influence on functional risks as it reduces the labour unrest risk, and tacit knowledge risk.

Group-decision making has an influence on internal risks including rising labour costs, and obsolescence. As for external risks, group-decision making reduces the threat of terrorism risks, and economic instability risks. Concerning network risks, it reduces the threat of competitive risk, and lower consumer spending risk.

Control

Accountability affects external risks as it reduces the unstable government policies risk. While the process excellence affects internal risks as it reduces the risk of excess inventory and procurement risk. It also has an influence on external risk by reducing the risk of political instabilities, poor transportation infrastructure risk and power and energy risks. Regarding network risk, process excellence reduces the risk of market instability, outsourcing, dis-honest suppliers, and monopoly. Process excellence affects functional risks by reducing the technological risks, financial risks, and unskilled human resources. Lastly, leadership has an impact on network risks as it reduces the threat of lower consuming spending risk.

Learning and innovation

SC risk management awareness has an impact on network risks as it reduces the competitive risks, and price volatility risks. It also affects external risks by reducing the theft risk, power and energy risks, and corruption risks. Regarding functional risks, SCRM awareness reduces the threat of labour unrest risks, and tacit knowledge risks.

Market intelligence has a great influence on internal risks as it reduces logistics risks, process instability risks, capacity shortage risk, machine breakdown risk, raw materials issues, poor planning risks, procurement risks, and rising labour costs. As for external risks, market intelligence reduces the threat of terrorism risks, and economic instability risks. It also affects network risks by reducing the threat of lack of network communication risk, supplier delivery failure risk, and third party logistics risk.

Development in human resources has a significant impact on internal risks as it reduces excess inventory risks, and procurement risks. It also has an influence on external risk by reducing the risk of political instabilities, poor transportation infrastructure risk and power and energy risks. Regarding network risk, development in human resources reduces the risk of outsourcing, dis-honest suppliers, and monopoly. Development in human resources affects functional risks by reducing the technological risks, financial risks, and unskilled human resources.

Eventually, internal risk factors can be better managed by enhancing the flexibility as referred by 16 companies. As for network risk factors, 16 companies asserted that they are highly interrelated with enhancements in SC Collaboration. Similarly, to overcome external risk factors, it has been reported with seven evidences that Collaboration between different network partners will give the best results. Finally, functional risks are best controlled by learning and innovation capabilities as pointed out with five evidences.

4.8 Extending stage one findings

As explicated in the research methodology chapter, this research will include 2 stages in the empirical study in order to answer the research questions addressed earlier. Stage 2 of the empirical study is primarily based on the findings revealed from stage 1 and extends the discussion to provide more depth to the research findings. Thus, it will be easier for SC managers to use the model of SC resilience. There are certain motives to extend the findings of this research, they are:

- To extend and provide more value to the findings by prioritizing the SC resilience constructs (risks, capabilities, and KPIs) explored and analysed in stage 1.
- To make the model easy to be understood by SC managers to help them to enhance resilience in SCs – if there is a list of ranks for risks, capabilities, and KPIs, it would help managers to anticipate risks, enhance their capabilities, and improve the performance of the entire chain.

4.9 Summary

This chapter deliberated stage one of empirical study and its findings. Purposive and snow-ball sampling techniques were adopted. Semi-structured interviews were used to collect data from 30 FMCG companies operating in the MER. Thematic and comparative analysis methods were used to analyse the transcribed data from the interviews. During the analysis, a preliminary qualitative ranking was developed to the risk factors identified during data collection. The ranking was the probability of occurrences of the different risk factors as perceived by different participants. Furthermore, SC KPIs were collected from the companies and then shortlisted based on understanding definition of SC resilience. Then, the shortlisted KPIs were transformed to the SCOR KPIs in order to have a standard set of SC resilience KPIs for the entire chain members.

Accordingly, the first part of the three research questions was answered in this chapter, i.e. to explore the risks facing SC managers in FMCG in MER, to investigate capabilities employed to manage SC risks, and to define possible KPIs for SC performance to manage resilience.

Based on the empirical findings, the conceptual model developed based on the literature review was refined and improved. Furthermore, three matrices were developed to demonstrate the interrelations between risks, capabilities, and KPIs to ensure resilience into SCs. The matrices are risks/capabilities matrix, risks/KPIs matrix, and KPIs/capabilities matrix.

The final section highlights the reasons behind extending the findings of stage one to rank the three SC resilience constructs.

Chapter five: Stage 2 of the empirical study – prioritizing supply chain resilience constructs using AHP

5.1 Introduction

This chapter explores SC resilience constructs using AHP method to extend the findings from the stage one of empirical analysis. The decision to use this technique was based on its advantage for analysing several factors and gaining a weight for each, in order to enable to prioritize each of the three SC resilience constructs (risks, capabilities, and KPIs).

5.2 Analytic hierarchy process (AHP) method

The AHP method developed by Thomas L. Saaty was developed to work as a tool that works with complex multi-criteria decision problems. Over the years, AHP has proven to be a highly effective decision-analysis tool because of its ability to incorporate intangibles into the decision-making process and its ease of use. AHP requires decision maker to provide judgments about the relative importance of each criterion, and then specify a preference for each decision alternative using each criterion. The output of AHP is a prioritized ranking of the decision alternatives based on the overall preferences expressed by the decision maker. It has been argued that AHP is one of the effective tools in SCM and logistics decision making (Sipahi and Timor, 2010). Moreover, it has been effectively used for logistics applications; such as, the analysis of international consolidation terminals, locating airports and determining what to benchmark (Partovi, 1994). This can be done through setting priorities or weighing different alternatives based on a pre-defined criterion to achieve a certain goal. Consequently, this enables the most suitable alternatives to be chosen (Tramarico et al., 2015).

Thus, the application of AHP methodology involves four phases, namely:

- Phase 1: Structuring problems and building the AHP model.
- Phase 2: Collecting data through pairwise comparisons carried out by interviews.

- Phase 3: Determining normalized priority weights of individual factors.
- Phase 4: Analysing priority weights of the three SC resilience constructs.

The main advantage provided by AHP is eliminating any bias that could result from subjective value judgements and subsequently providing both consistent and robust results with the use of AHP related software, Expert Choice (EC).

The relevant data were collected from the same 30 companies interviewed in stage one of the data collection to determine the relative importance of criteria. The nine-point scale, as suggested by Saaty (1977), was used to assign the relative scores. Each was asked to carefully evaluate and assign relative scores using the nine-point scaling system in a pairwise style with respect to the criteria of one level of hierarchy given the criteria at the next higher level. This process was continued in relation to all levels of the whole hierarchy. Thus, a series of pairwise comparison judgement matrices were obtained with respect to the criteria, and the alternatives used in the AHP model. Furthermore, by conducting face-to-face interviews with SC managers, problems due to definitions or interruptions were minimized. Also, face-to-face interviews helped in solving any inconsistency that may occur. This could not have taken place if a questionnaire was sent to them.

Evaluators could be interviewed again and any problems would subsequently be resolved much faster. Based on the normalized priority weights, the relative importance of success factors is assessed, as explained in the following sections. It should be noted; however, that the priority weights obtained by using the EC software, and the conclusions drawn from them are the results of the analysis of the collective judgements selected for this research.

5.2.1 Fundamentals of AHP

There are several basic terms and steps which involve in AHP method (Vargas, 1990; Forman and Gass, 2001). A decision criterion or objective is a variable used to prioritize a choice over the other choices. An alternative decision is an item required to be ranked over other available items. The decision maker compares two items at a particular time with respect to a criterion/objective, which is called a pairwise comparison. AHP method requires several pairwise comparisons to perform the analysis (Anderson et al., 2015). In AHP, matrix is a rectangular array of pairwise comparisons of decision alternatives with respect to a particular criterion. Always there may be inconsistencies in decision maker's pairwise comparisons. For example, one may say (A) is more important than (B), or (B) is more important than (C). Therefore, (A) should be more important than (C). However, he/she may mistakenly say (C) is more important than A. AHP calculates inconsistency ratios for each matrix by taking such errors into consideration. Moreover, those ratio values should be within the acceptable range.

In application to this research, the objective is to use the SC attributes (reliability, responsiveness, agility, costs, and assets), previously discussed in chapter four, while the decision alternatives will be drawn from three main resilience construct.

As for the risks associated with SCs as seen in Figure 5.1, they are internal Risk, network risk, external risk and functional risk which need to be prioritized in relation to the SC attributes.

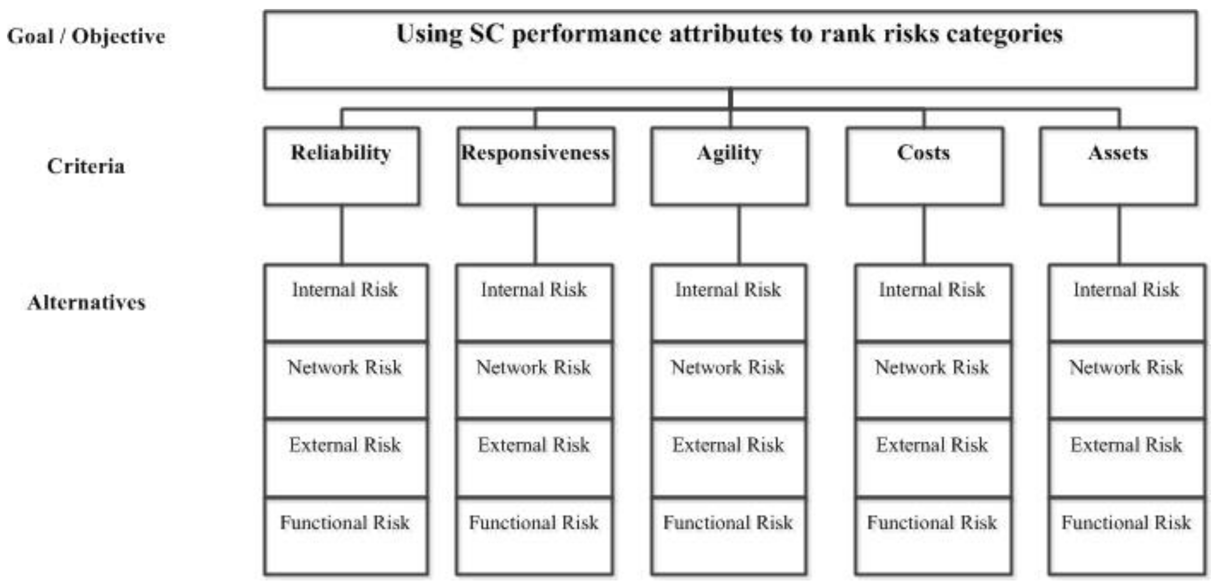

Figure 5.1: AHP decision hierarchy for SC risks

However, the SC capabilities as seen in Figure 5.2 are visibility, flexibility, Collaboration, control, and learning and innovation. Those capabilities need to be prioritized in relation to the SC attributes.

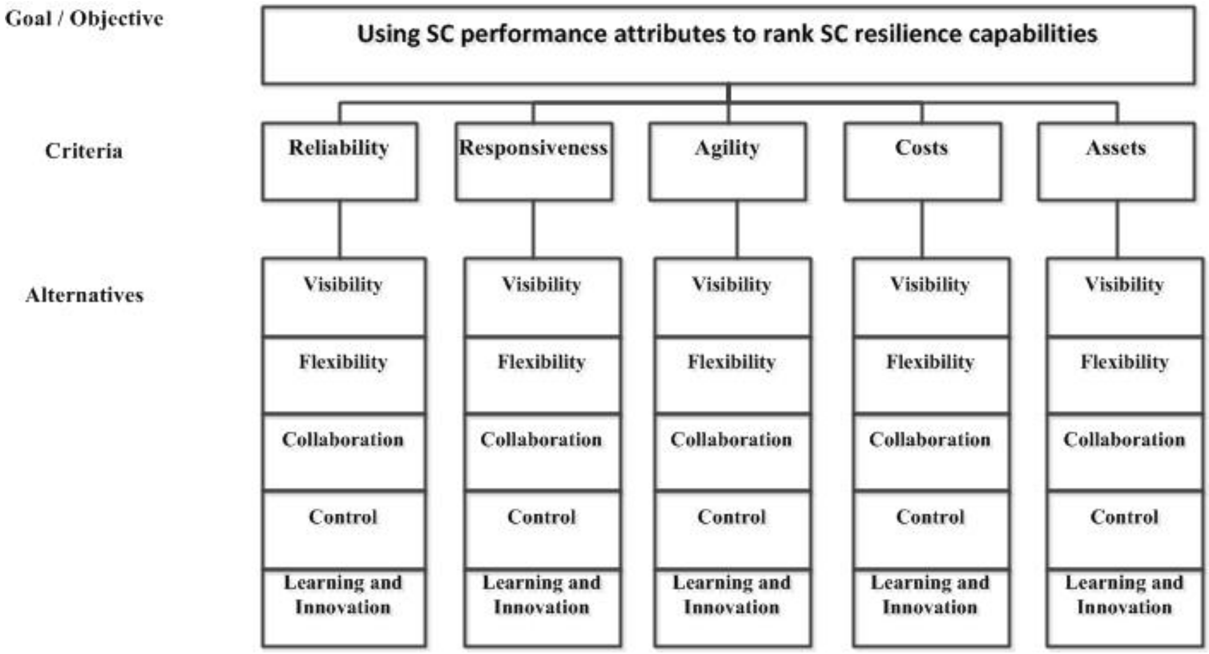

Figure 5.2: AHP decision hierarchy for SC capabilities

Finally, level one KPIs, as previously identified in Figure 5.3, are as follows;

- Perfect order fulfilment
- Order fulfilment cycle time
- Upside SC flexibility
- Upside SC Adaptability
- Downside SC adaptability
- SCM cost
- Cost of goods sold
- Cash-to-cash cycle time
- Return on SC fixed assets
- Return on working capital

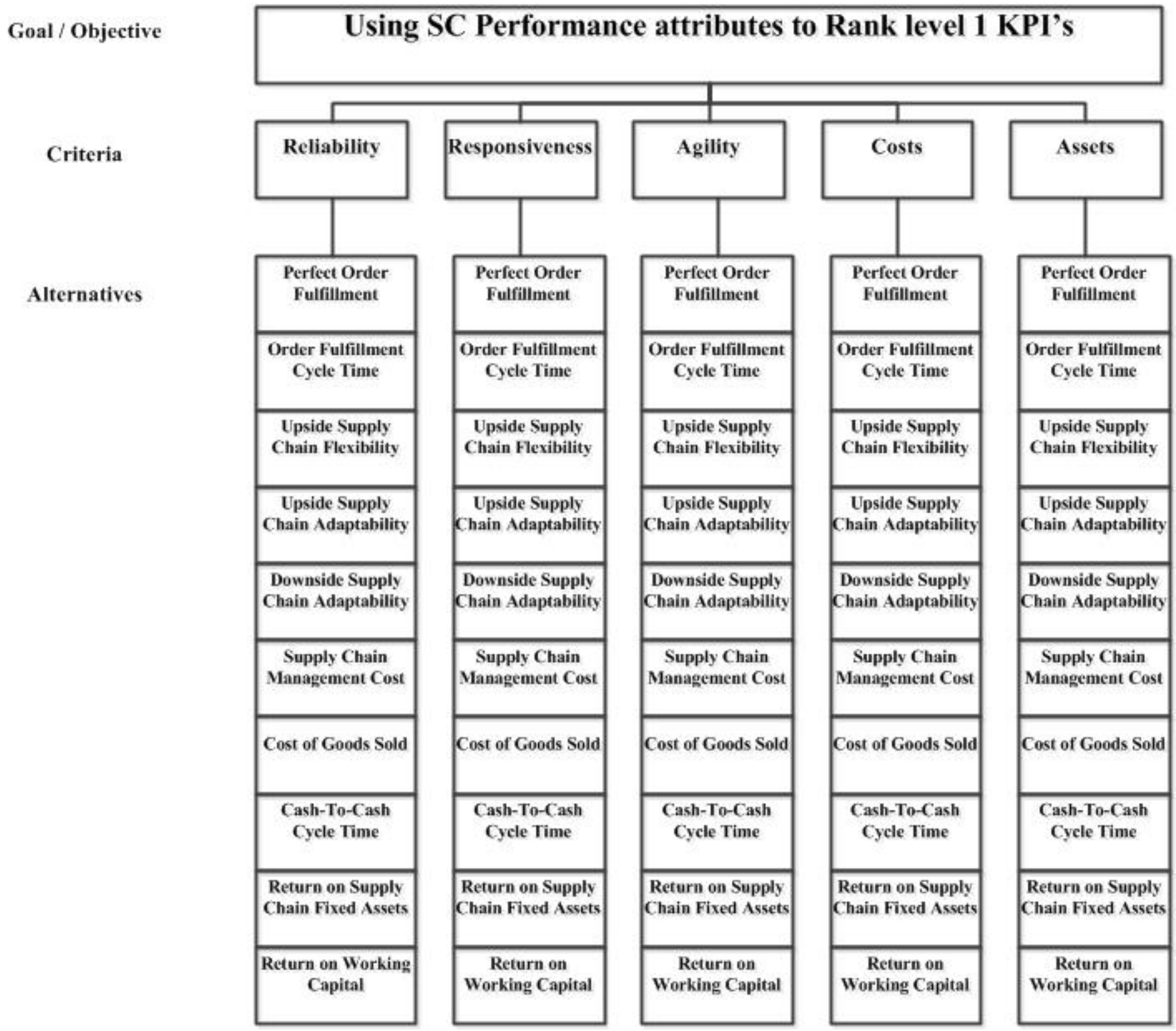

Figure 5.3: AHP decision hierarchy for KPIs

AHP is characterized by having complex mathematics and equations. However, scholars in this field have made AHP easier to use and flexible for decision making (Chan et al., 2004; Ishizaka and Labib, 2009; Jayawickrama, 2015). They were able to explain complex mathematics using simple steps to perform AHP analysis in numerous fields, in other words, the same complex mathematical process can be performed using sequence of organized steps with less complex mathematics (Anderson et al., 2015). Therefore, this makes it easier to use AHP for many real-world and business problems without having deeper mathematical understanding.

5.2.2 AHP using Expert Choice software tool

It is very hard to perform AHP analysis manually especially with large number of decision criteria, alternatives and survey participants (Ho, 2008; Subramanian and Ramanathan, 2012). For this reason, people have worked to develop different software tools over the years to perform the AHP analysis automatically. There are several software tools available in the market to perform AHP analysis such as Priority Estimation Tool, AHP Online Calculator, Make It Rational AHP software and EC (Ishizaka and Labib, 2009). However, EC was selected and used over the other software tools for this study. Mainly because;

- Expert Choice was developed by Thomas L. Saaty who founded the AHP method. He automated the manual AHP procedures to make it user-friendly by locating complex mathematics to run in the backend of the software.
- Expert Choice software has two types of applications i.e., desktop version (windows-based) and web-based version called EC Comparison Suite. Both versions follow identical AHP analysis procedures in calculations. However, the desktop version was more suitable for this study since the desktop version has all the features needed is available. Only questionnaire based AHP may use the EC Comparison Suite since it has a feature to develop the AHP based online questionnaire through the software itself, which the desktop version does not have.

There are various other unique features readily available with EC software that will be clear in appropriate sections of this chapter.

5.3 Steps to perform AHP analysis

By considering several studies into account, Anderson et al. (2015) defined several simple steps to carry out the AHP analysis with less complex mathematics to apply the method to different purposes. Those steps have been widely used to make decisions and priorities factors in various fields including SCM as stated earlier. This study uses these steps to rank the three SC resilience constructs. The whole process consisting of 9 steps as explained below with the actual pairwise data. The decision hierarchy displays in Figures (5.1, 5.2 and 5.3) are based on 5 matrices or clusters for criteria. Alternatives are based on 5 matrices for capabilities (Figure 5.1) matrices for risks (Figure 5.2) and 10 matrices for KPIs (Figure 5.3).

The steps will be divided into 4 sub sections; first, the first 5 steps will be calculated that will be the same for the 3 main AHP models constructed (risks, capabilities, and KPIs), second to fourth sub sections, steps from 6 to 9 will be calculated for each model separately.

5.3.1 Steps from 1 to 5

Step 1: Develop the hierarchy

The first step in AHP is to develop a diagrammatic representation of the problem in terms of the overall goal, the criteria to be used and the decision alternatives. The overall goal of this decision hierarchy is ranking risks, capabilities, and KPIs. The decision hierarchy has already been developed based on the findings of stage one of empirical phases in chapter four (see Figures 5.1., 5.2., and 5.3).

The interviews specify judgments about the relative importance of each of five criteria in terms of its contribution to the achievement of the overall goal (Saaty, 2003). At the next level, the structured interviews have been conducted to indicate a preference for each decision alternative (risks, capabilities and KPI's) based on each criterion (Using SC attributes to act vulnerability sensors for potential risks). A mathematical process is used to synthesis the information on the relative importance of the criteria and preferences for the decision alternatives to provide an overall priority ranking of the decision alternatives (Saaty, 2000).

Step 2: Pairwise comparison using the scale 1 to 9

The interviews can express the importance or preference about two factors at a time using a scale of 1 to 9. Pairwise comparisons form the fundamental building block of AHP (Anderson et al., 2015). AHP require the interviewee to state how important each criterion is relative to the other criterion, when the criteria are compared two at a time (pairwise) to establish the priorities for five criteria. In each comparison, interviewee must select the more important criterion and then express a judgment of how much more important the selected criterion is (Jayawickrama, 2015). Moreover, the interviewee can convert the verbal importance of a criterion over another criterion to numerical value when providing pairwise judgments using below scale as stated earlier in this chapter.

Table 5.1: Comparison scale for the importance of criteria

Verbal judgment	**Numerical rating**
Extremely more important	9
	8
Very strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

Source: Saaty and Vargas (2012)

For example, interviewee must provide his/her judgments for the pairwise comparisons; such as, the importance of reliability compared to responsiveness, the importance of agility compared to costs, the importance of reliability compared to assets, etc.

Step 3: Pairwise comparison matrix

All combinations of pairwise comparisons for the five criteria can be represented using a 5x5 matrix. The actual pairwise comparisons provided by interviews can be seen as follows;

Item Description	Reliability	Responsiveness	Agility	Costs	Assets
Reliability	1.000	2.000	5.000	3.000	3.000
Responsiveness	0.500	1.000	9.000	7.000	4.000
Agility	0.200	0.111	1.000	0.500	0.500
Costs	0.333	0.143	2.000	1.000	0.333
Assets	0.333	0.250	2.000	3.000	1.000

The maximum number of pairwise comparisons required for a matrix for AHP analysis is denoted by:

Maximum number of comparisons = n (n-1)/2

Where n is the number of items being compared in each matrix / cluster. It requires values only for one half of the rectangular to populate the rest of the values for the matrix. In this case n=5, hence maximum number of comparisons required is 10. The figures highlighted with yellow are provided by the interviews for 10 pairwise comparisons. If reliability is compared with reliability, obviously, the answer is equally important. Therefore, there are 5 ones highlighted with black in the above matrix. The rest of the 10 values can be derived by inversing the respective 10 values provided by the interviews. For example, start reading from row 2, reliability is equally to moderately less important than responsiveness, therefore the importance is 2. Bearing that in mind, it is possible to derive the value for row 1 and column 2 i.e., responsiveness is 1/2 as important as reliability. Likewise, the rest of the values can be derived by 1 dividing by the respective scale value, which the interviews have provided.

Step 4: Synthetization

It would be able to calculate the priority of each criterion in terms of its contribution to the overall goal of ranking risks, capabilities, and KPIs using the pairwise comparisons matrix. This aspect of AHP is referred to as synthetization. Although the exact complex mathematical calculation is beyond the scope of this thesis, the following three-step procedure provides a good appropriation to the complex mathematical procedure performed at the backend of the software to produce systemization results (Anderson et al., 2015; Ishizaka and Labib, 2009).

Step 4.1: Sum the values in each column.

Item Description	Reliability	Responsiveness	Agility	Costs	Assets
Reliability	1.000	2.000	5.000	3.000	3.000
Responsiveness	0.500	1.000	9.000	7.000	4.000
Agility	0.200	0.111	1.000	0.500	0.500
Costs	0.333	0.143	2.000	1.000	0.333
Assets	0.333	0.250	2.000	3.003	1.000
Sum	2.37	3.50	19.00	14.50	8.83

Step 4.2: Divide each value of the matrix by its column total – the resulting matrix is referred to as the normalized pairwise comparison matrix.

	Reliability	Responsiveness	Agility	Costs	Assets
Reliability	0.42	0.57	0.26	0.21	0.34
Responsiveness	0.21	0.29	0.47	0.48	0.45
Agility	0.08	0.03	0.05	0.03	0.06
Costs	0.14	0.04	0.11	0.07	0.04
Assets	0.14	0.07	0.11	0.21	0.11

Step 4.3: Average the values in each row to determine the priority of each criterion.

	Reliability	Responsiveness	Agility	Costs	Assets	Weight
Reliability	0.42	0.57	0.26	0.21	0.34	36.1%
Responsiveness	0.21	0.29	0.47	0.48	0.45	38.1%
Agility	0.08	0.03	0.05	0.03	0.06	5.2%
Costs	0.14	0.04	0.11	0.07	0.04	7.9%
Assets	0.14	0.07	0.11	0.21	0.11	12.8%

AHP determines that responsiveness impact with a priority of 38.1% is the most important attribute. Reliability is ranked the second most important criterion with a priority of 36.1%. While assets with a priority of 12.8% is ranked third in importance and is costs with a priority of 7.9% ranks fourth in importance, and agility has the least priority given by 5.2%. The below matrix shows the same values with two more additional columns at the end, i.e., the manually calculated priorities in percentage and priorities obtained from the EC software for the same participant's responses.

	Reliability	Responsiveness	Agility	Costs	Assets	Weight	**EC**
Reliability	0.42	0.57	0.26	0.21	0.34	36.1%	**37.1**
Responsiveness	0.21	0.29	0.47	0.48	0.45	38.1%	**38.1**
Agility	0.08	0.03	0.05	0.03	0.06	5.2%	**5**
Costs	0.14	0.04	0.11	0.07	0.04	7.9%	**7.4**
Assets	0.14	0.07	0.11	0.21	0.11	12.8%	**12.5**

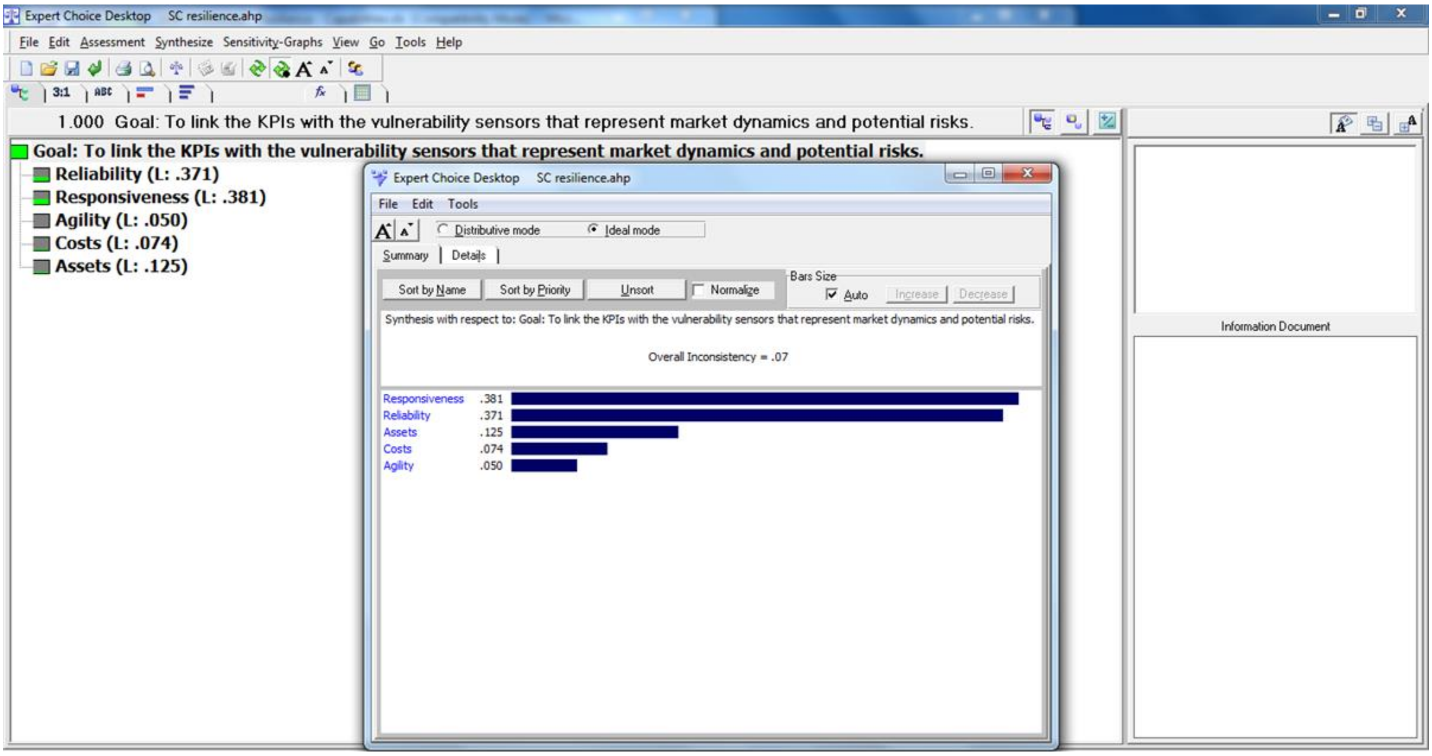

Figure 5.4: EC results for the ranking of AHP criteria

The difference of the last two columns is very minimal for the demonstration purpose of the manual procedure with less complex mathematics and software procedure with complex mathematics. The ranks remain same in both calculations which prove that these steps can be used to illustrate the software procedure with complex mathematics to priorities attributes.

Step 5: Calculating consistency

An important consideration in this process is the consistency of the pairwise judgments provided by the interviews or decision maker. For example, if criterion A compared to criterion B has a numerical rating of 3 and if criterion B compared to criterion C has a numerical rating of 2, perfect consistency of criterion A compared to criterion C would have a numerical rating of 3x2 = 6. If the A to C numerical rating assigned by the interviews was 4 or 5, some inconsistency would exist among the pairwise comparisons. It is difficult to gain perfect consistency with several pairwise comparisons. However, some degree of inconsistency can be expected to exist in almost any set of pairwise comparisons. AHP provides a method for measuring the degree of consistency among the pairwise comparisons provided by the interviews to handle the consistency issue. If the degree of consistency is unacceptable, the interviews should review and revise the pairwise comparisons before any further proceeding to the next steps (Jayawickrama, 2015).

AHP provides a measure of the consistency for the pairwise comparisons by calculating a Consistency Ratio (CR) or inconsistency ratio. This ratio is designed in such a way that a value greater than 0.10 indicates an inconsistency in the pairwise judgment (Saaty and Vargas, 2012). Thus, it is a very distinctive characteristic provided by the AHP approach to enhance the robustness of collected data. It is not uncommon to obtain inconsistent judgements during the pairwise comparisons due to a decision-maker's inaccurate evaluation. CR works as a monitor to adjust any inconsistent data using a numerical scope of [0.0 to 0.1] (see Table 5.2). Furthermore, it is essential to ask the decision-maker or respondent to re-rank the pairwise comparison if the CR is greater than 0.1 until the CR becomes less than 0.1.

Table 5.2: Consistency ratio (CR) possible outcomes

Value of CR	Result / Action
Greater than or equal 0.1	Pairwise judgment requires re-evaluation
Smaller than 0.1	Judgment consistent and acceptable
Equal 0.0	Theoretical best fit judgment

Source: Expert Choice (2002)

Therefore, if the inconsistency ratio is 0.10 or less, the consistency of the pairwise comparisons is considered reasonable and the AHP process can continue (Saaty and Vargas, 2012). The following step 5 procedure calculates the inconsistency ratio for the criteria matrix/cluster (SC performance attributes).

Step 5.1: Multiply each value in the first column of the pairwise comparison matrix by the priority of the first item; multiply each value in the second column of the pairwise comparison matrix by the priority of the second item; continue this process for all columns of the pairwise comparison matrix. Add the values across the rows to obtain a vector of values labelled "weighted sum". The calculated weighted sums are as follows;

	Reliability	Responsiveness	Agility	Costs	Assets	SUM
Reliability	0.36	0.76	0.26	0.24	0.38	2.00
Responsiveness	0.18	0.38	0.47	0.55	0.51	2.09
Agility	0.07	0.04	0.05	0.04	0.06	0.27
Costs	0.12	0.05	0.10	0.08	0.04	0.40
Assets	0.12	0.10	0.10	0.24	0.13	0.68

Step 5.2: Divide the elements of the weighted sum vector obtained in Step 5.1 by the corresponding priority for each criterion.

	SUM/Weight
Reliability	5.55
Responsiveness	5.48
Agility	5.19
Costs	5.08
Assets	5.36

Step 5.3: Calculating the average of the values found in "Step 5.2"; this average is called as maximal eigenvalue and denoted by λmax.

$$\lambda max = \frac{(5.70 + 5.45 + 5.12 + 5.08 + 5.21)}{5} = 5.332$$

Step 5.4: Calculating the consistency index (CI) as follow;

$$CI = \frac{\lambda max - n}{n - 1}$$

Where n is the number of items being compared in each matrix / cluster.

$$CI = \frac{5.332 - 5}{5 - 1}$$

CI = 0.083

Step 5.5: Computing the inconsistency ratio which is defined as;

$$IR = \frac{CI}{RI}$$

Where random index (RI) is the consistency index of a randomly generated pairwise comparison matrix (Saaty and Vargas, 2012). The Value of RI depends on the number of items being compared and is provided below;

n	3	4	5	6	7	8	9	10
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty and Vargas, 2012)

Hence, for this calculation n =5 criteria, RI = 1.12 and inconsistency ratio is;

IR = 0.083 / 1.12 = 0.074

This is equal to the inconsistency ratio calculated by EC software. As mentioned earlier, an inconsistency ratio of 0.10 or less is considered as acceptable. Since the pairwise comparisons in this criteria matrix shows an IR of 0.07 and the degree of consistency in the pairwise comparisons is acceptable, the inconsistency ratios must be calculated for each matrix / cluster in the decision hierarchy. EC software provides the same value of 0.07 as an inconsistency ratio for this criteria matrix. Hence, it further proves that the EC software follows the actual AHP procedure in calculating priorities and inconsistency ratios.

5.3.1 Risks as alternatives

In this sub section, the steps from 6 to 9 for the AHP model of risks as alternatives will be calculated.

Step 6: Calculate priorities for each Risks using each criterion

Continuing with the AHP analysis, the pairwise comparison procedure must be used to determine the priorities for the four types of risks using each of the criteria / objectives: internal risk, network risk, external risk and functional risk. Determining these priorities require interviews to express pairwise comparison preferences for attributes using each criterion one at a time. For example, using the reliability, interviews must make 6 comparisons; likewise, 30 pairwise comparisons in total with respect to 5 objectives. In each comparison, interviews must select the more preferred risks and then express a judgment of how much more preferred the selected risks is. As previously shown in Table 5.1 how AHP uses participant's verbal description of the preferences between 2 risks s to determine a numerical rating of the preference. For example, suppose that the interviews state that based on the reliability criteria, the external risks are "strongly more important to the companies". Thus, using the reliability objective, a numerical rating of 5 is assigned to the external risks column of the pairwise comparison.

The following table shows the summary of the actual pairwise comparisons that the interviews had provided for each criterion of ranking 4 risks.

Table 5.3: Pairwise comparison for risks

Reliability				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000	0.200	0.333	4.000
Network Risk	5.000	1.000	3.000	7.000
External Risk	3.000	0.333	1.000	3.000
Functional Risk	0.250	0.143	0.333	1.000
Responsiveness				
	Internal Risk	Network Risk	External Risk	Functional Risk

Internal Risk	1.000	3.000	2.000	5.000
Network Risk	0.333	1.000	0.200	2.000
External Risk	0.500	5.000	1.000	3.000
Functional Risk	0.200	0.500	0.333	1.000
Agility				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000	0.200	0.250	2.000
Network Risk	5.000	1.000	3.000	5.000
External Risk	4.000	0.333	1.000	8.000
Functional Risk	0.500	0.200	0.125	1.000
Costs				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000	0.500	0.125	2.000
Network Risk	2.000	1.000	0.200	3.000
External Risk	8.000	5.000	1.000	5.000
Functional Risk	0.500	0.333	0.200	1.000
Assets				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000	0.200	2.000	0.500
Network Risk	5.000	1.000	2.000	2.000
External Risk	0.500	0.500	1.000	0.500
Functional Risk	2.000	0.500	2.000	1.000

AHP continues by synthesizing each of the 5 pairwise comparison matrices to determine the priority of each risks using each criterion. The synthetization process is carried out for each pairwise comparison matrix using a three-step procedure described previously for the criteria pairwise comparison matrix. Table 5.4 displays the results of four synthetization computations which provide the four sets of priorities.

Table 5.4: Priorities for each Risks using each criterion

Attributes / Risks	Reliability	Responsiveness	Agility	Costs	Assets
Internal Risk	14.14%	45.70%	9.82%	10.60%	15.48%
Network Risk	56.16%	12.69%	51.28%	18.10%	45.71%
External Risk	23.44%	33.20%	32.55%	63.44%	13.85%
Functional Risk	6.26%	8.41%	6.35%	7.86%	24.96%

It can be observed from above priorities that network risk is the highest risk based on reliability attribute (56.16%), internal risk is the highest risks based on responsiveness attribute

(45.70%%), network risk is the highest risk based on agility attribute (51.28%), external risk is the highest risk based on Costs Attribute (63.44%), and network risk is the highest risk based on assets attribute (45.71%). As a result, network risk is claimed to be the highest risk. The next step shows the inconsistency ratios for 5 matrixes and Step 8 explains how to combine the priorities for the criteria and develop an overall priority ranking using values in Table 5.4.

Step 7: Check consistency of pairwise comparisons in each decision alternative matrix

Before performing further steps in AHP analysis, it is vital to calculate the inconsistency ratios of each decision alternative matrix and check whether the ratios are within the acceptable range. In this case, there are five separate ratio values for 5 decision alternative matrices. The inconsistency ratios are calculated for every pairwise comparison matrix using five-step procedure previously stated for the criteria pairwise comparison matrix. The manually calculated inconsistency ratios and EC inconsistency ratios for the same interviews responses can be seen below:

	IR for Reliability	IR for Responsiveness	IR for Agility	IR for Costs	IR for Assets
Manual calculation	0.085	0.071	0.090	0.065	0.088
EC calculation	0.08	0.07	0.09	0.06	0.09

All five inconsistency ratios are identical in both manual and EC calculations and they further prove the reliability of the EC software for AHP analysis. Moreover, five IRs are less than 0.1; thus, the pairwise comparisons are acceptable to proceed with calculating overall priorities.

Step 8: Develop overall priority ranking

In this step, participant's pairwise comparisons of the five criteria are used to develop the priorities in step 4.3.

Reliability	Responsiveness	Agility	Costs	Assets
36.1%	**38.1%**	**5.2%**	**7.9%**	**12.8%**

These priorities and the priorities shown in Table 5.3 are used to develop overall priority for the five risks.

The procedure used to calculate the overall priority is to weight each risk's priority shown in Table 5.4 by the corresponding criterion priority. For example, the reliability criterion has a priority of 36.1% and visibility has a priority of 56.16% in terms of the reliability criterion. Thus, 36.1 x 56.16% is the priority value of visibility based on the reliability criterion. To obtain the overall priority of visibility, it requires to making similar calculations for flexibility, Collaboration, control and learning and innovation criteria; and then adds the values to obtain the overall priority. The manually calculated overall priorities for each risk and the overall priorities of the EC software can be seen in Table 5.5.

Table 5.5: Risks overall priority ranking

Risks	Overall priority	Rank	Overall priorities of EC software
Internal Risk	25.84%	3	27.00%
Network Risk	35.01%	1	33.90%
External Risk	29.56%	2	29.50%
Functional Risk	9.59%	4	9.60%
Sum	100.00%		100.00%

It can be observed that priorities are very similar according to the above overall priorities. Therefore, the rankings are the same on both manual and EC calculation procedures. Network risk is the most important risk (35.01%), the second most important risks is external risk (29.5%) followed by internal risk (25.84%) and the least important risks is functional risk (9.59%) according to the pairwise comparisons of this participant.

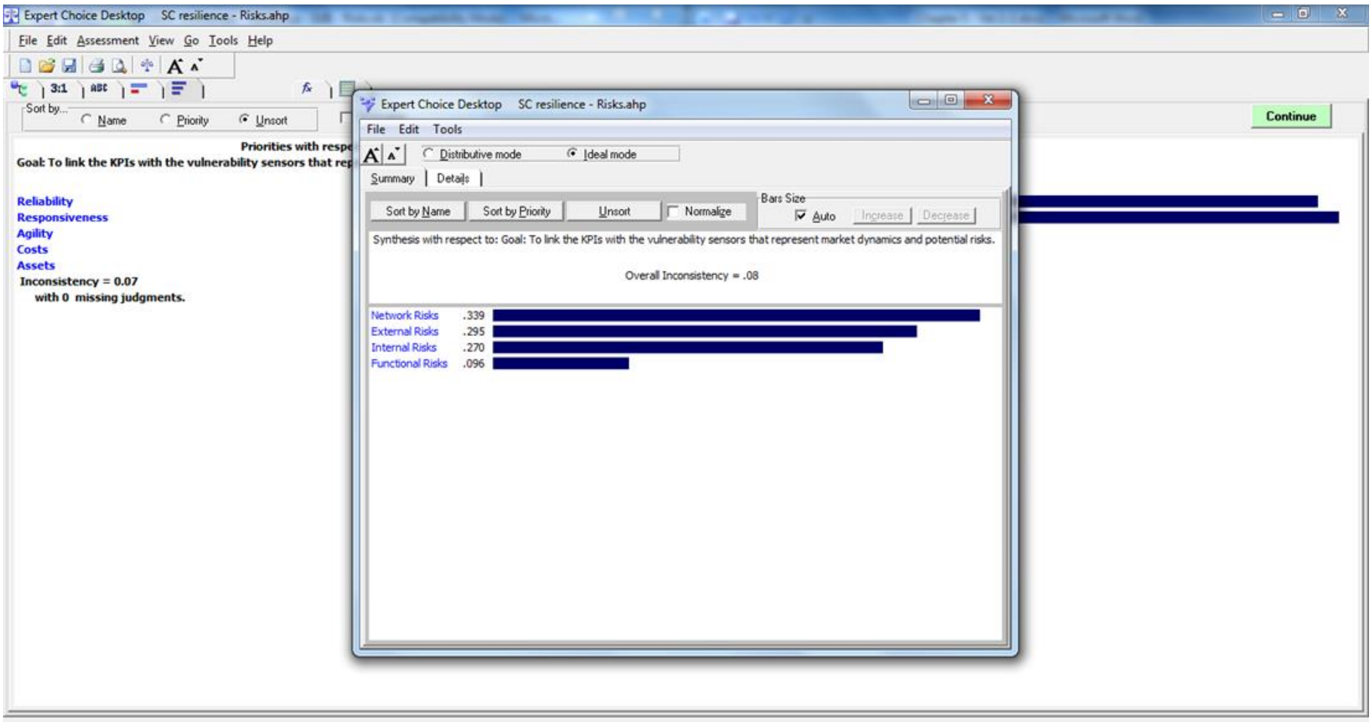

Figure 5.5-a: EC results for the ranking of AHP alternatives (risks)

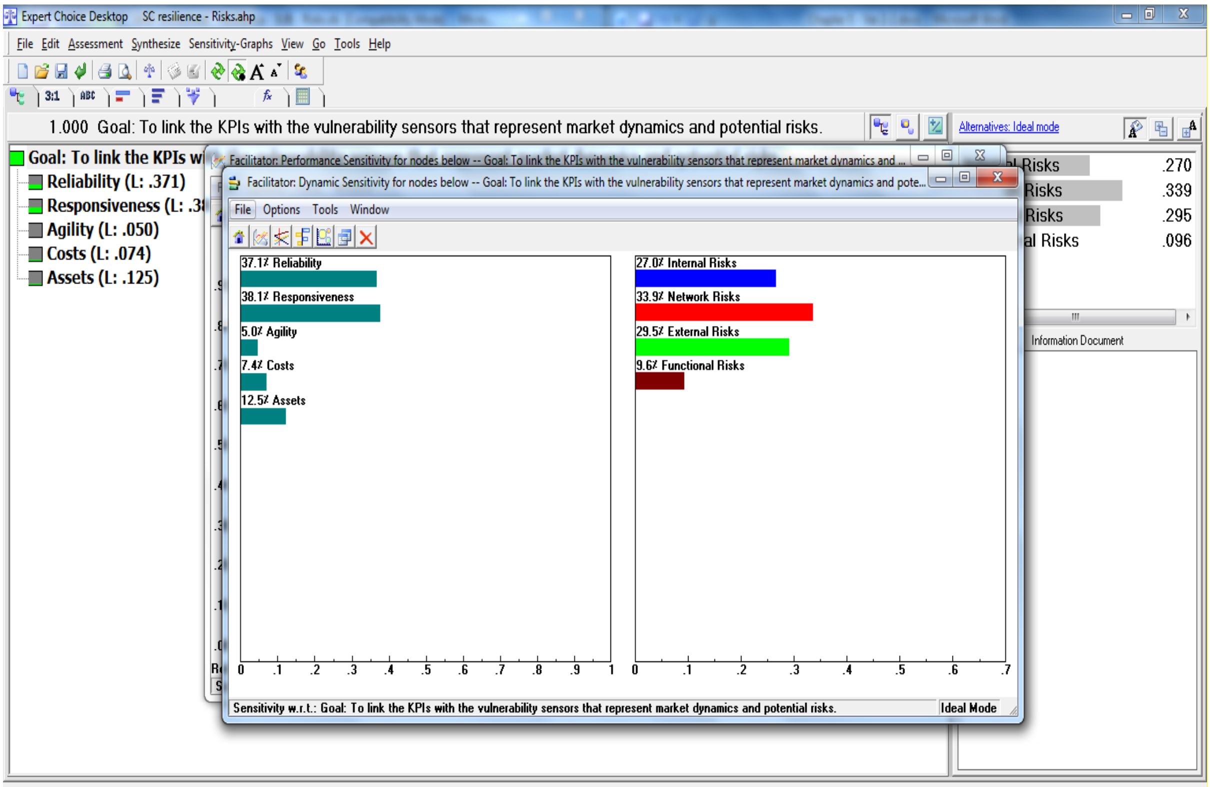

Figure 5.5-b: EC results for the ranking of AHP alternatives (risks) – sensitivity graphs - dynamic

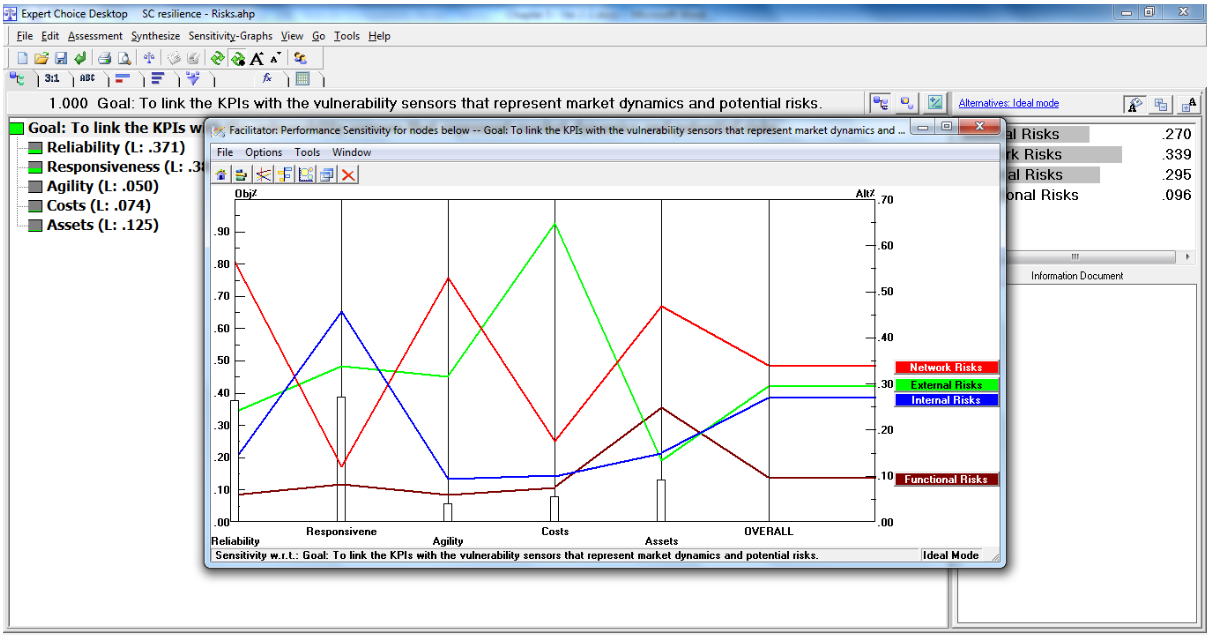

Figure 5.5-c: EC results for the ranking of AHP alternatives (risks)- sensitivity graphs - performance

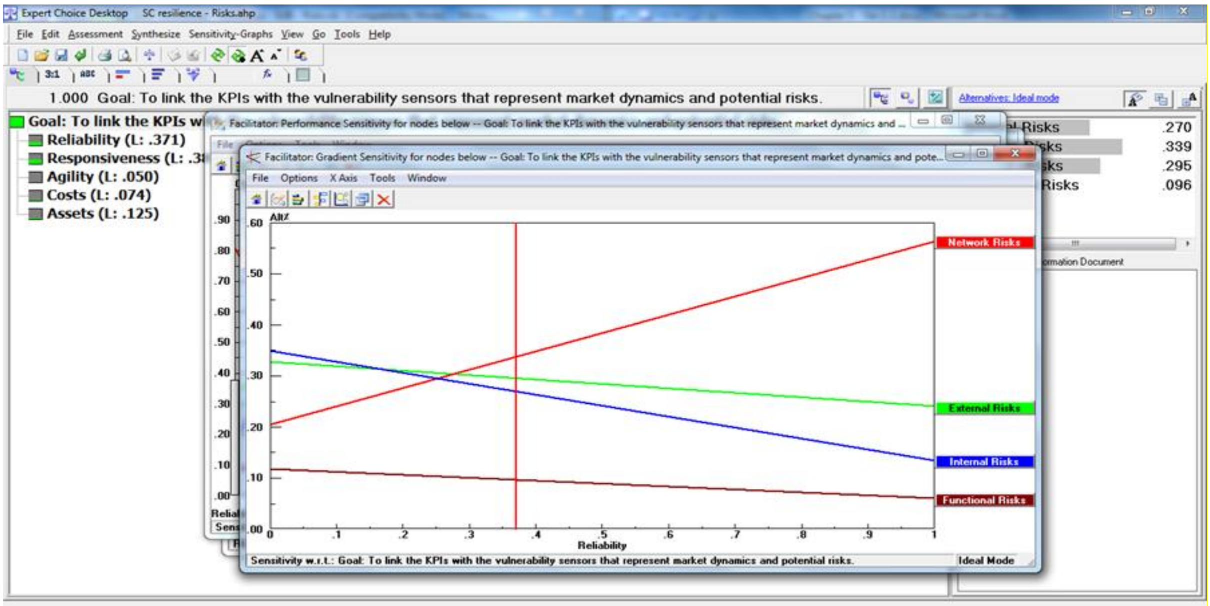

Figure 5.5-d: EC results for the ranking of AHP alternatives (risks) - sensitivity graphs- gradient

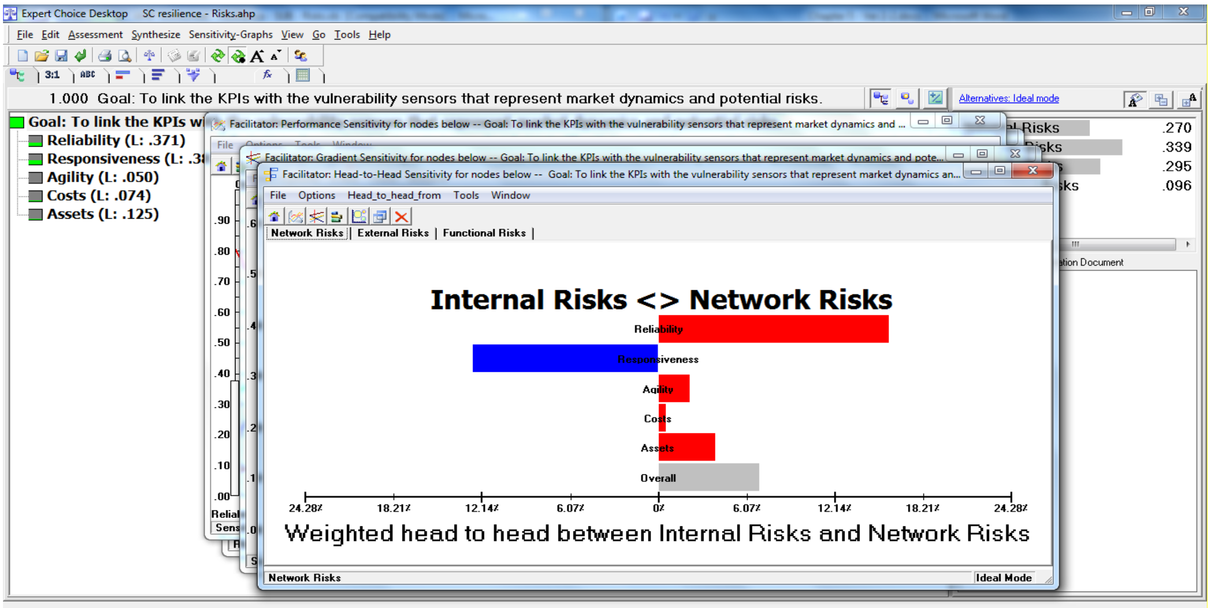

Figure 5.5-e: EC results for the ranking of AHP alternatives (risks) – sensitivity graphs - head to head

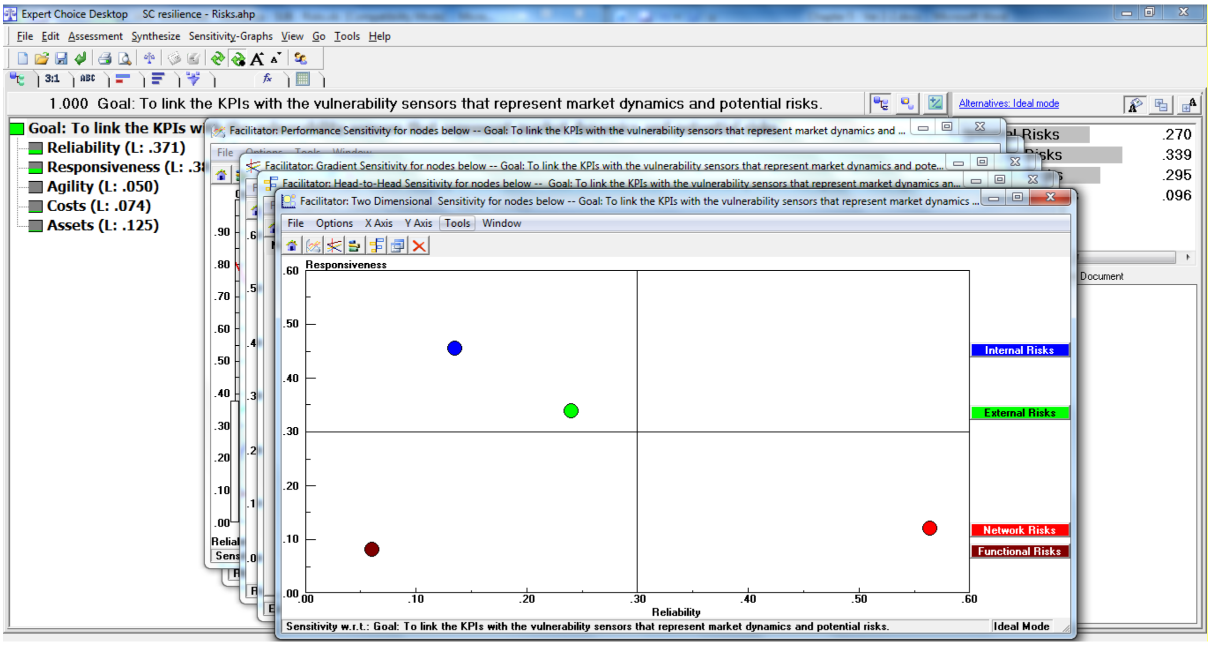

Figure 5.5-f: EC results for the ranking of AHP alternatives (risks) – sensitivity graphs - two D

Step 9: Aggregate results of all participants

Since this study was conducted among many participants, the EC software accumulates all the responses of the participants to provide final priority rankings. It is obvious that accumulating the results of such a complex decision hierarchy requires some automated form rather than a manual form to ensure the accuracy of the results (Forman and Peniwati, 1998; Saaty and

Vargas, 2012). EC does this task using the Aggregating Individual Judgments (AIJ) method. In this method, which is by far the most common, the individual judgments are combined by taking the geometric mean of the judgments to derive a 'recombined' set of priorities for each cluster of objectives in the hierarchy, as well as for alternatives with respect to each of the covering objectives (Saaty, 2000). It has been shown that the geometric mean is the only aggregation method that will assure that the reciprocal axiom of AHP holds for the combined judgments in a matrix of combined judgments (Harker, 1987; Forman and Peniwati, 1998).

5.3.1.1 Raking of sub-risks (risk factors)

Based on the results attained in ranking the relative importance of the risk categories, this sub-section presents the results of the AHP analysis attained by EC for ranking the risk factors under each of the two-most important main risks categories; network and external risks. The ranking of the network and external risks, which are based on all pairwise judgements of interviewees, will be interpreted and demonstrated as it extends the findings of the stage one in empirical study.

Network risks rankings

There are ten risk factors under the network risks category. The interviewees from the 30 companies involved in this study have ranked them in the second round of the AHP analysis performed after the first round where the main three SC resilience constructs were ranked.

The first step in AHP – as previously elaborated – is to develop the hierarchy in terms of the overall goal, the criteria to be used, and the decision alternatives. The overall goal of this hierarchy is to rank the risk factors under the network risks that was indicated based on the findings of stage one in the empirical study as shown in Figure 5.4

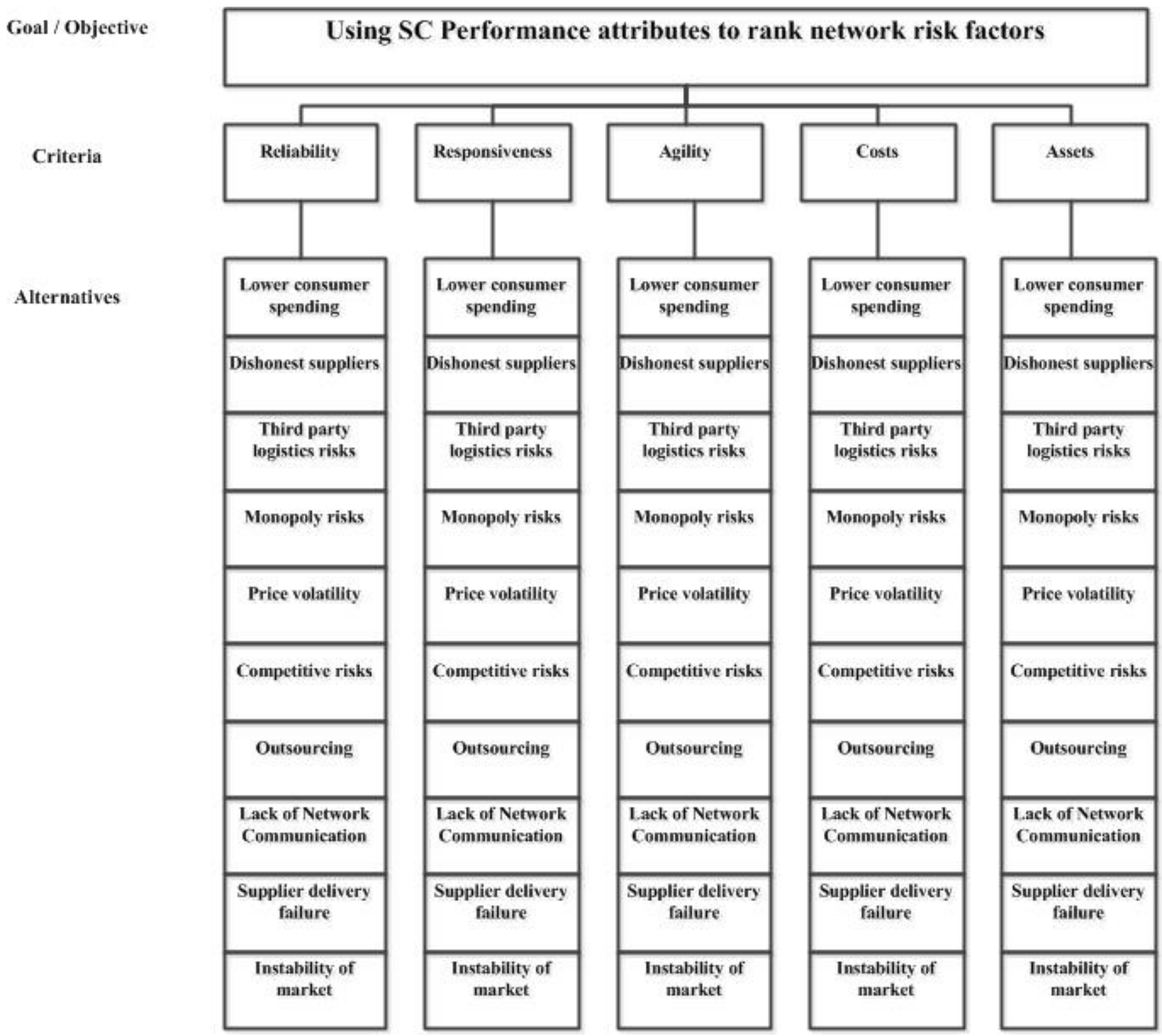

Figure 5.6: AHP decision hierarchy for risk factors under network risks

The ranks of network risk factors will be shown in the table below:

Table 5.6: Network risk factors overall priority ranking

Rank	Network risk factors (sub-risks)	Percentage
1	Lower consumer spending	19.00%
2	Dis-honest suppliers	14.50%
3	Third party logistics risks	13.10%
4	Monopoly risks	12.80%
5	Price volatility	8.80%
6	Competitive risks	7.80%
7	Outsourcing	7.00%
8	Lack of Network Communication risks	6.30%

9	Supplier delivery failure	5.90%
10	Instability of market	4.80%

Table 5.6 shows that the lower consumer spending, which is the most important risk factor, needs to be managed to enhance SC resilience with 19%, based on practitioners' judgements. Next comes dis-honest suppliers' risks with 14.5%, then the third-party logistics risks with 13.10% and the monopoly risks with 12.80%. On the other side, the instability of market was considered the least important risk with 4.80%. The results revealed from the EC will be presented to provide more explanation to the ranks provided.

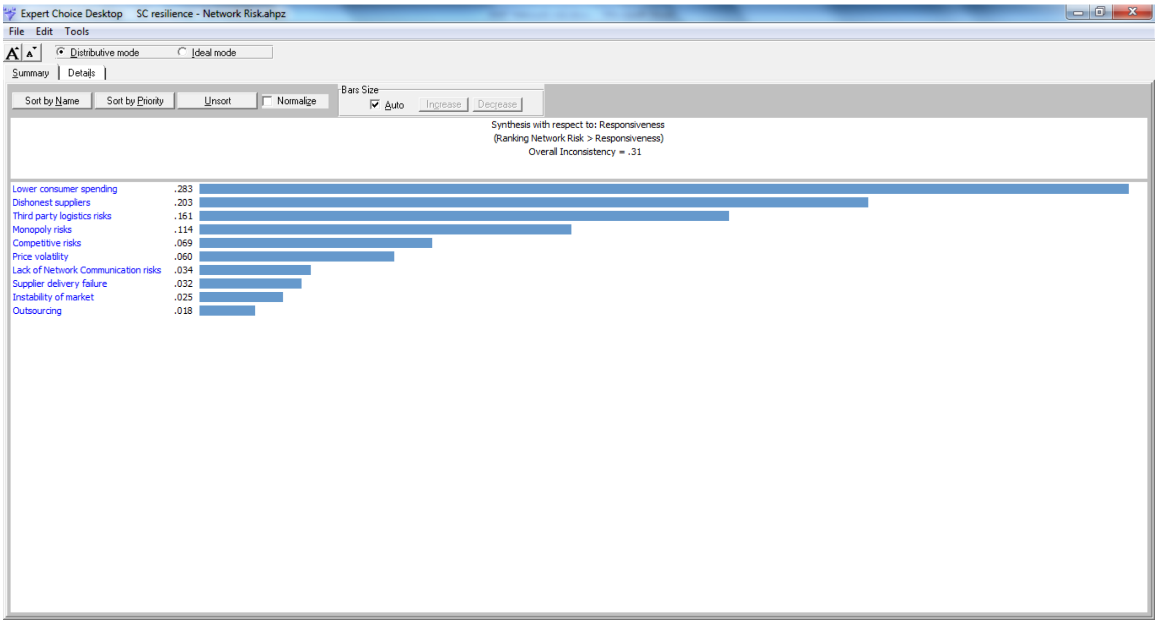

Figure 5.7-a: EC results for the ranking of AHP alternatives (sub-risks) - network risks

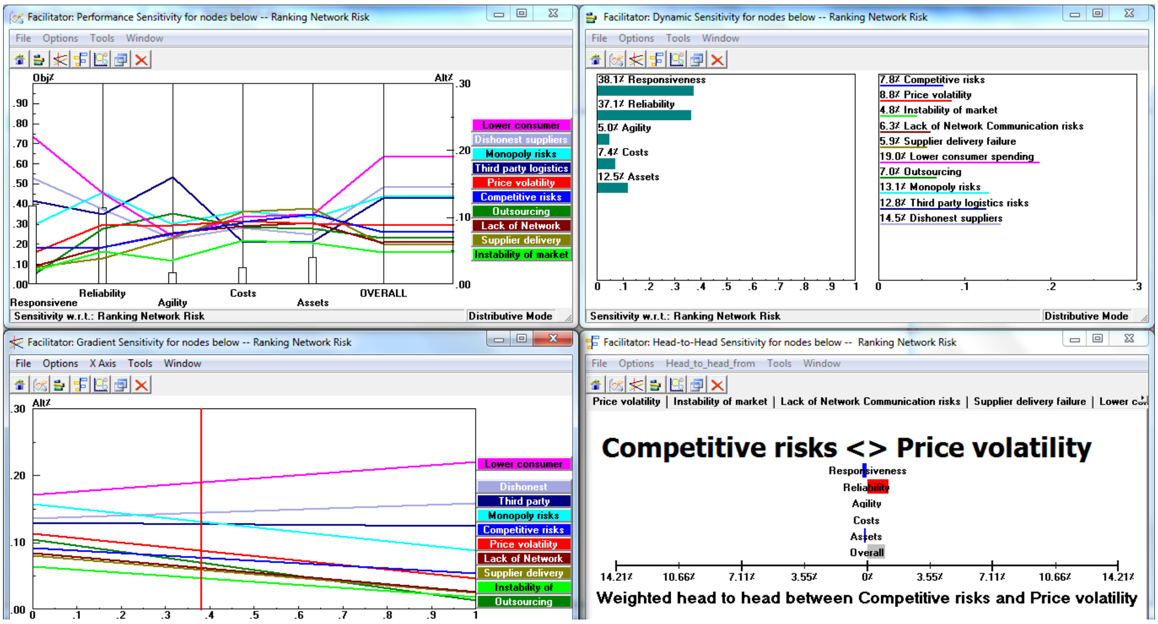

Figure 5.7-b: EC results for the ranking of AHP alternatives (sub-risks) - network risks - sensitivity

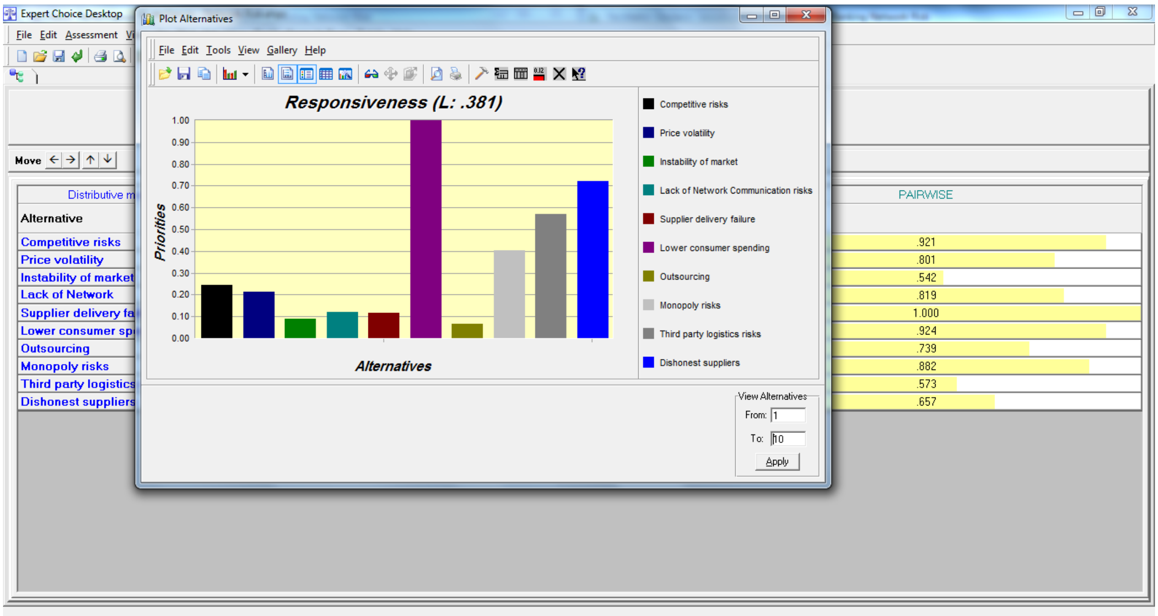

Figure 5.7-c: EC results for the ranking of AHP alternatives (sub-risks) - network risks - Pareto chart

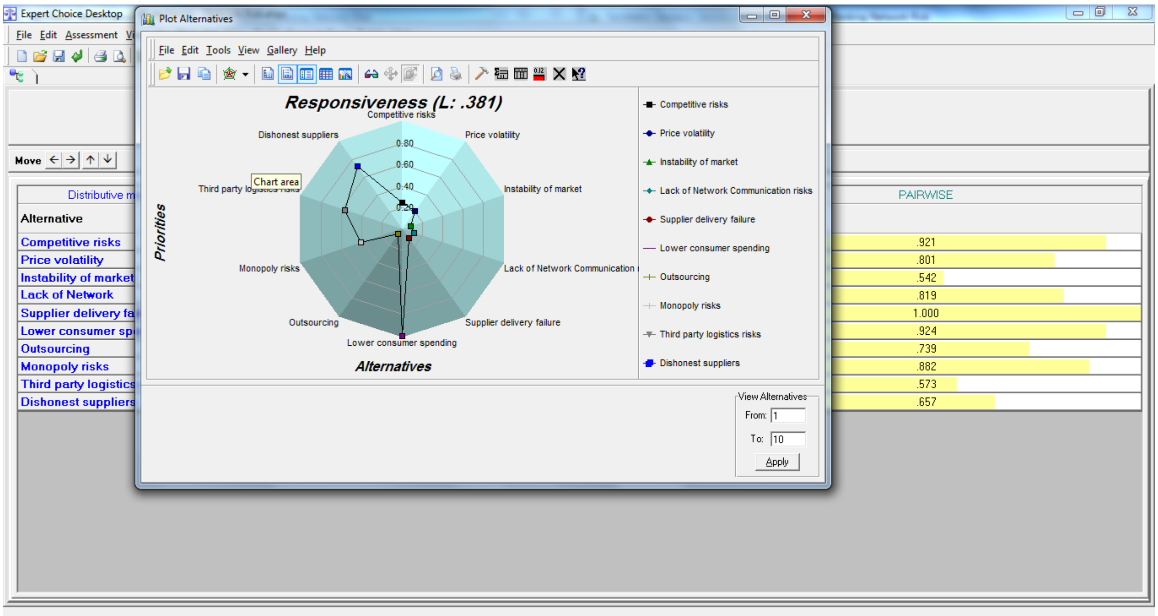

Figure 5.7-d: EC results for the ranking of AHP alternatives (sub-risks) - network risks - radar chart

External risks rankings

There are eight risk factors under the external risks category. The interviewees from the 30 companies involved in this study have ranked them in the second round of the AHP analysis performed after the first round where the main three SC resilience constructs were ranked.

The first step in AHP – as previously elaborated – is to develop the hierarchy in terms of the overall goal, the criteria to be used, and the decision alternatives. The overall goal of this hierarchy is to rank the risk factors under the external risks that was indicated based on the findings of stage one in empirical study as shown in Figure 5.5

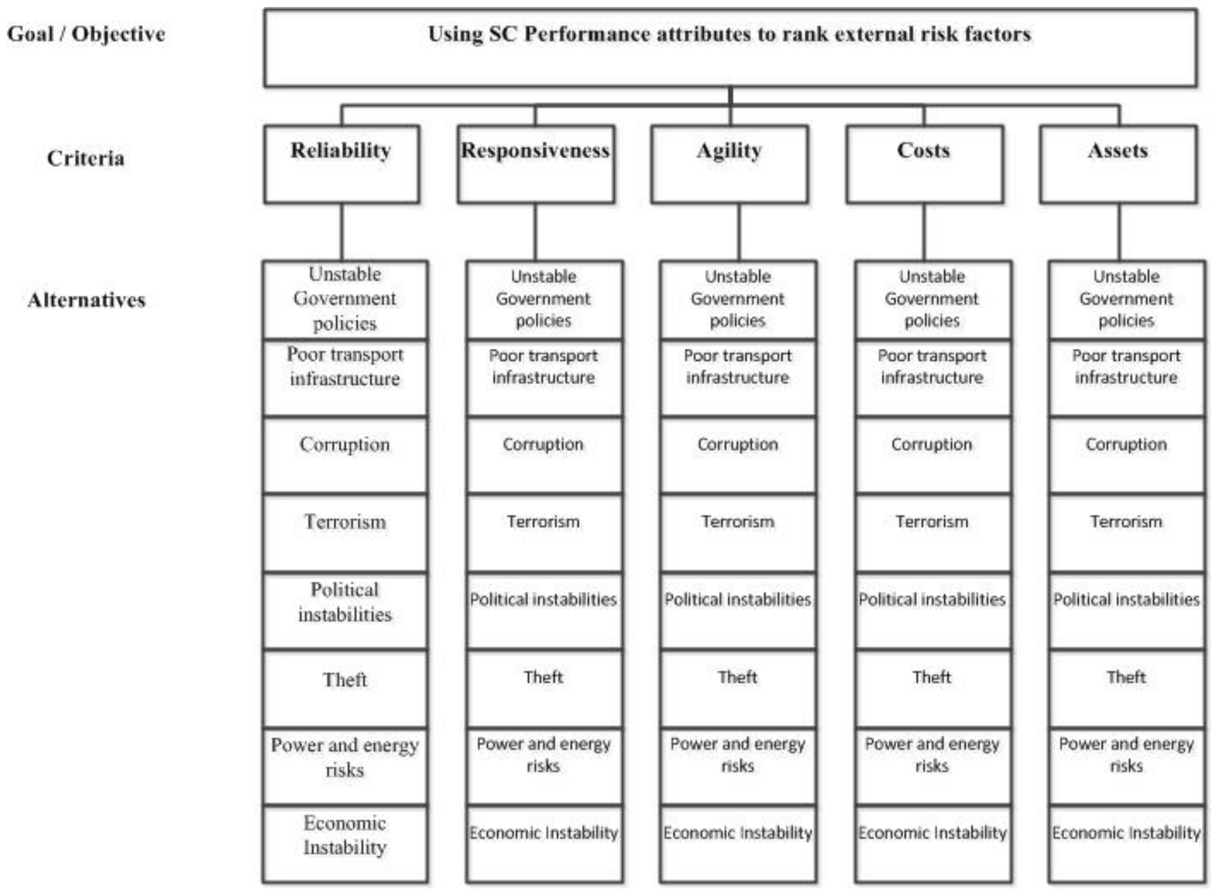

Figure 5.8: AHP decision hierarchy for risk factors under external risks

The ranks of external risk factors will be shown in the table below:

Table 5.7: External risk factors overall priority ranking

Rank	External risk factors (sub-risks)	Percentage
1	Unstable Government policies	15.70%
2	Poor transport infrastructure	15.40%
3	Corruption	14.80%
4	Terrorism	14.50%
5	Political instabilities	12.90%
6	Theft	11.30%
7	Power and energy risks	9.10%
8	Economic Instability	6.10%

Table 5.7 shows that the unstable government policies risk as the most important risk factors that need to be managed to enhance SC resilience with 15.70%, based on practitioners' judgements. Next comes the poor transport infrastructure risks with 15.40%, then the corruption risks with 14.80% and the terrorism risks with 14.50%. On the other side, the economic instability was perceived to be the least important risk with 6.10%.

The results revealed from the EC will be presented to provide more explanation to the ranks provided.

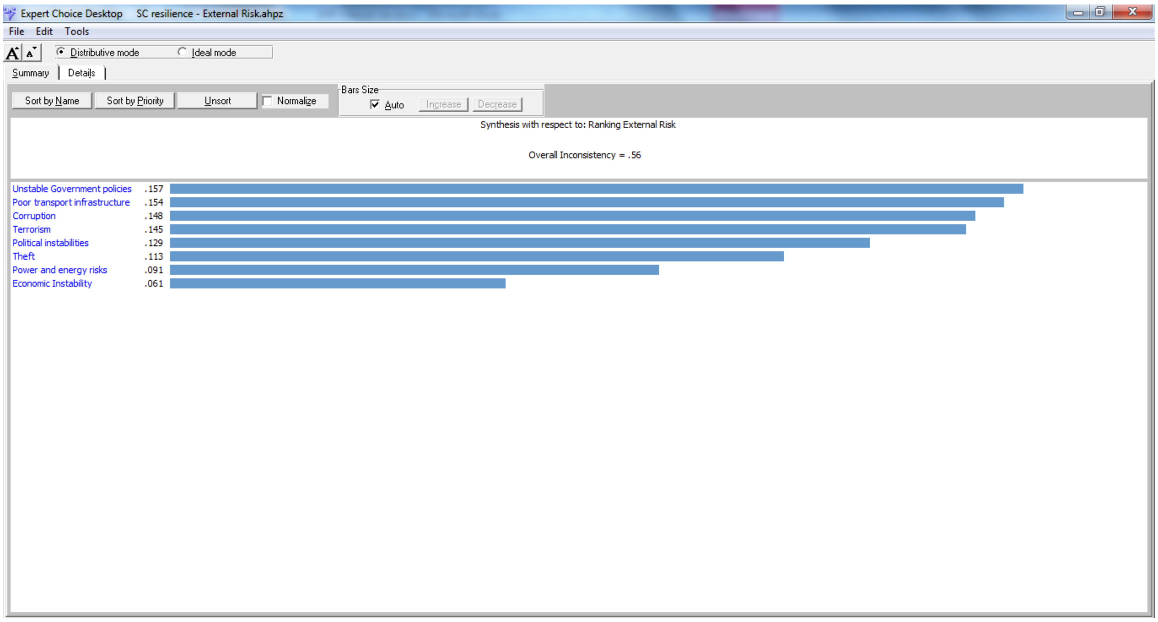

Figure 5.9-a: EC results for the ranking of AHP alternatives (sub-risks) - external risks

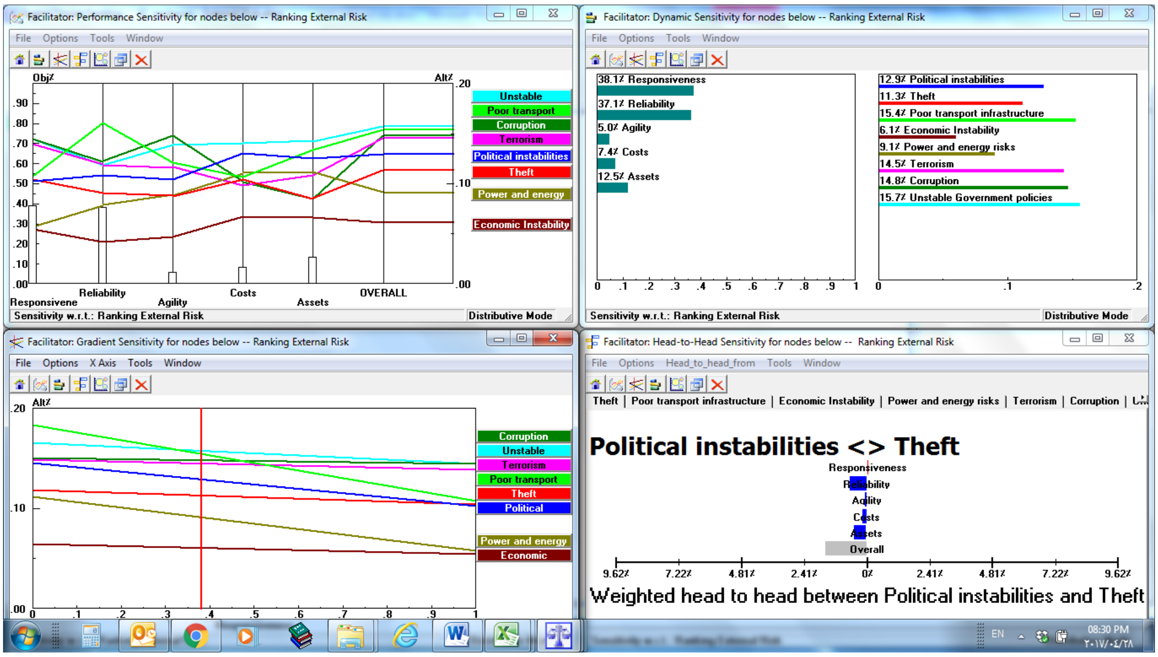

Figure 5.9-b: EC results for the ranking of AHP alternatives (sub-risks) - external risks - sensitivity

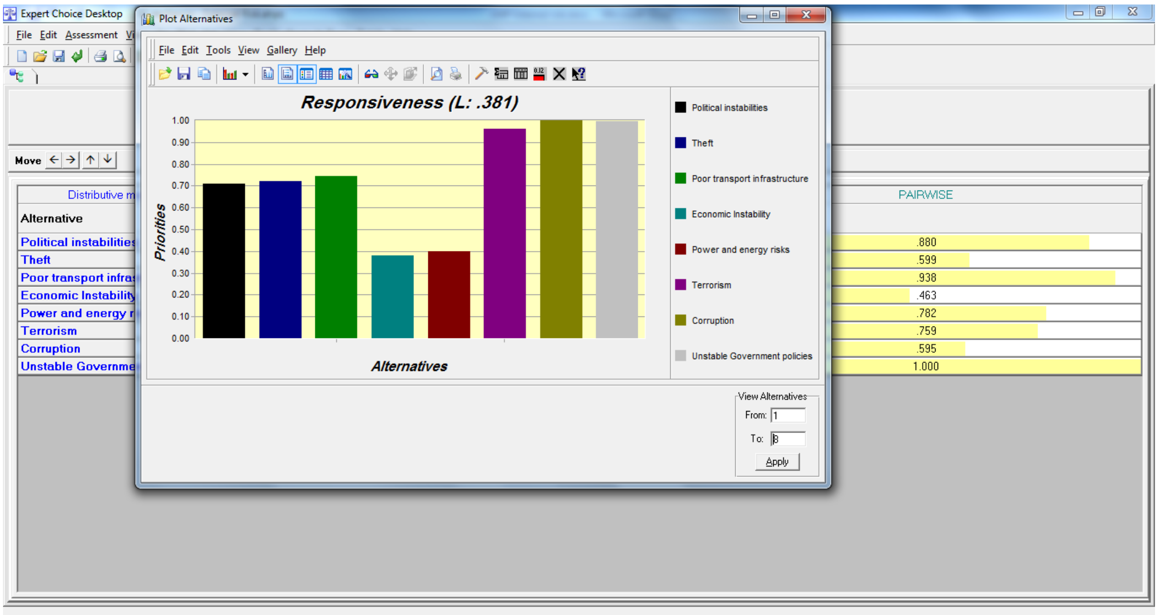

Figure 5.9-c: EC results for the ranking of AHP alternatives (sub-risks) - external risks - Pareto chart

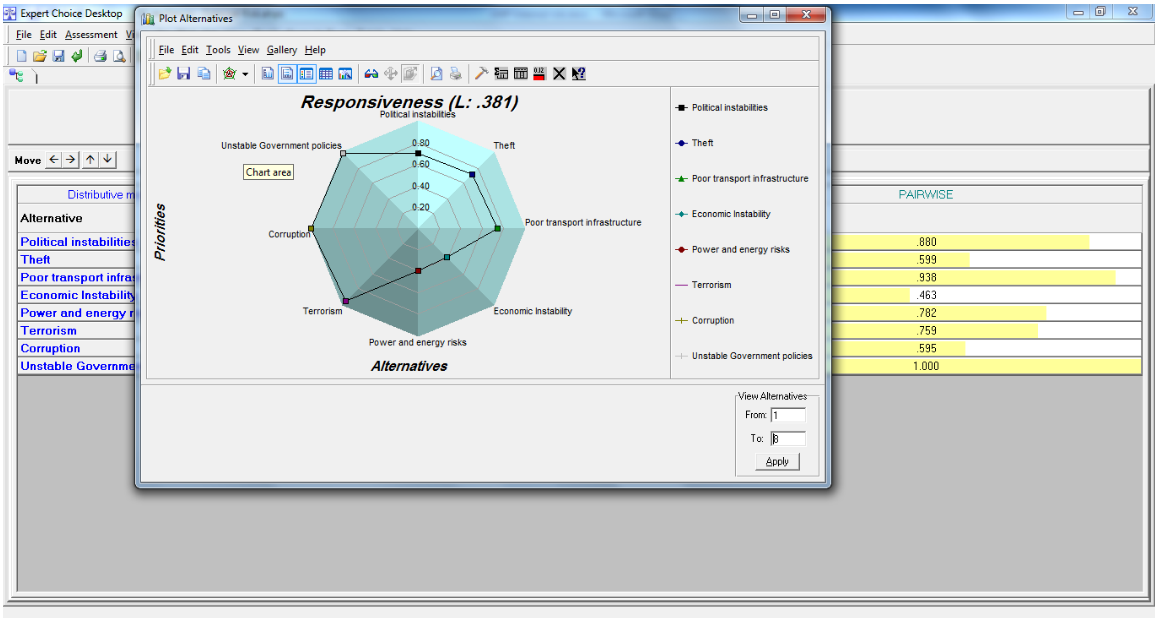

Figure 5.9-d: EC results for the ranking of AHP alternatives (sub-risks) - external risks - radar chart

5.3.2 Capabilities as alternatives

In this sub section, the steps from 6 to 9 for the AHP model of capabilities as alternatives will be calculated.

Step 6: Calculate priorities for each capability using each criterion

Continuing with the AHP analysis, the pairwise comparison procedure must be used to determine the priorities for 5 capabilities identified from stage one of the data analysis using each of the criteria/objectives; reliability, responsiveness, agility, costs and assets. Determining these priorities required interviews to express pairwise comparison preferences for attributes using each criterion one at a time. For example, using the reliability, interviews must make 10 comparisons; likewise, 50 pairwise comparisons in total with respect to 5 objectives. In each comparison, interviews must select the more preferred capabilities and then express a judgment of how more preferred the selected capabilities are. As previously shown in Table 5.1, AHP uses participant's verbal description of the preferences between 2 capabilities to determine a numerical rating of the preference. For example, suppose that the interviews stated that based on the responsiveness criteria, the visibility capability is "strongly preferred by the companies".

Thus, using the responsiveness criteria, a numerical rating of 5 is assigned to the visibility column of the pairwise comparison.

The following table shows the summary of the actual pairwise comparisons that the interviews provided for each criterion of ranking five capabilities.

Table 5.8: Pairwise comparison for the capabilities

Reliability					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000	5.000	6.000	7.000	9.000
Flexibility	0.200	1.000	4.000	3.000	5.000
Collaboration	0.167	0.250	1.000	0.500	2.000
Control	0.143	0.333	2.000	1.000	3.000
Learning and Innovation	0.111	0.200	0.500	0.333	1.000
Responsiveness					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000	0.333	3.000	2.000	2.000
Flexibility	3.000	1.000	4.000	7.000	9.000
Collaboration	0.333	0.250	1.000	0.500	2.000
Control	0.500	0.143	2.000	1.000	3.000
Learning and Innovation	0.500	0.111	0.500	0.333	1.000
Agility					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000	5.000	6.000	7.000	8.000
Flexibility	0.200	1.000	3.000	2.000	3.000
Collaboration	0.167	0.333	1.000	0.333	3.000
Control	0.143	0.500	3.003	1.000	3.000
Learning and Innovation	0.125	0.333	0.333	0.333	1.000
Costs					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000	0.500	5.000	0.250	2.000
Flexibility	2.000	1.000	2.000	0.500	5.000
Collaboration	0.200	0.500	1.000	0.125	0.500
Control	4.000	2.000	8.000	1.000	3.000
Learning and Innovation	0.500	0.200	2.000	0.333	1.000
Assets					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000	0.200	3.000	2.000	3.000
Flexibility	5.000	1.000	5.000	4.000	9.000
Collaboration	0.333	0.200	1.000	0.500	0.500
Control	0.500	0.250	2.000	1.000	3.000
Learning and Innovation	0.333	0.111	2.000	0.333	1.000

AHP continues by synthesizing each of the 5 pairwise comparison matrices in order to determine the priority of each capability using each criterion. The synthetization process is carried out for each pairwise comparison matrix using three-step procedure described previously for the criteria pairwise comparison matrix. Table 5.9 displays the results of five synthetization computations which provide the five sets of priorities.

Table 5.9: Priorities for each capability using each criterion

Attributes / Capabilities	Reliability	Responsiveness	Agility	Costs	Assets
Visibility	56.80%	19.14%	57.20%	16.28%	18.42%
Flexibility	21.41%	53.27%	16.82%	25.40%	54.12%
Collaboration	7.12%	9.15%	8.43%	6.01%	6.62%
Control	10.40%	12.62%	12.86%	43.08%	13.50%
Learning and Innovation	4.27%	5.83%	4.70%	9.23%	7.33%

It can be observed from the above-mentioned priorities that visibility is the preferred capabilities based on reliability attribute (56.8%), flexibility is the preferred capabilities based on responsiveness attribute (53.27%), visibility is the preferred capabilities based on agility attribute (57.20%), control is the preferred capabilities based on costs attribute (43.08%), and flexibility is the preferred capabilities based on assets attribute (54.12%). Thus, it is difficult to state the most preferred capability. The next step shows the inconsistency ratios for 5 matrices and Step eight explains how to combine the priorities for the criteria and develop an overall priority ranking using values in Table 5.9.

Step 7: Check consistency of pairwise comparisons in each decision alternative matrix

Before going further to the AHP steps, it is important to calculate the inconsistency ratios of each decision alternative matrix and check whether the ratios are within the acceptable range or no. In this case, there are five separate ratio values for 5 decision alternative matrices. The inconsistency ratios will be calculated for each pairwise comparison matrix using five-step procedure described previously for the criteria pairwise comparison matrix. The manually calculated inconsistency ratios and EC inconsistency ratios for the same interviews responses are found below:

	IR for Reliability	IR for Responsiveness	IR for Agility	IR for Costs	IR for Assets
Manual calculation	0.05	0.05	0.07	0.09	0.06
EC calculation	0.05	0.05	0.07	0.09	0.06

All five inconsistency ratios are identical in both manual and EC calculations and it further proves the reliability of the EC software for AHP analysis. Furthermore, the five IRs are less than 0.1, thus the pairwise comparisons are acceptable to proceed with calculating overall priorities.

Step 8: Develop overall priority ranking

In this step, participant's pairwise comparisons of the five criteria are used to develop the priorities in step 4.3.

Reliability	Responsiveness	Agility	Costs	Assets
36.1%	**38.1%**	**5.2%**	**7.9%**	**12.8%**

These priorities and the priorities shown in Table 5.9 are used to develop overall priority for the five capabilities.

The procedure used to calculate the overall priority is to weight each capabilities' priority shown in Table 5.9 by the corresponding criterion priority. For example, the reliability criterion has a priority of 36.1% and visibility has a priority of 56.80% in terms of the reliability criterion. Thus, 36.1 x 56.80% is the priority value of visibility based on the reliability criterion. To obtain the overall priority of visibility, it requires to make similar calculations for flexibility, Collaboration, control and learning and innovation criteria; and then add the values to obtain the overall priority. The manually calculated overall priorities for each capabilities and the overall priorities of the EC software can be seen in Table 5.10.

Table 5.10: Capabilities overall priority ranking

Capabilities	Overall priority	Rank	Overall priorities of EC software
Visibility	34.38%	2	35.40%
Flexibility	37.80%	1	38.00%
Collaboration	7.81%	4	7.40%
Control	14.34%	3	13.70%
Learning and Innovation	5.67%	5	5.40%
Sum	100.00%		99.90%

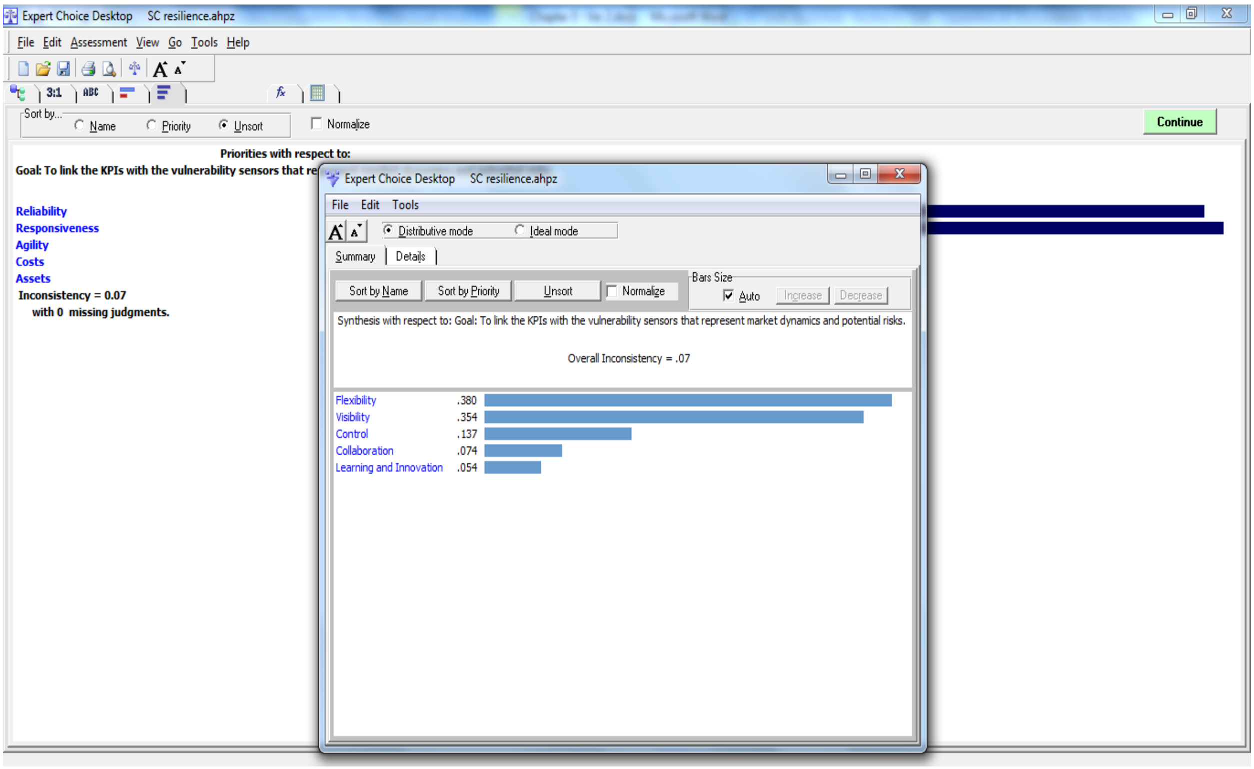

Figure 5.10-a: EC results for the ranking of AHP alternatives (capabilities)

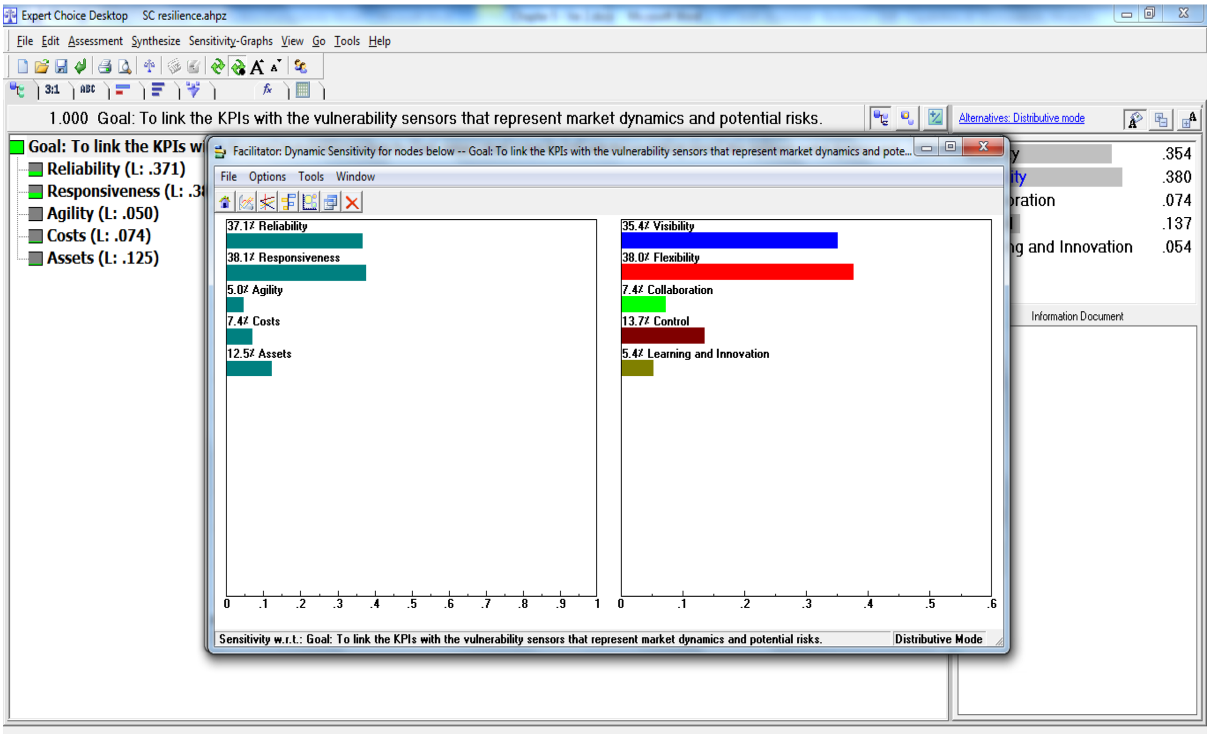

Figure 5.10-b: EC results for the ranking of AHP alternatives (capabilities) - sensitivity graphs - dynamic

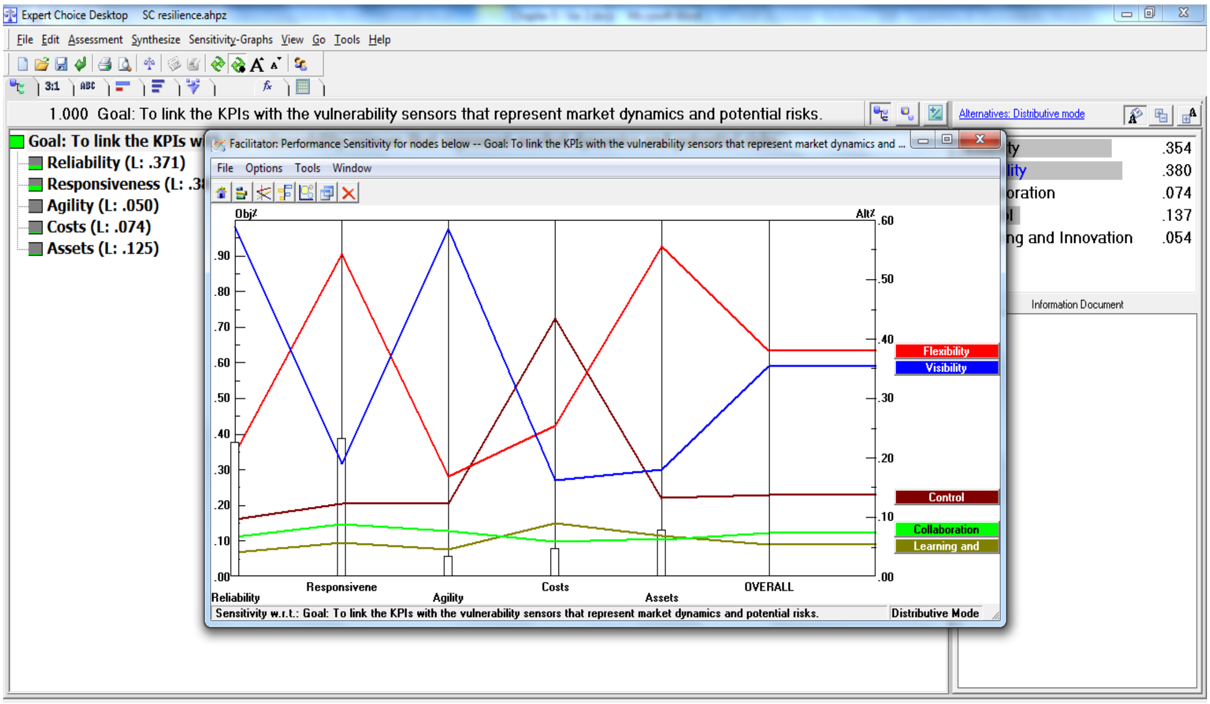

Figure 5.10-c: EC results for the ranking of AHP alternatives (capabilities) - sensitivity graphs - performance

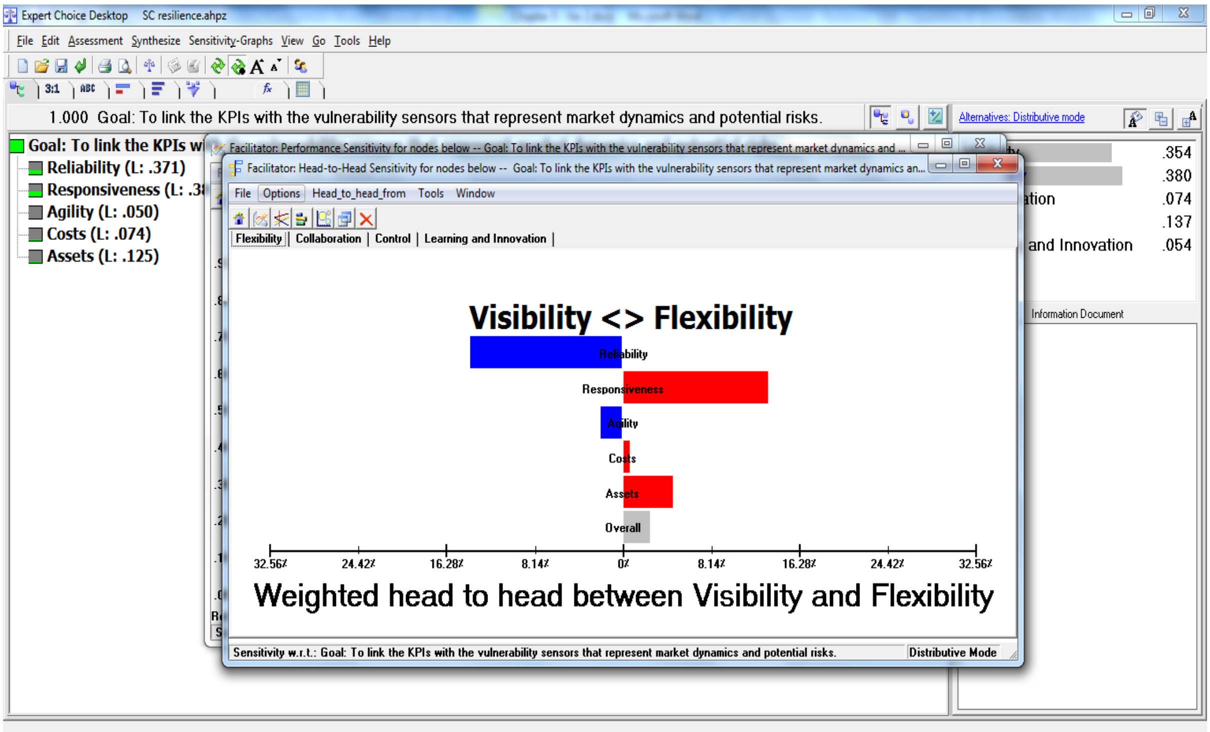

Figure 5.10-d: EC results for the ranking of AHP alternatives (capabilities) -sensitivity graphs - head to head

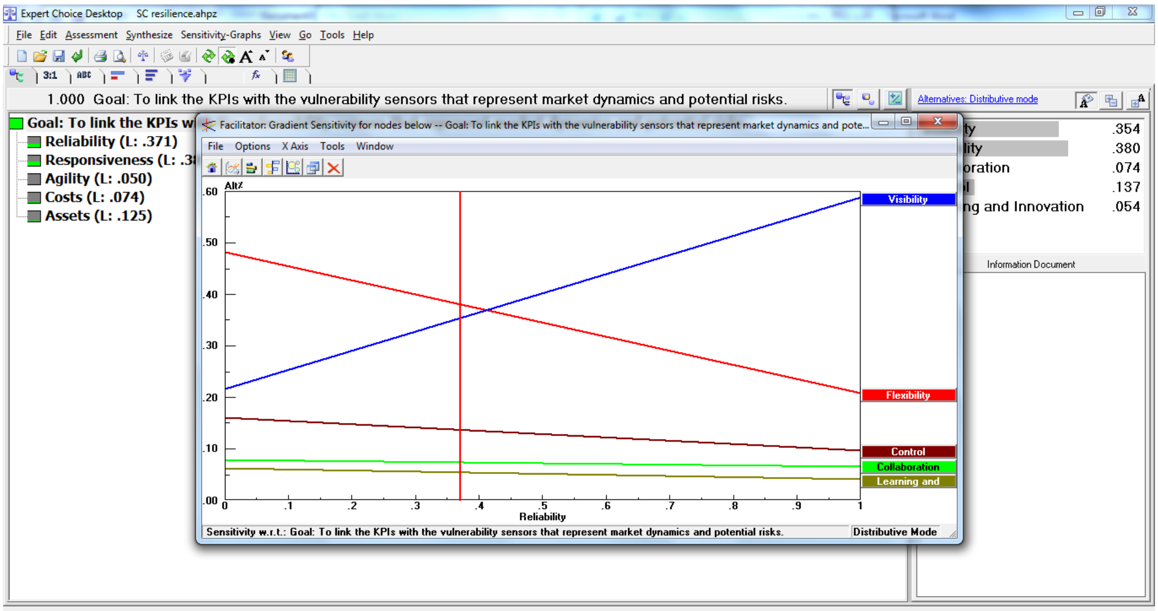

Figure 5.10-e: EC results for the ranking of AHP alternatives (capabilities) - sensitivity graphs - gradient

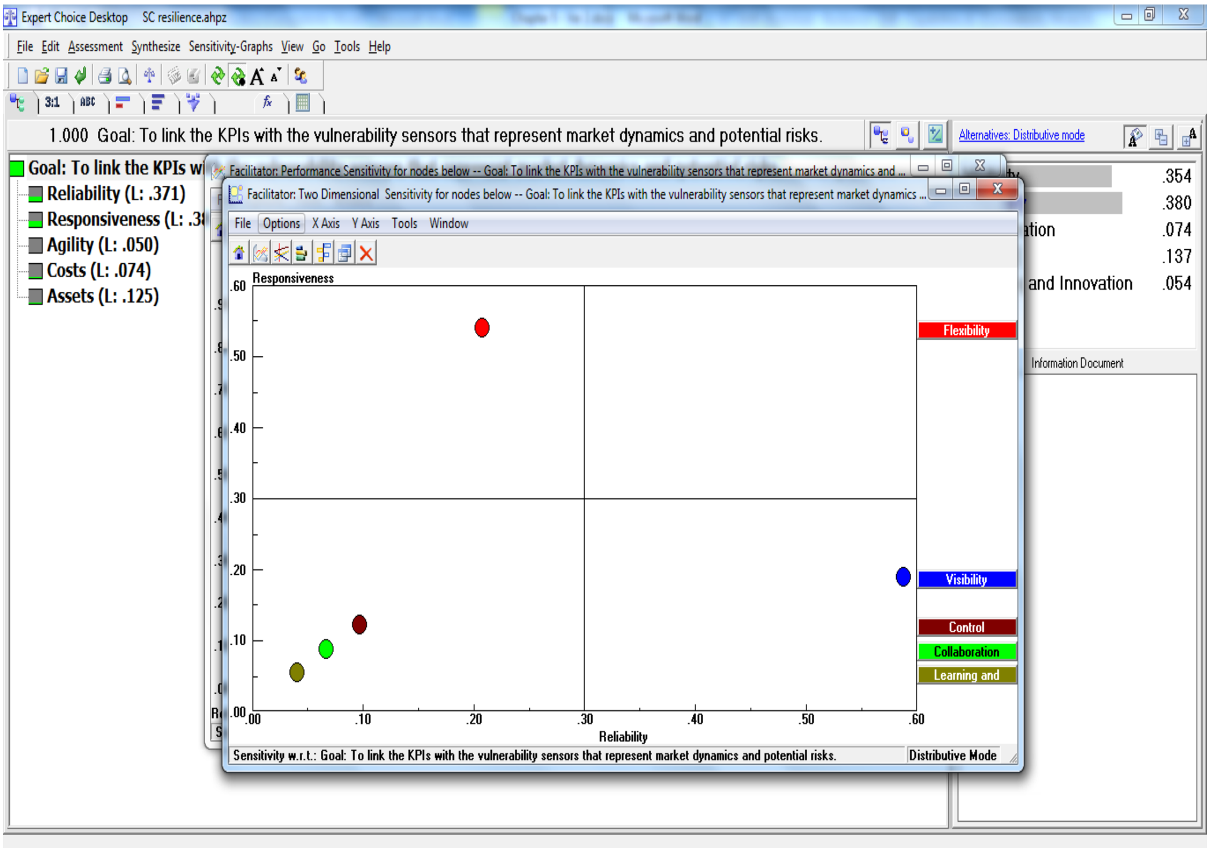

Figure 5.10-f: EC results for the ranking of AHP alternatives (capabilities) - sensitivity graphs - two D

It can be observed that priorities are very similar according to the above overall priorities. Therefore, the rankings are identical based on both manual and EC calculation procedures. Flexibility is the most important capability (38%), the second most important capability is visibility (35%) followed by control (14%) then Collaboration (8%), and the least important capability is learning and innovation (6%) according to the pairwise comparisons of this participant.

Step 9: Aggregate results of all participants

Since this study was conducted among many participants, the EC software accumulates all the responses of the interviewees to provide final priority rankings. It obviously shows that the accumulating results of such a decision hierarchy requires some automated procedure other than a manual way to ensure the accuracy of the results (Forman and Peniwati, 1998; Saaty and Vargas, 2012). EC does this task using AIJ method. In this method, which is by far the most common, the individual judgments are combined by taking the geometric mean of the judgments to derive a recombined set of priorities for each cluster of objectives in the hierarchy, as well as for alternatives with respect to each of the covering objectives (Saaty, 2000). It has been shown that the geometric mean is the only aggregation method that will assure that the reciprocal axiom of AHP holds for the combined judgments in a matrix of combined judgments (Harker, 1987; Forman and Peniwati, 1998).

5.3.2.1 Raking of sub-capabilities

Based on the results attained in ranking the relative importance of the capabilities, this sub-section presents the results of the AHP analysis attained by EC for ranking the sub-capabilities under each of the two-most important main capability categories; flexibility and visibility. The ranking of the network and external risks, which is based on all pairwise judgements of interviewees, will be interpreted and demonstrated as it extends the findings of the stage one in empirical study.

Flexibility sub-rankings

There are six sub-capabilities under the flexibility category. The interviewees from the 30 companies involved in this study have ranked them in the second round of the AHP analysis performed after the first round where the main three SC resilience constructs were ranked.

The first step in AHP – as previously elaborated – is to develop the hierarchy in terms of the overall goal, the criteria to be used, and the decision alternatives. The overall goal of this hierarchy is to rank the risk factors under the flexibility that was indicated based on the findings of stage one in empirical study as shown in Figure 5.6

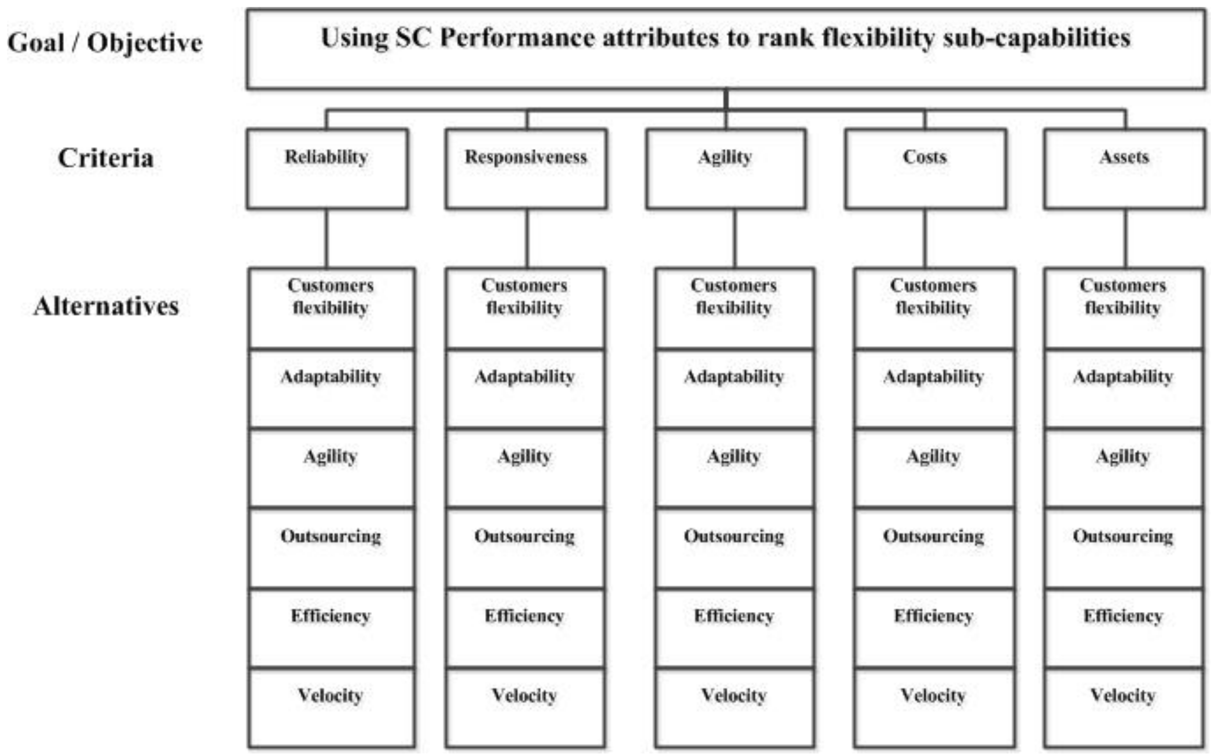

Figure 5.11: AHP decision hierarchy for sub-capabilities under flexibility category

The ranks of the sub-capabilities will be shown in the table below:

Table 5.11: Flexibility sub-capability overall priority ranking

Rank	Capability Sub-Category	Percentage
1	Customers flexibility	25.20%
2	Adaptability	21.00%
3	Outsourcing	18.00%
4	Velocity	16.50%
5	Agility	14.30%
6	Efficiency	5.10%

It can be shown from Table 5.11 that customers flexibility was perceived the most important sub-capability under flexibility with 25.20%. Adaptability comes second with 21%, while the efficiency as a capability comes last with 5.10%.

The results revealed from the EC will be presented to provide more explanation to the ranks provided.

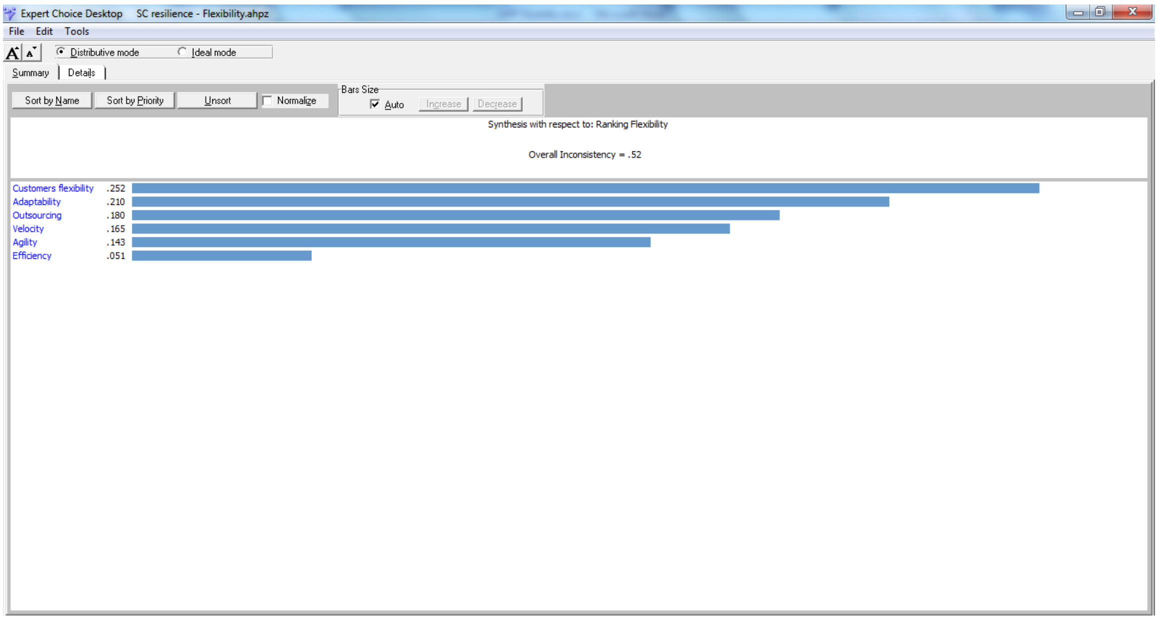

Figure 5.12-a: EC results for the ranking of AHP alternatives (sub-capabilities) - flexibility

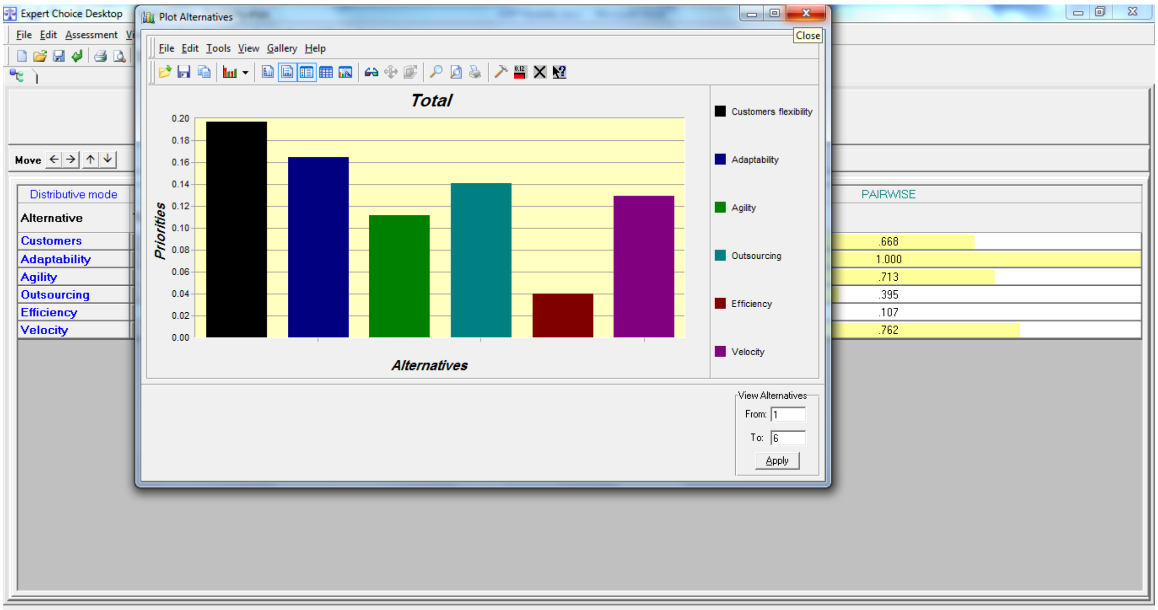

Figure 5.12-b: EC results for the ranking of AHP alternatives (sub-capabilities) - flexibility - Pareto chart

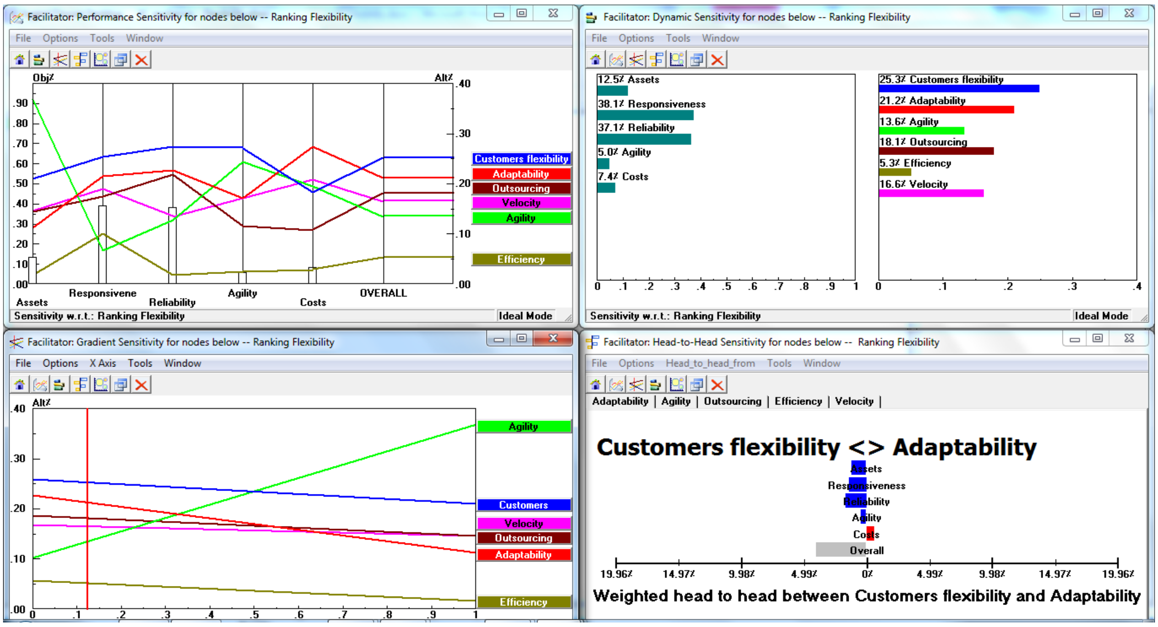

Figure 5.12-c: EC results for the ranking of AHP alternatives (sub-capabilities) - flexibility - sensitivity

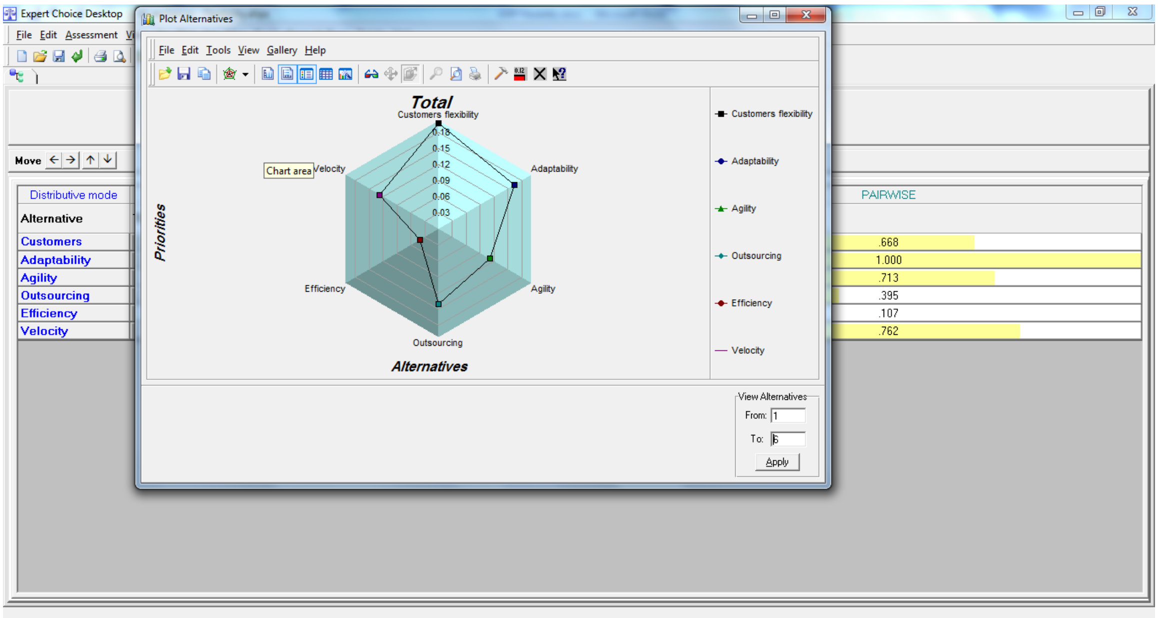

Figure 5.12-d: : EC results for the ranking of AHP alternatives (sub-capabilities) – flexibility - radar chart

Visibility sub-rankings

There are six sub-capabilities under the visibility category. The interviewees from the 30 companies involved in this study have ranked them in the second round of the AHP analysis performed after the first round where the main 3 SC resilience constructs were ranked.

The first step in AHP – as previously elaborated – is to develop the hierarchy in terms of the overall goal, the criteria to be used, and the decision alternatives. The overall goal of this hierarchy is to rank the risk factors under the visibility that was indicated based on the findings of stage one in empirical study as shown in Figure 5.7

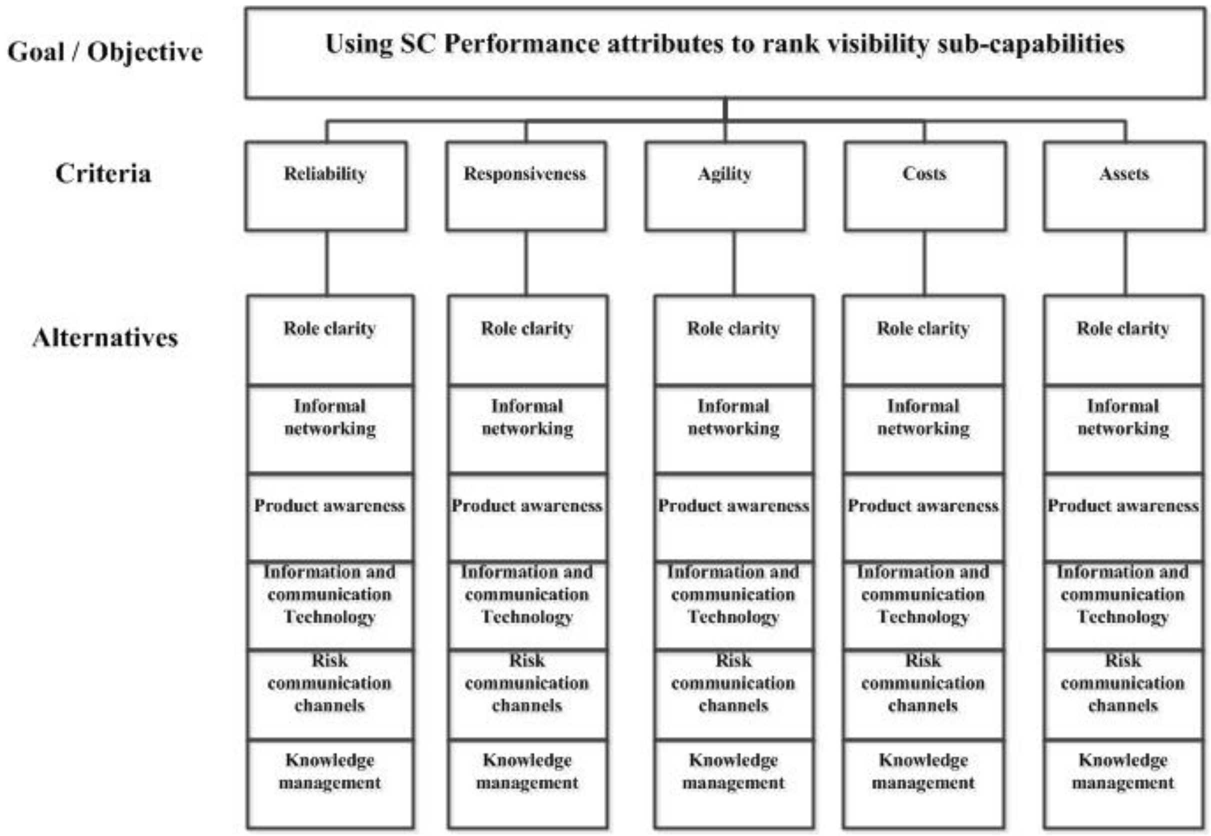

Figure 5.13: AHP decision hierarchy for sub-capabilities under visibility category

The ranks of the sub-capabilities will be shown in the table below:

Table 5.12: Visibility sub-capability overall priority ranking

Rank	Capability Sub-Category	Percentage
1	Role clarity	19.30%
2	Informal networking	15.60%
3	Product awareness	14.00%
4	Information and communication Technology	12.90%
5	Risk communication channels	11.50%
6	Knowledge management	5.50%

It is clear from Table 5.12 that the role clarity was perceived as the most important capability under visibility with 19.30%. Secondly, comes the informal networking with 15.60%, while the knowledge management comes last with 5.50%.

The results revealed from the EC will be presented to provide more explanation to the ranks provided.

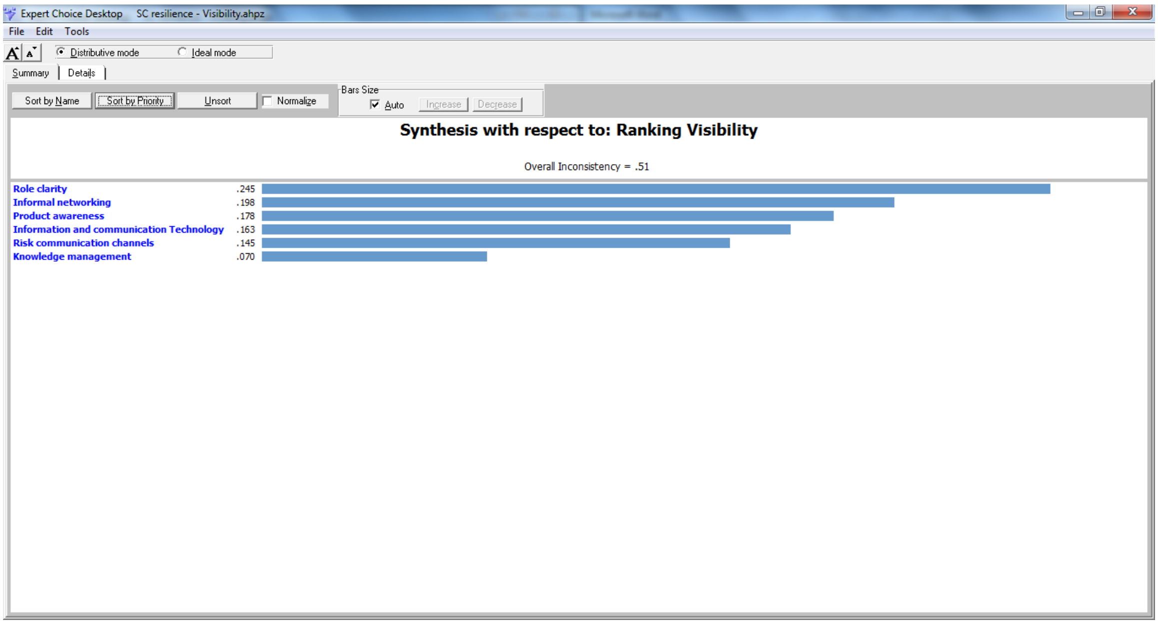

Figure 5.14-a: EC results for the ranking of AHP alternatives (sub-capabilities) - visibility

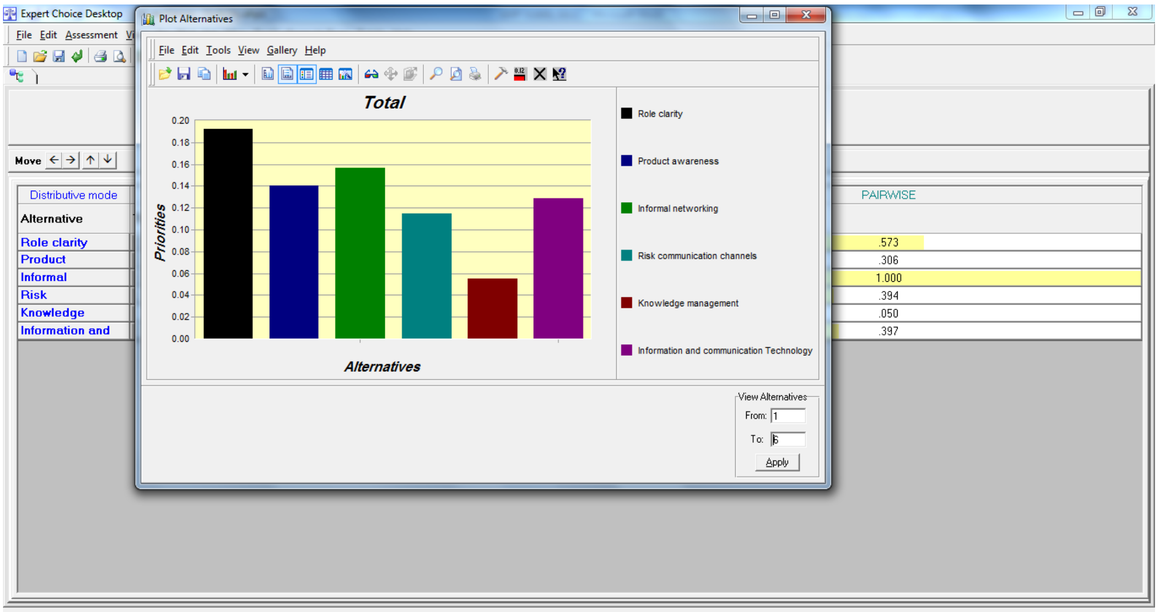

Figure 5.14-b: : EC results for the ranking of AHP alternatives (sub-capabilities) - visibility - Pareto chart

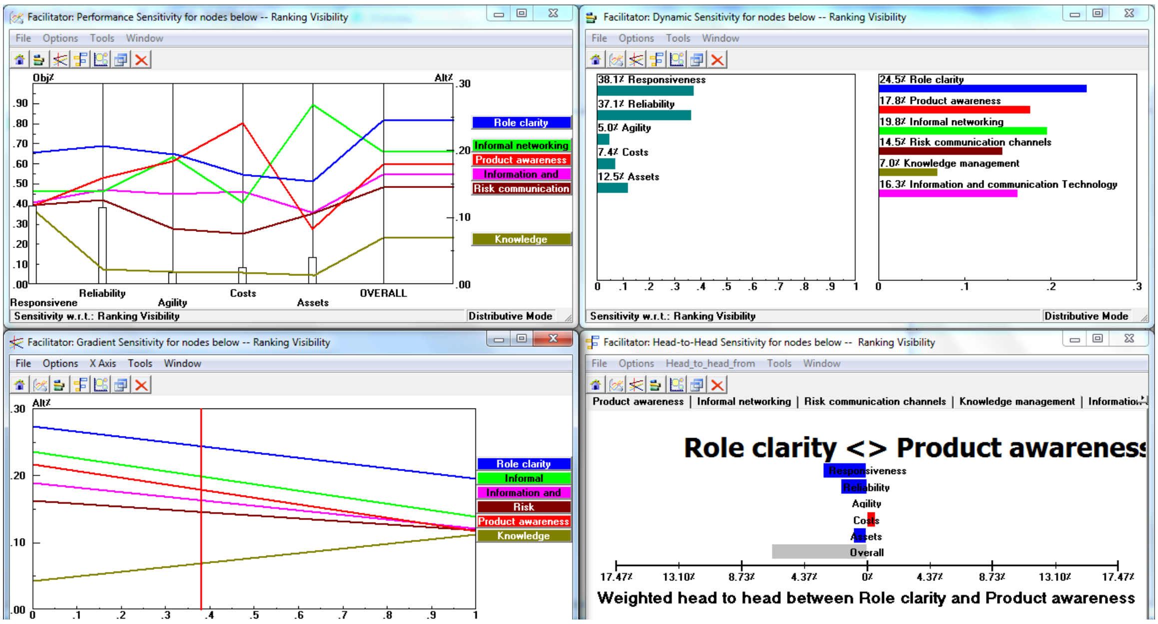

Figure 5.14-c: : EC results for the ranking of AHP alternatives (sub-capabilities) - visibility - sensitivity

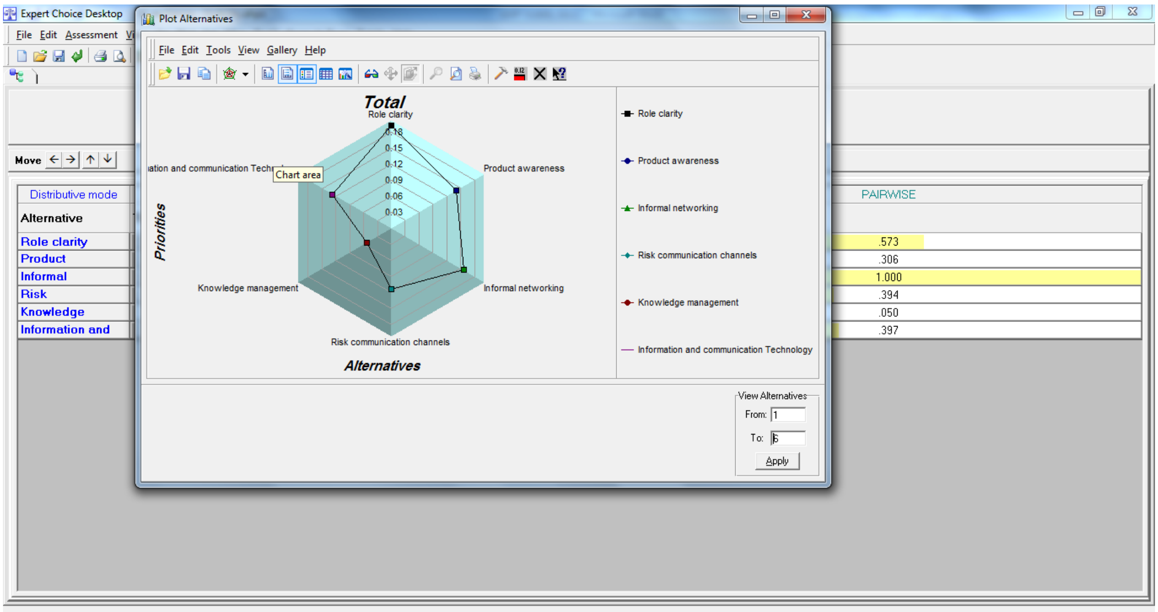

Figure 5.14-d: EC results for the ranking of AHP alternatives (sub-capabilities) – visibility - radar chart

5.3.3 KPIs as alternatives

In this sub section, the steps from 6 to 9 for the AHP model of KPIs as alternatives will be calculated.

Step 6: Calculate priorities for each KPIs using each criterion

Continuing with the AHP analysis, the pairwise comparison procedure must be used to determine the priorities for 10 level 1 KPIs identified from stage one of the data analysis using each of the criteria/objectives; reliability, responsiveness, agility, costs and assets. Determining these priorities required interviews to express pairwise comparison preferences for attributes using each criterion one at a time. In each comparison, interviews must select the more preferred KPI and then express a judgment of how more preferred the selected KPIs are. As previously shown in Table 5.1, AHP uses participant's verbal description of the preferences between 2 capabilities to determine a numerical rating of the preference. For example, suppose that the interviews stated that based on the responsiveness criteria, the order fulfilment cycle time KPIs is "Extremely preferred". Thus, using the responsiveness criteria, a numerical rating of 9 is assigned to the order fulfilment cycle time column of the pairwise comparison.

As shown below, a summary is given for the actual pairwise comparisons that the interviews provided for each criterion of ranking 10 KPIs.

Table 5.13: Pairwise comparison for the KPIs

Reliability										
	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside Supply Chain Flexibility	Upside Supply Chain Adaptability	Downside Supply Chain Adaptability	Supply Chain Management Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on Supply Chain Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.000	7.000	2.000	2.000	2.000	2.000	9.000	5.000	0.200	0.111
Order Fulfilment Cycle Time	0.143	1.000	3.000	3.000	3.000	4.000	2.000	0.500	0.500	9.000
Upside Supply Chain Flexibility	0.500	0.333	1.000	2.000	3.000	0.500	0.500	0.500	0.333	5.000

Upside Supply Chain Adaptability	0.500	0.333	0.500	1.000	5.000	0.500	2.000	0.200	0.500	0.200
Downside Supply Chain Adaptability	0.500	0.333	0.333	0.200	1.000	0.250	3.000	0.250	4.000	0.111
Supply Chain Management Cost	0.333	0.250	2.000	2.000	4.000	1.000	0.200	0.111	5.000	0.333
Cost of Goods Sold	0.333	0.500	2.000	0.500	0.333	5.000	1.000	3.000	0.200	0.111
Cash-To-Cash Cycle Time	0.200	2.000	2.000	5.000	4.000	9.009	0.333	1.000	4.000	3.000
Return on Supply Chain Fixed Assets	1.000	2.000	3.000	2.000	0.250	0.200	5.000	0.250	1.000	3.000
Return on Working Capital	0.25	0.111	0.200	5.000	9.000	3.000	9.000	0.333	0.333	1.000
Responsiveness										
	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside Supply Chain Flexibility	Upside Supply Chain Adaptability	Downside Supply Chain Adaptability	Supply Chain Management Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on Supply Chain Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.000	0.200	9.000	2.000	3.000	0.500	3.000	2.000	2.000	3.000
Order Fulfilment Cycle Time	5.000	1.000	3.000	5.000	7.000	9.000	0.500	5.000	5.000	3.000
Upside Supply Chain Flexibility	0.111	0.333	1.000	0.500	0.500	5.000	3.000	3.000	2.000	3.000
Upside Supply Chain Adaptability	0.500	0.200	2.000	1.000	3.000	3.000	3.000	3.000	3.000	2.000
Downside Supply Chain Adaptability	0.333	0.143	2.000	0.333	1.000	2.000	2.000	2.000	3.000	2.000
Supply Chain Management Cost	0.143	0.111	0.200	0.333	0.500	1.000	0.200	9.000	5.000	3.000
Cost of Goods Sold	2.000	2.000	0.333	0.333	0.500	5.000	1.000	0.111	0.200	0.333

Cash-To-Cash Cycle Time	0.333	0.200	0.333	0.333	0.500	0.111	9.000	1.000	7.000	3.000
Return on Supply Chain Fixed Assets	1.000	0.200	0.500	0.333	0.333	0.200	5.000	0.143	1.000	3.000
Return on Working Capital	2.000	0.333	0.333	0.500	0.500	0.333	3.000	0.333	0.333	1.000

Agility

	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside Supply Chain Flexibility	Upside Supply Chain Adaptability	Downside Supply Chain Adaptability	Supply Chain Management Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on Supply Chain Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.000	0.200	0.333	0.500	3.000	0.500	7.000	9.000	2.000	0.333
Order Fulfilment Cycle Time	5.000	1.000	0.200	0.333	5.000	0.500	3.000	3.000	3.000	5.000
Upside Supply Chain Flexibility	3.003	5.000	1.000	3.000	0.333	3.000	7.000	3.000	5.000	3.000
Upside Supply Chain Adaptability	2.000	3.003	0.333	1.000	7.000	5.000	5.000	2.000	3.000	2.000
Downside Supply Chain Adaptability	0.333	0.200	3.003	0.143	1.000	2.000	3.000	9.000	5.000	9.000
Supply Chain Management Cost	0.200	2.000	0.333	0.200	0.500	1.000	7.000	4.000	5.000	3.000
Cost of Goods Sold	3.003	0.333	0.143	0.200	0.333	0.143	1.000	3.000	7.000	0.111
Cash-To-Cash Cycle Time	0.143	0.333	0.333	0.500	0.111	0.250	0.333	1.000	7.000	3.000
Return on Supply Chain Fixed Assets	1.000	0.333	0.200	0.333	0.200	0.200	0.143	0.143	1.000	3.000
Return on Working Capital	2.000	0.200	0.333	0.500	0.111	0.333	9.000	0.333	0.333	1.000

Costs

	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside Supply Chain Flexibility	Upside Supply Chain Adaptability	Downside Supply Chain Adaptability	Supply Chain Management Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on Supply Chain Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.000	5.000	0.333	0.500	3.000	0.500	7.000	0.500	0.333	0.200
Order Fulfilment Cycle Time	0.200	1.000	0.200	0.333	5.000	0.500	3.000	3.000	5.000	0.333
Upside Supply Chain Flexibility	3.003	5.000	1.000	0.333	0.500	0.333	0.333	3.000	2.000	0.500
Upside Supply Chain Adaptability	2.000	3.003	3.003	1.000	0.500	0.200	5.000	2.000	3.000	0.250
Downside Supply Chain Adaptability	0.333	0.200	2.000	2.000	1.000	0.200	3.000	9.000	0.200	0.333
Supply Chain Management Cost	0.200	2.000	3.000	5.000	5.000	1.000	7.000	4.000	3.000	9.000
Cost of Goods Sold	2.000	0.333	3.003	0.200	0.333	0.143	1.000	2.000	5.000	7.000
Cash-To-Cash Cycle Time	2.000	0.333	0.333	0.500	0.111	0.250	0.500	1.000	0.200	3.000
Return on Supply Chain Fixed Assets	1.000	0.200	0.500	0.333	5.000	0.333	0.200	5.000	1.000	0.200
Return on Working Capital	0.200	3.000	2.000	4.000	3.000	0.111	0.143	0.333	5.000	1.000

Assets

	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside Supply Chain Flexibility	Upside Supply Chain Adaptability	Downside Supply Chain Adaptability	Supply Chain Management Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on Supply Chain Fixed Assets	Return on Working Capital

Perfect Order Fulfilment	1.000	3.000	3.000	3.000	2.000	0.200	5.000	5.000	0.200	0.143
Order Fulfilment Cycle Time	0.333	1.000	2.000	3.000	2.000	3.000	0.500	3.000	0.111	7.000
Upside Supply Chain Flexibility	0.333	0.500	1.000	5.000	0.500	5.000	0.500	0.250	0.200	0.500
Upside Supply Chain Adaptability	0.333	0.333	0.200	1.000	3.000	3.000	2.000	0.200	0.250	0.200
Downside Supply Chain Adaptability	0.500	0.500	2.000	0.333	1.000	4.000	3.000	0.250	2.000	0.250
Supply Chain Management Cost	0.500	0.333	0.200	0.333	0.250	1.000	0.200	0.500	0.250	0.333
Cost of Goods Sold	2.000	2.000	2.000	0.500	0.333	5.000	1.000	2.000	0.111	0.500
Cash-To-Cash Cycle Time	0.333	0.333	4.000	5.000	4.000	2.000	0.500	1.000	9.000	5.000
Return on Supply Chain Fixed Assets	1.000	9.000	5.000	4.000	0.500	4.000	9.009	0.111	1.000	0.200
Return on Working Capital	4.000	0.143	2.000	5.000	4.000	3.000	2.000	0.200	5.000	1.000

AHP continues by synthesizing each of the 5 pairwise comparison matrices in order to determine the priority of each KPIs using each criterion. The synthetization process is carried out for each pairwise comparison matrix using a three-step procedure, which is previously described, for the criteria pairwise comparison matrix. Table 5.14 displays the results of five synthetization computations which provide the ten sets of priorities.

Table 5.14: Priorities for each KPIs using each criterion

Attributes / Capabilities	Reliability	Responsiveness	Agility	Costs	Assets
Perfect Order Fulfilment	18.17%	13.67%	8.99%	9.55%	12.74%
Order Fulfilment Cycle Time	12.24%	25.20%	11.73%	8.85%	12.37%
Upside Supply Chain Flexibility	7.04%	8.18%	19.10%	9.20%	5.71%
Upside Supply Chain Adaptability	5.03%	9.85%	16.61%	10.44%	4.95%
Downside Supply Chain Adaptability	5.70%	6.68%	15.19%	8.43%	6.46%
Supply Chain Management Cost	8.09%	8.07%	8.72%	20.83%	2.21%

Cost of Goods Sold	7.78%	9.14%	5.76%	10.75%	8.48%
Cash-To-Cash Cycle Time	14.98%	8.68%	5.10%	5.13%	16.45%
Return on Supply Chain Fixed Assets	10.23%	5.46%	3.27%	6.81%	16.21%
Return on Working Capital	10.73%	5.07%	5.53%	10.02%	14.42%

It can be observed from above priorities that Perfect Order Fulfilment is the preferred KPI's based on Reliability Attribute (18.17%), Order Fulfilment Cycle Time is the preferred KPI's based on Responsiveness Attribute (25.20%), Upside Supply Chain Flexibility is the preferred KPIs based on Agility Attribute (19.10%), Supply Chain Management Cost is the preferred KPIs based on Costs Attribute (20.83%), and Cash-To-Cash Cycle Time is the preferred KPIs based on Assets Attribute (16.45%). According to these results, it is difficult to state the most preferred KPI. The next step shows the inconsistency ratios for 10 matrices, while step eight explains how to combine the priorities for the criteria and develop an overall priority ranking using values in Table 5.14.

Step 7: Check consistency of pairwise comparisons in each decision alternative matrix

Before performing further steps in AHP analysis, it is vital to calculate the inconsistency ratios of each decision alternative matrix and check whether the ratios are within the acceptable range. In this case, there are five separate ratio values for 10 decision alternative matrices. The inconsistency ratios can be calculated for each pairwise comparison matrix using five-step procedure described previously for the criteria pairwise comparison matrix. The manually calculated inconsistency ratios and EC inconsistency ratios for the same interviews responses can be seen below:

	IR for Reliability	IR for Responsiveness	IR for Agility	IR for Costs	IR for Assets
Manual calculation	0.052	0.051	0.085	0.088	0.091
EC calculation	0.06	0.05	0.09	0.09	0.09

All five inconsistency ratios are identical in both manual and EC calculations, and they further prove the reliability of the EC software for AHP analysis. Moreover, Five IRs are less than 0.1, thus the pairwise comparisons are acceptable to proceed with calculating overall priorities.

Step 8: Develop overall priority ranking

In this step, participants' pairwise comparisons of the five criteria are used to develop the priorities in step 4.3

Reliability	Responsiveness	Agility	Costs	Assets
36.1%	**38.1%**	**5.2%**	**7.9%**	**12.8%**

These priorities and the priorities shown in Table 5.14 are used to develop overall priority for the ten KPIs.

The procedure used to calculate the overall priority is to weight each KPIs' priority shown in Table 5.14 by the corresponding criterion priority. For example, the Reliability criterion has a priority of 36.1% and Visibility has a priority of 56.80% in terms of the Reliability criterion. Thus, 36.1 x 56.80% is the priority value of Visibility based on the Reliability criterion. To obtain the overall priority of Visibility, it requires to making similar calculations for Flexibility, Collaboration, Control and Learning and Innovation criteria; and then add the values to obtain the overall priority. The manually calculated overall priorities for each KPI and the overall priorities of the EC software can be seen in Table 5.15.

Table 5.15: KPIs overall priority rankings

Capabilities	**Overall priority**	**Rank**	**Overall priorities of EC**
Perfect Order Fulfilment	14.61%	2	13.50%
Order Fulfilment Cycle Time	16.90%	1	16.50%
Upside Supply Chain Flexibility	8.10%	8	8.50%
Upside Supply Chain Adaptability	7.89%	9	6.90%

Downside Supply Chain Adaptability	6.88%	10	6.40%
Supply Chain Management Cost	8.37%	7	8.70%
Cost of Goods Sold	8.52%	6	6.70%
Cash-To-Cash Cycle Time	11.48%	3	11.80%
Return on Supply Chain Fixed Assets	8.54%	5	9.80%
Return on Working Capital	8.72%	4	11.30%
Sum	100.00%		100.00%

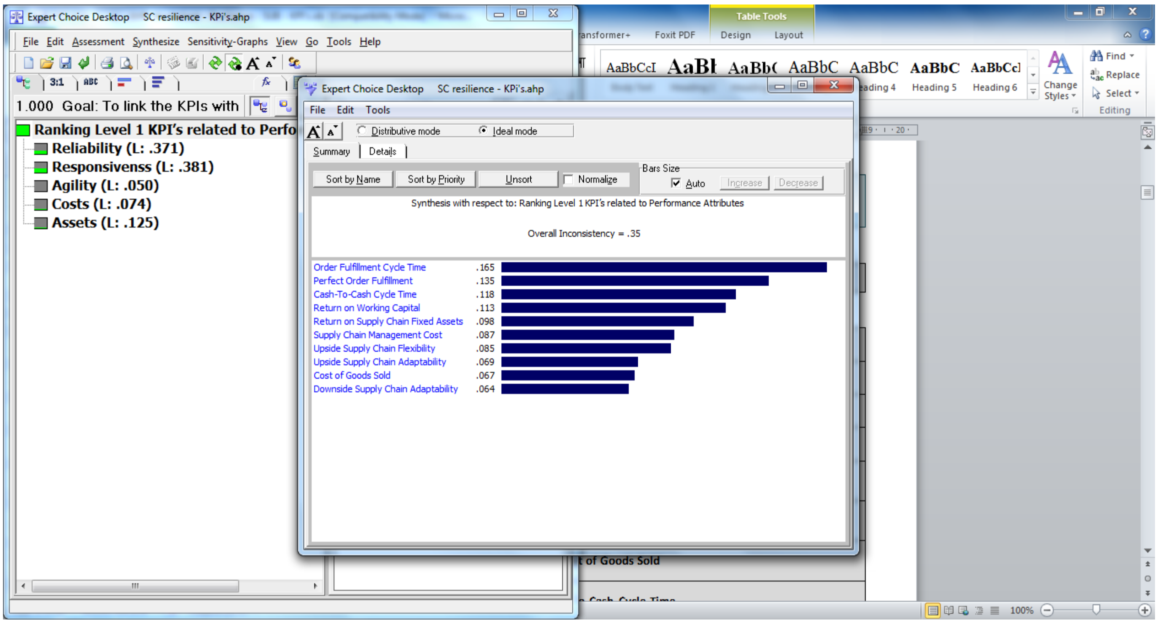

Figure 5.15-a: EC results for the ranking of AHP alternatives (KPIs)

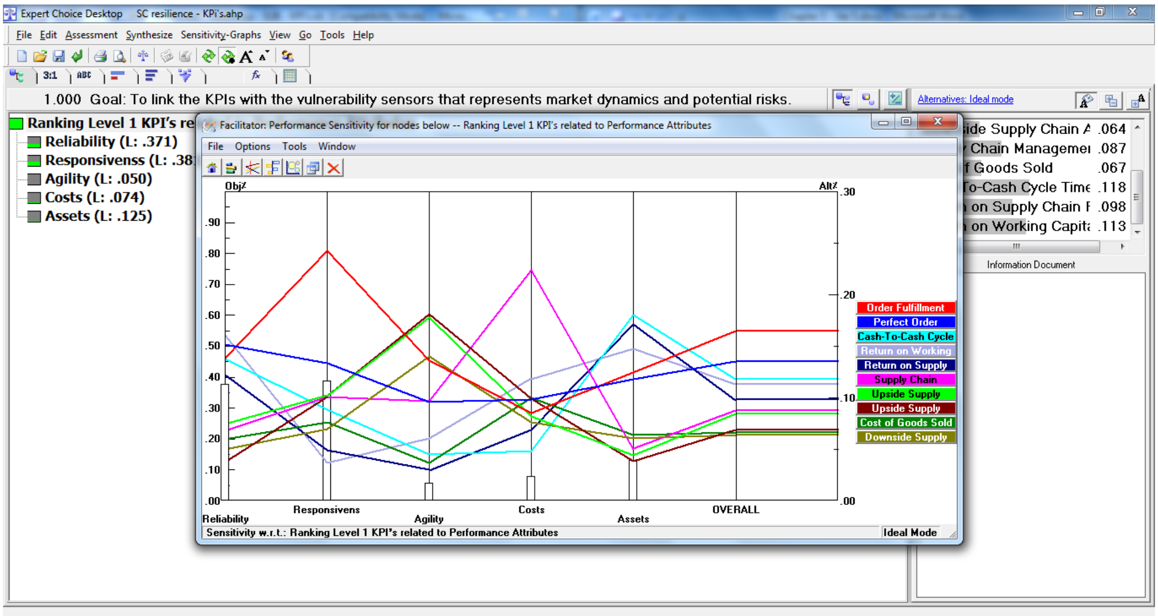

Figure 5.15-b: EC results for the ranking of AHP alternatives (KPIs) - sensitivity graphs - performance

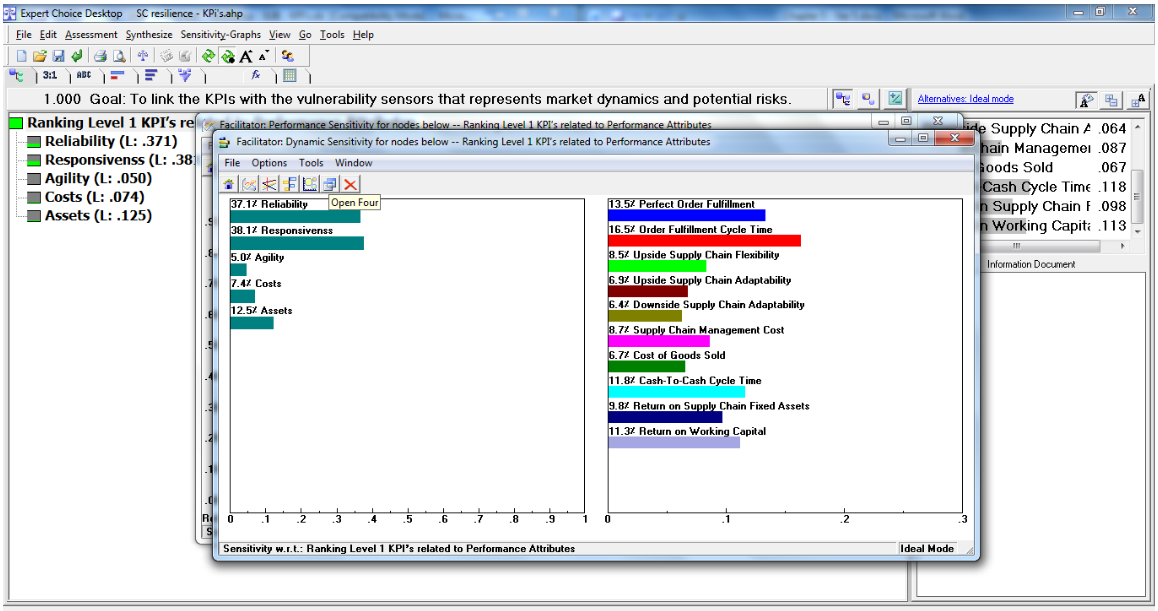

Figure 5.15-c: EC results for the ranking of AHP alternatives (KPIs) - sensitivity graphs - dynamic

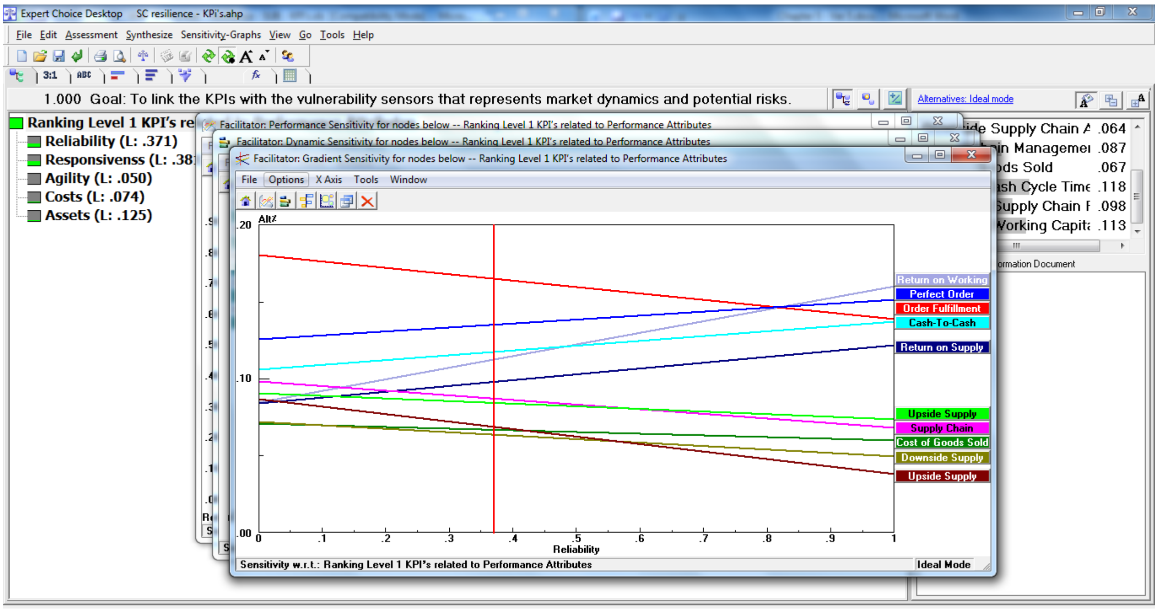

Figure 5.15-d: EC results for the ranking of AHP alternatives (KPIs) - sensitivity graphs - gradient

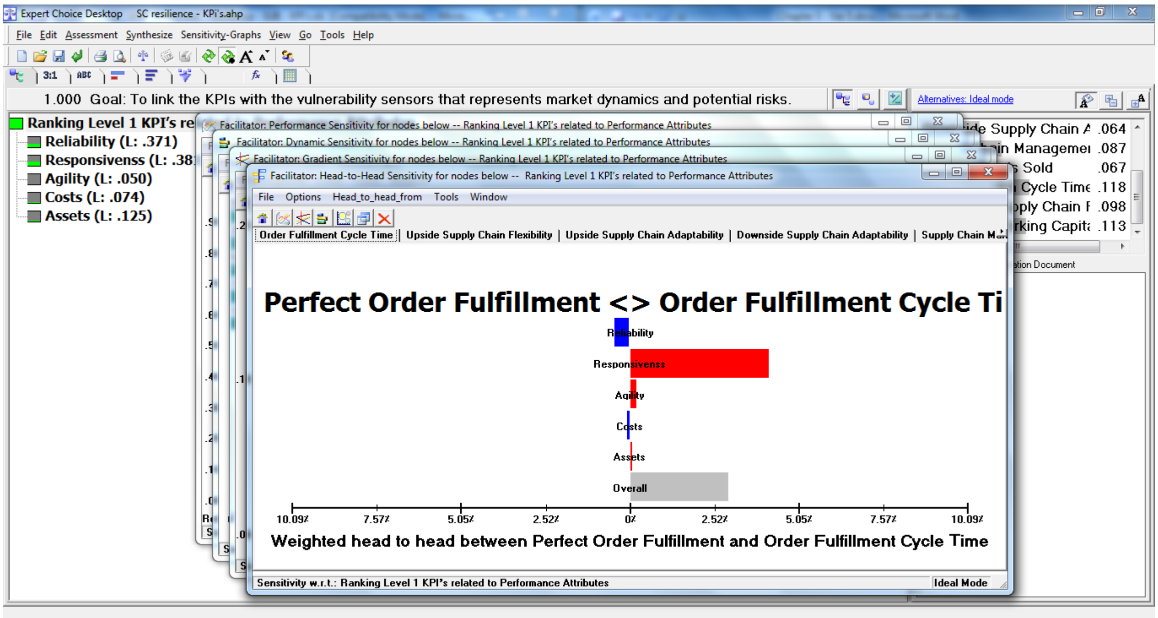

Figure 5.15-e: EC results for the ranking of AHP alternatives (KPIs) - sensitivity graphs - head to head

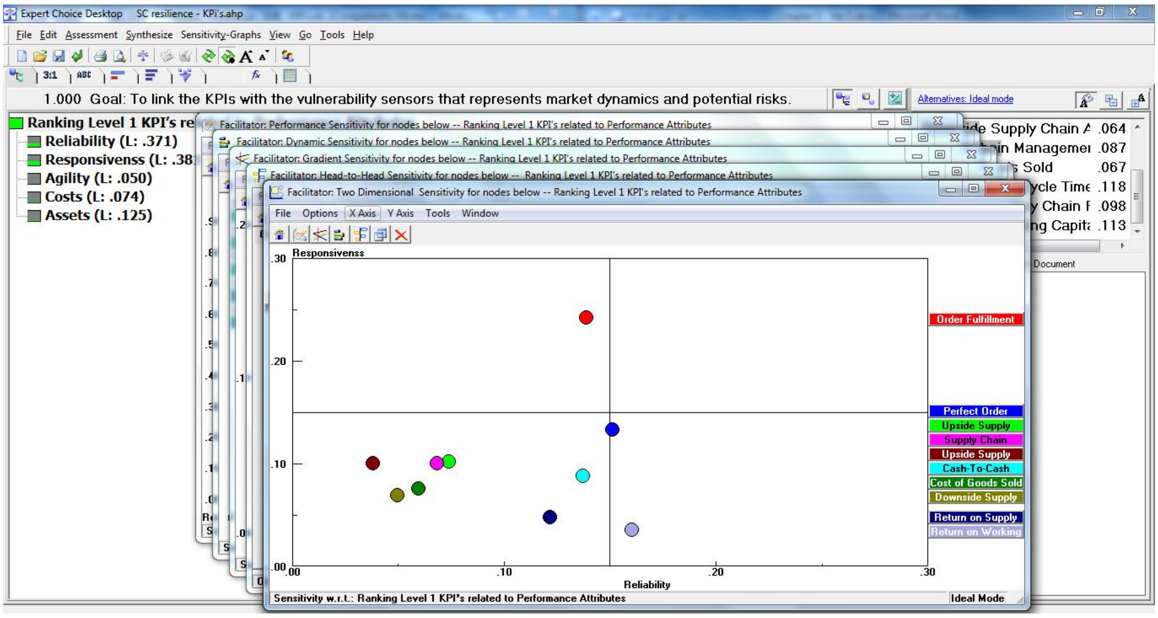

Figure 5.15-f: EC results for the ranking of AHP alternatives (KPIs) - sensitivity graphs - two D

It can be observed that priorities are very similar according to the above overall priorities. Therefore, the rankings are identical based on both manual and EC calculation procedures. Order Fulfilment Cycle Time is the most important KPIs (16.90%), the second most important KPI is Perfect Order Fulfilment (14.61%) followed by Cash-To-Cash Cycle Time (11.48%) then Return on Working Capital (8.72%), then:

- Return on SC Fixed Assets 8.54%
- Cost of goods sold 8.52%
- SCM Cost 8.37%
- Upside SC Flexibility 8.10%
- Upside SC Adaptability 7.89%
- Downside SC Adaptability 6.88%

Step 9: Aggregate results of all participants

Since this study was conducted among many participants, the EC software accumulates all the responses of the participants to provide final priority rankings. It is obvious that accumulating the results of such a complex decision hierarchy requires some automated form rather than a manual form to ensure the accuracy of the results (Forman and Peniwati, 1998; Saaty and Vargas, 2012). EC does this task using AIJ method. In this method, which is by far the most common, the individual judgments are combined by taking the geometric mean of the judgments to derive a 'recombined' set of priorities for each cluster of objectives in the hierarchy, as well as for alternatives with respect to each of the covering objectives (Saaty, 2000). It has been shown that the geometric mean is the only aggregation method that will assure that the reciprocal axiom of AHP holds for the combined judgments in a matrix of combined judgments (Harker, 1987; Forman and Peniwati, 1998).

5.4 AHP data collection using interviews

After developing the AHP hierarchies, data collection process should take place to allocate the pair-wise comparisons (Rajesh and Malliga, 2013). The 9-point scale (refer to Table 5.1) proposed by Saaty and Vargas (2012) was used to allocate the relative scores based on how much more important the selected criterion is (Jayawickrama, 2015).

Since AHP is not limited to tangible attributes and it can be used to measure qualitative criteria as well (Leung and Cao, 2001). Therefore, an advantage is the ability to deal with both qualitative and quantitative criteria (Leung and Cao, 2001; De Vreese and Boomgaarden, 2003). For this reason, structure interviews were conducted to collect data used to perform the seven AHP hierarchies discussed earlier in this chapter. A Structured interview is used so that the researcher can explain and discuss all related issue or doubts in the hierarchy in details to the interviewees (Dikmen and Birgonul., 2006). Moreover, all the interviewees were asked to fill the same AHP template to be able to repeat the interview and submit valuable and reliable qualitative data. The same 30 companies interviewed in stage one of data collections were interviewed in this stage. Furthermore, this stage (stage 2 of data collection and analysis) included 2 rounds of interviews. The first round was conducted to collect data for the first 3 hierarchies for the three SC resilience constructs (risks, capabilities, and KPIs) to rank the main categories underneath each of them. To extend the outputs of the three AHP hierarchies of the three SC resilience constructs, a second round of interviews was conducted to find out the priorities of the sub-categories of the SC resilience constructs. In this round, four AHP hierarchies were developed to rank the top two sub-categories for the risks (network and external risks) and the capabilities (flexibility and visibility).

The AHP interview template for the seven hierarchies were developed to collect data to rank the SC resilience constructs based on AHP method (For more details about the templates refer to **Appendix 13**).

The interview template consists of 204 pairwise comparisons in order to rank the SC attributes, risks, capabilities, KPIs, network risks, external risks, visibility capabilities, and flexibility capabilities.

The total of 204 pairwise comparisons had been allocated for eight ranking purposes as follows;

- First, there are 10 pairwise comparisons to initiate the importance of decision criteria for enhancing SC resilience according to the SC managers' opinions.
- Second, there are 6 pairwise comparisons in order to rank the four types of risks using each criterion.
- Third, there are 10 pairwise comparisons in order to rank the five types of capabilities using each criterion.
- Fourth, there are 45 pairwise comparisons to rank the SC KPIs using each criterion.
- Fifth, there are 55 pairwise comparisons to rank the risk factors under the network risks with respect to 5 criteria.
- Sixth, there are 36 pairwise comparisons to rank the risk factors under the external risks with respect to 5 criteria.

- Seventh, there are 21 pairwise comparisons to rank the sub-capabilities under the flexibility capability with respect to five criteria.
- Finally, there are 21 pairwise comparisons to rank the sub-capabilities under the visibility capability with respect to five criteria.

In the next section, the results, which are revealed from the pairwise comparison conducted, will be discussed in details.

5.5 Discussion of ranking of the SC resilience constructs

This section discusses the results of the AHP analysis for ranking the SC resilience constructs. The ultimate rank priorities based on all pairwise judgments of participants will be interpreted for this research context and how it extends the finding of qualitative phase will be illustrated. Ranking will be discussed in four perspectives i.e., SC performance attributes perspective, SC risks perspective, SC capabilities perspective and SC KPIs perspective.

5.5.1 Ranking SC performance attributes (criteria)

This section discusses and compares the ranking of SC performance attributes (criteria) with respect to the responses provided by managers in companies. Table 5.16 highlights the priorities of five criteria which were used to rank SC risks, capabilities and KPIs.

Table 5.16: Results of ranking SC performance attributes

Criteria (SC performance attributes)	**Priority**	**Rank**
Responsiveness	38.1%	**1**
Reliability	36.1%	**2**
Assets	12.8%	**3**
Costs	7.9%	**4**
Agility	5.2%	**5**

Table 5.16 shows that responsiveness is the most important attribute according to managers. Time is a vital element in a resilient SC, so managers chooses responsiveness as number one priority with 38.1%. Second important attribute is reliability, in other words, the ability to perform tasks as expected. Managers gave reliability a priority of 36.1%. In the third place come assets, which means the ability to efficiently utilize assets. Assets took a priority of 12.8% according to managers. After assets come costs, which had a priority of 7.9% from managers. Costs refer to the cost of operating the process including labour costs, materials costs, transportation cost, cost of goods sold, etc. The least important attribute is agility according to mangers in companies.

5.5.2 Ranking SC risks

Table 5.17 highlights the ranks and priorities of SC risks based on AHP method.

Table 5.17: Results of ranking SC risks

Attributes (Risks)	**Reliability**	**Responsiveness**	**Agility**	**Costs**	**Assets**	**Overall Priority**	**Rank**
Network Risk	20.3%	4.8%	2.7%	1.4%	5.8%	35.0%	**1**
External Risk	8.5%	12.7%	1.7%	5.0%	1.8%	29.6%	**2**
Internal Risk	5.1%	17.4%	0.5%	0.8%	2.0%	25.8%	**3**
Functional Risk	2.3%	3.2%	0.3%	0.6%	3.2%	9.6%	**4**

By using SC performance attributes to rank risks categories, network risk seems to be the most threatening risk –by 35.0% priority- according to SC managers, as they stated that most of the problems come from SC network i.e., suppliers, customers and distributors. Therefore, it is worthy to focus on SC network rather than focusing on the firm itself. Second threatening risk is external risk –by 29.6% priority- according to SC managers. External risk is an uncontrollable risk such as terrorism, economic instability, corruption, etc. Thus, it demands high responsiveness to control such risk. After external risk comes internal risk which had a priority of 25.8% according to SC managers. Internal risk includes risks within the firm such as logistics risks, capacity shortage, raw materials issues, etc. The least threatening risk according to SC managers is functional risk.

To give further clarification about risk ranking and to help SC managers understanding risks, the research attempts to rank sub-risks included in the top two risk factors ranked before. Table 5.18 highlights the ranks and priorities of the risk factors within network risks.

Table 5.18: Results of ranking network risk factors

Rank	Network risk factors (sub-risks)	Percentage
1	Lower consumer spending	19.00%
2	Dis-honest suppliers	14.50%
3	Third party logistics risks	13.10%
4	Monopoly risks	12.80%
5	Price volatility	8.80%
6	Competitive risks	7.80%
7	Outsourcing	7.00%
8	Lack of Network Communication risks	6.30%
9	Supplier delivery failure	5.90%
10	Instability of market	4.80%

In Table 5.18, SC managers stated that lower consumer spending is the most intimidating sub-risk within network risk factors with a priority of 19%. This is because of the economic instability which pushes the consumer to save money rather than spending it. Second intimidating sub-risk within network risk factors is dis-honest suppliers with the priority of 14.5% according to SC managers. Suppliers play a vital role in the SC, so if the supplier was dis-honest or unreliable, this creates a significant risk to the whole SC. After dis-honest suppliers, comes third party logistics risks with a priority of 13.1% according to the SC managers. Then comes monopoly risks with a 12.8% priority according to SC managers who stated that government regulations and policies play a significant role controlling monopoly activities. The 5th rank is price volatility with a priority of 8.8% according to SC managers.

Competitive risks occupy the 6th ranking with a priority of 7.8% according to SC managers as competitors represent threats not only to the SC, but also to the whole organisation. Next comes outsourcing risks with a priority of 7% according to SC managers. Outsourcing risks includes risks caused by other entities outside the firm itself, for example third party logistics. Lack of network communication risks came in the 8th place with a priority of 6.3% according to SC managers. The least threatening risks within network risk factors are supplier delivery failure –with a priority of 5.9%- and instability of market – with a priority of 4.8%-.

Here after, Table 5.19 highlights the ranks and priorities of the external risk factors

Table 5.19: Results of ranking external risk factors

Rank	External risk factors (sub-risks)	Percentage
1	Unstable Government policies	15.70%
2	Poor transport infrastructure	15.40%
3	Corruption	14.80%
4	Terrorism	14.50%
5	Political instabilities	12.90%
6	Theft	11.30%
7	Power and energy risks	9.10%
8	Economic Instability	6.10%

As shown in Table 5.19, SC managers stated that unstable government policies are the most threatening sub-risk within the external risk factors with a priority of 15.7%. Unstable government policies affect many activities regarding SC specially importing raw materials from other countries, as import tariffs are not fixed. The second threatening sub-risk within external risk factors is poor transport infrastructure. SC managers gives poor transport infrastructure a priority of 15.4% because there are many countries in the MER, which lack good transport infrastructure, has a direct effect on the SC resilience. The third rank is corruption with a priority of 14.8% according to SC managers. Corruption is a common phenomenon in many governments in the MER, so it represents a significant threat to SC resilience. Terrorism comes in the fourth rank after corruption. SC managers gave terrorism a priority of 14.5% due to the unstable atmosphere in the MER. After terrorism comes political instabilities with a priority of 12.9% according to SC managers. After the Arab spring in 2011, the political situation in the MER was unstable which caused a significant threat to many organisations. Theft took the sixth rank with a priority of 11.3% according to SC managers because of the lack of security after the Arab spring in 2011. Power and energy risks, and economic instability are the least threatening sub-risk within the external risk factors according to SC managers who gave power and energy risks a priority of 9.10% and the economic instability a priority of 6.1%.

5.5.3 Ranking SC capabilities

Table 5.20 highlights the ranks and priorities of SC capabilities based on AHP method.

Table 5.20: Results of ranking SC capabilities

Attributes (Capabilities)	Reliability	Responsiveness	Agility	Costs	Assets	Overall Priority	Rank
Flexibility	7.7%	20.3%	0.9%	2.0%	6.9%	37.8%	**1**
Visibility	20.5%	7.3%	3.0%	1.3%	2.3%	34.4%	**2**
Control	3.7%	4.8%	0.7%	3.4%	1.7%	14.3%	**3**
Collaboration	2.6%	3.5%	0.4%	0.5%	0.8%	7.8%	**4**
Learning and Innovation	1.5%	2.2%	0.2%	0.7%	0.9%	5.7%	**5**

By using SC performance attributes to rank SC capabilities, flexibility seems to be the most important SC capability according to SC managers who gave it a priority of 37.8%. In other words, being able to change quickly and efficiently to market changes is a vital capability of resilient SC. The second important SC capability is visibility with a priority of 34.4% according SC managers. This is due to the importance of having knowledge of the conditions of operating assets to enhance SC resilience. The third rank capability is control, which has a priority of 14.3% from SC managers. Having control over SC internal and external activities helps improving overall SC resilience, so no wonder why control capability comes after flexibility and visibility. According to SC managers, the least important SC capabilities are Collaboration capability with a priority of 7.8%, and learning and innovation capability with a priority of 5.7%.

To give further clarification about capabilities ranking, and help SC managers understand how to use capabilities to control reduce risks and enhance SC resilience, the research attempts to rank sub-capabilities included in the top two capabilities factors ranked before. Table 5.21 highlights the ranks and priorities of the sub-capabilities within flexibility.

Table 5.21: Results of ranking sub-capabilities under flexibility

Rank	Capability Sub-Category	Percentage
1	Customers flexibility	25.20%
2	Adaptability	21.00%
3	Outsourcing	18.00%
4	Velocity	16.50%
5	Agility	14.30%
6	Efficiency	5.10%

As shown in Table 5.21, SC managers stated that customers' flexibility is the most important sub-category in flexibility with a priority of 25.2%. In other words, having a customer who is flexible -for example- regarding delivery dates, or quantities demanded is an important capability to enhance the overall SC resilience. The second important sub-category in flexibility is adaptability. Adaptability is vital for company sustainability in the market. For this reason, SC managers gave adaptability a priority of 21%. After adaptability comes outsourcing. Thanks to its importance in improving SC –as it eliminates unfavourable headaches –SC managers gave it a priority of 18%. In the fourth rank comes velocity as SC managers gave it a priority of 16.5% The least important sub-category of flexibility capabilities is agility with a priority of 14.3% and efficiency with a priority of 5.1%.

On the other hand, Table 5.22 highlights the ranks and priorities of the sub-capabilities under visibility.

Table 5.22: Results of ranking sub-capabilities under visibility

Rank	Capability Sub-Category	Percentage
1	Role clarity	19.30%
2	Informal networking	15.60%
3	Product awareness	14.00%
4	Information and communication Technology	12.90%
5	Risk communication channels	11.50%
6	Knowledge management	5.50%

In Table 5.22, SC managers stated that role clarity is the most important sub-category in visibility with a priority of 19.3%, which means having every employee within the company knows how exactly his/her responsibilities and duties are vital for a successful SC resilience. The second important sub-category in visibility is informal networking. In MER, business is mainly based on friendly relations, so informal networking is very important to enhance SC visibility. For this reason, SC managers gave informal networking a priority of 15.6%. In the third rank comes product awareness which means that customers are aware of the product. Therefore, SC managers gave product awareness a priority of 14%. After product awareness coms information and communication technology. Nowadays, ERP systems are essential for a resilient SC, it allows employees to manage relationships within SC i.e., supplier relationship management and customer relationship management. Thus, SC managers gave information and communication technology a priority of 12.9%. The least important sub-categories in visibility are risk communication channels with 11.5% priority, and knowledge management with 5.5% priority.

5.5.4 Ranking SC KPIs

Table 5.23 highlights the ranks and priorities of SC KPIs based on AHP method.

Table 5.23: Results of ranking SC KPIs

Attributes (SC level 1 KPIs)	Reliability	Responsiveness	Agility	Costs	Assets	Overall Priority	Rank
Order Fulfilment Cycle Time	4.4%	9.6%	0.6%	0.7%	1.6%	16.9%	1
Perfect Order Fulfilment	6.6%	5.2%	0.5%	0.8%	1.6%	14.6%	2
Cash-To-Cash Cycle Time	5.4%	3.3%	0.3%	0.4%	2.1%	11.5%	3
Return on Working Capital	3.9%	1.9%	0.3%	0.8%	1.8%	8.7%	4
Return on Supply Chain Fixed Assets	3.7%	2.1%	0.2%	0.5%	2.1%	8.5%	5
Cost of Goods Sold	2.8%	3.5%	0.3%	0.8%	1.1%	8.5%	6
Supply Chain Management Cost	2.9%	3.1%	0.5%	1.6%	0.3%	8.4%	7
Upside Supply Chain Flexibility	2.5%	3.1%	1.0%	0.7%	0.7%	8.1%	8
Upside Supply Chain Adaptability	1.8%	3.8%	0.9%	0.8%	0.6%	7.9%	9
Downside Supply Chain Adaptability	2.1%	2.5%	0.8%	0.7%	0.8%	6.9%	10

By using SC performance attributes to rank SC KPIs, order fulfilment cycle time seems to be the most important SC KPI as time element is very crucial to build a resilient SC. For this reason, SC managers gave order fulfilment cycle time a priority of 16.9%. The second important SC KPI is perfect order fulfilment with a priority of 14.6% according to SC managers. The reason behind this is delivering orders to the right place, with the right product, at the right time, in the right condition, in the right package, in the right quantity, to the right customer is very important in a resilient SC. In the third rank comes cash-to-cash cycle time with a priority of 11.5% according to SC managers. After cash-to-cash cycle time comes the return on working capital which has a priority of 8.7% according to SC managers. Return on

SC fixed assets occupies the fifth rank according to SC managers with a priority of 8.5%. Cost of goods sold, SC management cost, upside supply chain flexibility, and upside SC adaptability almost have the same priorities as cost of goods sold has 8.5%, and SC management cost has 8.4%, while upside supply chain flexibility has a priority of 8.1%, and upside supply chain adaptability has a priority of 7.9% according to SC managers. The least important SC KPI – according to SC managers –is downside SC adaptability with a priority of 6.9%.

Based on the findings revealed from ranking the SC KPIs using AHP, new relations have been discovered as highlighted in Table 5.24. Table 5.24 was adopted from the findings of step six in section 5.3.4

Table 5.24: SC KPIs links with SC performance attributes

Attributes / KPI's	Reliability	Responsiveness	Agility	Costs	Assets
Perfect Order Fulfilment	18.2%	13.7%	9.0%	9.5%	12.7%
Order Fulfilment Cycle Time	12.2%	25.2%	11.7%	8.8%	12.4%
Upside SC Flexibility	7.0%	8.2%	19.1%	9.2%	5.7%
Upside SC Adaptability	5.0%	9.9%	16.6%	10.4%	5.0%
Downside SC Adaptability	5.7%	6.7%	15.2%	8.4%	6.5%
Supply Chain Management Cost	8.1%	8.1%	8.7%	20.8%	2.2%
Cost of Goods Sold	7.8%	9.1%	5.8%	10.7%	8.5%
Cash-To-Cash Cycle Time	15.0%	8.7%	5.1%	5.1%	16.4%
Return on Supply Chain Fixed Assets	10.2%	5.5%	3.3%	6.8%	16.2%
Return on Working Capital	10.7%	5.1%	5.5%	10.0%	14.4%
Sum	100.0%	100.0%	100.0%	100.0%	100.0%

In Table 5.24, there are the familiar relations between KPIs and performance attributes (level 1 SCOR model) highlighted in black cells, and there are new relations discovered beside the level one SCOR model relations with performance attributes highlighted in red cells. The new relations were discovered by assuming that any percentage above 10% -except for the level 1

SCOR model relations- represents a strong relation. Therefore, according to level 1 SCOR model, perfect order fulfilment KPI has a relationship with reliability by 18.2%; It also has a relationship with responsiveness attribute by 13.7% and a relationship with assets attribute by 12.7%. As for order fulfilment cycle time, it has a relationship with responsiveness by 25.2% according to level one SCOR model. Order fulfilment cycle time also has a new relationship with reliability by 12.2%, with agility by 11.7%, and with assets by 12.4%. Upside SC flexibility, upside SC adaptability, and downside SC adaptability have relationship with agility by 19.1%, 16.6 and 15.2% according to level one SCOR model. In addition, upside SC adaptability has a new relationship with costs by 10.4%. Regarding SC management cost and cost of goods sold, they both have a relationship -as level one SCOR model states- with costs attribute by 20.8% and 10.7%. Concerning cash-to-cash cycle time, return on SC fixed assets and return on working capital have relationship with assets attribute -as level one SCOR model states- by 16.4%, 16.2% and 14.4%. However, they also have a new relationship with reliability attribute by 15%, 10.2% and 10.7%. Return on working capital also has a new relationship with costs attribute by 10%.

These links would enable SC managers to focus on the new contribution to improve the standard metrics adopted from the SCOR model, rather than focusing on certain KPIs provided to attain any of the five SC performance attributes (reliability, responsiveness, agility, costs, and assets). For example: to improve responsiveness, SC managers should monitor and improve “Perfect Order Fulfilment” (new contribution) beside “Order Fulfilment Cycle Time” (the main matric by SCOR model) to enhance the SC performance of the entire chain.

5.5.5 Refined supply chain resilience model (2)

Based on the findings revealed in this chapter, the new SC resilience model demonstrated the three main elements: (1) SC risks and its rankings, (2) SC capabilities and its rankings, (3) SC KPIs and its rankings in addition to the new discovered relations between SC KPIs and performance attributes. As per relationships between SC risks, capabilities and KPIs, they were previously discussed and defined in chapter four. Figure 5.8 highlights the impact of risks on KPIs, and which capabilities to focus on to control such risks. For instance, perfect order fulfilment is a high priority KPI according to the prior findings, if the KPI falls down, this means that there is a potential risk which needs to be controlled, and would be achieved by focusing on the right capabilities.

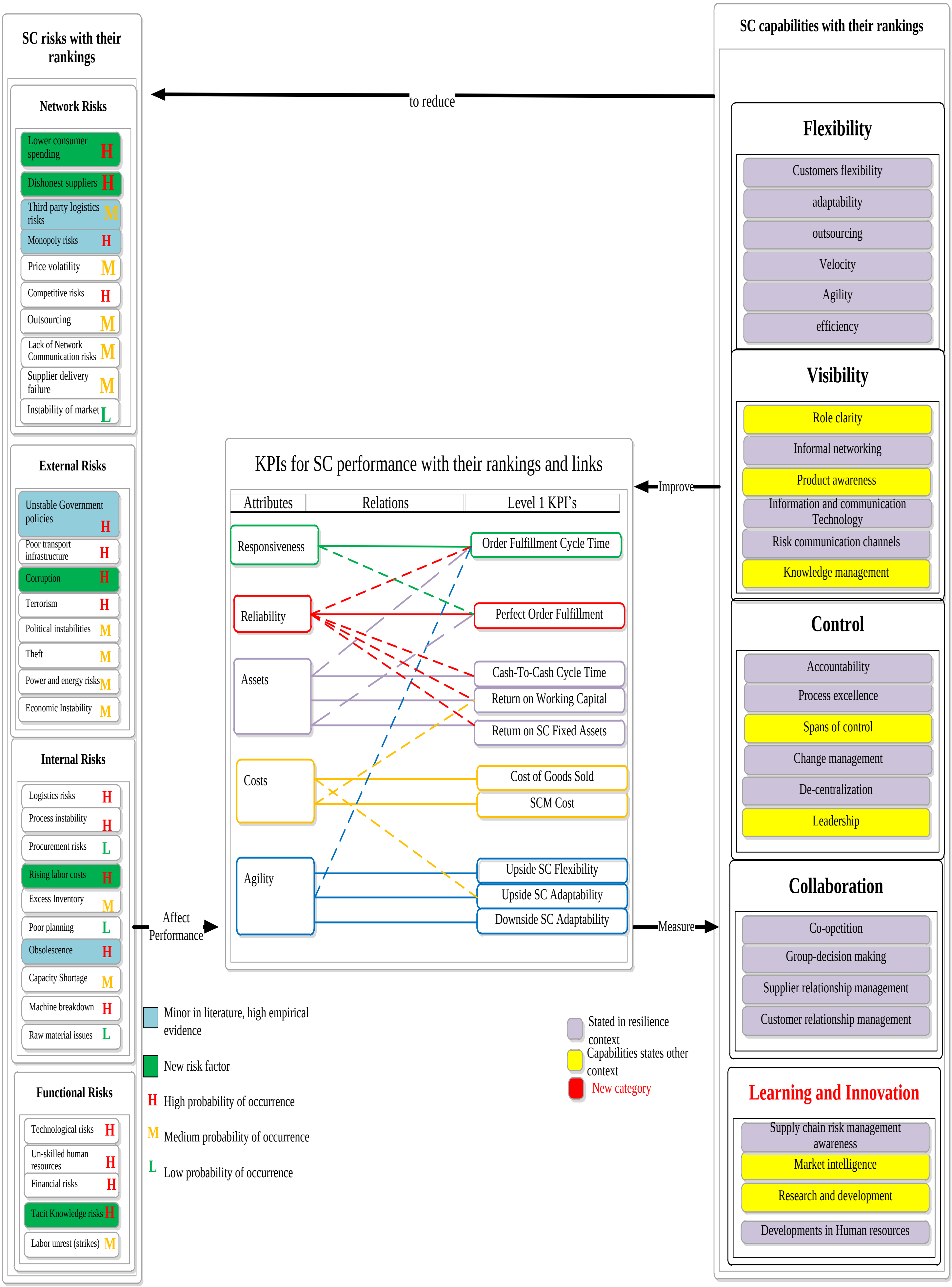

Figure 5.16: Refined SC resilience model (2)

5.6 Summary

This chapter extended the findings of stage one of empirical study, i.e., ranking the SC resilience constructs according to SC managers' judgements with the ultimate aim to enhance resilience in FMCG SCs. Accordingly, the three research questions are answered by the findings revealed from stage two of empirical study, i.e., what are the most important risks causing SC vulnerabilities, what are the most important capabilities to manage risks, and what are the most importance SC KPIs to enhance resilience.

This chapter deliberated in depth how the three SC resilience constructs were ranked using the AHP method. The basics and steps of AHP method were demonstrated to adopt the AHP in this research. Structured interviews were implemented to collect the data from the 30 FMCG companies. The results revealed from the AHP were discussed and elaborated to construct the refined SC resilience model (2) to achieve the aim of this research, developing a model of a resilient SC in FMCG industry in the MER context.

Chapter six: Discussion

6.1 Introduction

This chapter examines the empirical findings revealed from both stages of the empirical study with respect to the literature review, conceptual model versus refined model (1), and refined model (1) versus refined model (2). The findings revealed from this study are consistent with some of the previous studies but do not support some researches too. This chapter therefore aims to examine whether empirical evidence conform or contradict to previous researches in SC resilience context.

This research adopted qualitative methods due to the exploratory nature of the topic studied. In stage one in the empirical study, semi-structured interview was used to collect data from 30 companies to investigate the SC resilience constructs as well as the interrelations between them. Furthermore, structured interview was used in stage two in the empirical study incorporating the AHP method to extend the findings of stage one by ranking the constructs based on practitioner's judgements.

6.2 Supply chain resilience model for FMCG industry in MER

A conceptual model for SC resilience was developed in the conceptual phase through analysing the literature related concepts to investigate the research gaps of this research. In the stage of the empirical study, the conceptual model developed was refined based on the empirical data collected and analysed.

In the following sub-sections, the development of the conceptual model with the three SC resilience constructs (risks, capabilities, and KPIs) will be highlighted in addition to how each construct has been transformed across different stages of the empirical study. The refined model for SC resilience in FMCG industry in MER version (1) was developed based on the empirical data in order to investigate the risks that face SCs, capabilities that companies employ, and KPIs used to measure performance of the SC processes from industry perspective. Later, the understanding of these constructs helped in developing matrices to elaborate the interrelation between them. Thus, the revealed findings were ranked in stage two of empirical study to give more value to the findings of stage one.

6.2.1 Evolution of supply chain risks across different research stages

As mentioned earlier in chapter two, the literature is rich with several classification and interpretations of SC risks that cause SC vulnerabilities (Chopra and Sodhi 2004, 2014; Christopher and Peck 2004; Jüttner and Maklan, 2011; Scholten et al., 2014; Pettit et al., 2010). Moreover, it was noticed that many researches attempt to address similar risks, even though they were classified differently. Another important point to notice is that some authors focused on simple classification by describing the risks under broad categories; such as, internal and external (Christopher and Peck; 2004), qualitative and quantitative (Svensson, 2000), supply and demand (Minahan, 2005) while some authors expanded the classification to cover all risk sources (Manuj and Mentzer, 2008; Tukamuhabwa Rwakira et al., 2015; Chopra and Sodhi, 2004). Thus, there is no agreement on the most correct way to categorize SC risks (Tukamuhabwa Rwakira et al., 2015; Tukamuhabwa Rwakira, 2015).

The classification chosen for this research was consistent with previous researches (Manson-Jones and Towill, 1998; Christopher and Peck; 2004) which grouped the SC risks into three categories: internal, external, and network risks. A fourth category was presented in a research conducted by Deloitte Development LLC (2013) with not much support in the SC risk management literature.

Based on the categorisation adopted, in order to give more explanation to these risk categories, the conceptual model included several sub-risks based on the researcher understanding of the MER environment to be empirically examined.

Further, Figure 6.1 gives a spotlight on the risk categories and sub-risks (risk factors) in the conceptual phase, and how they were transformed during the empirical study.

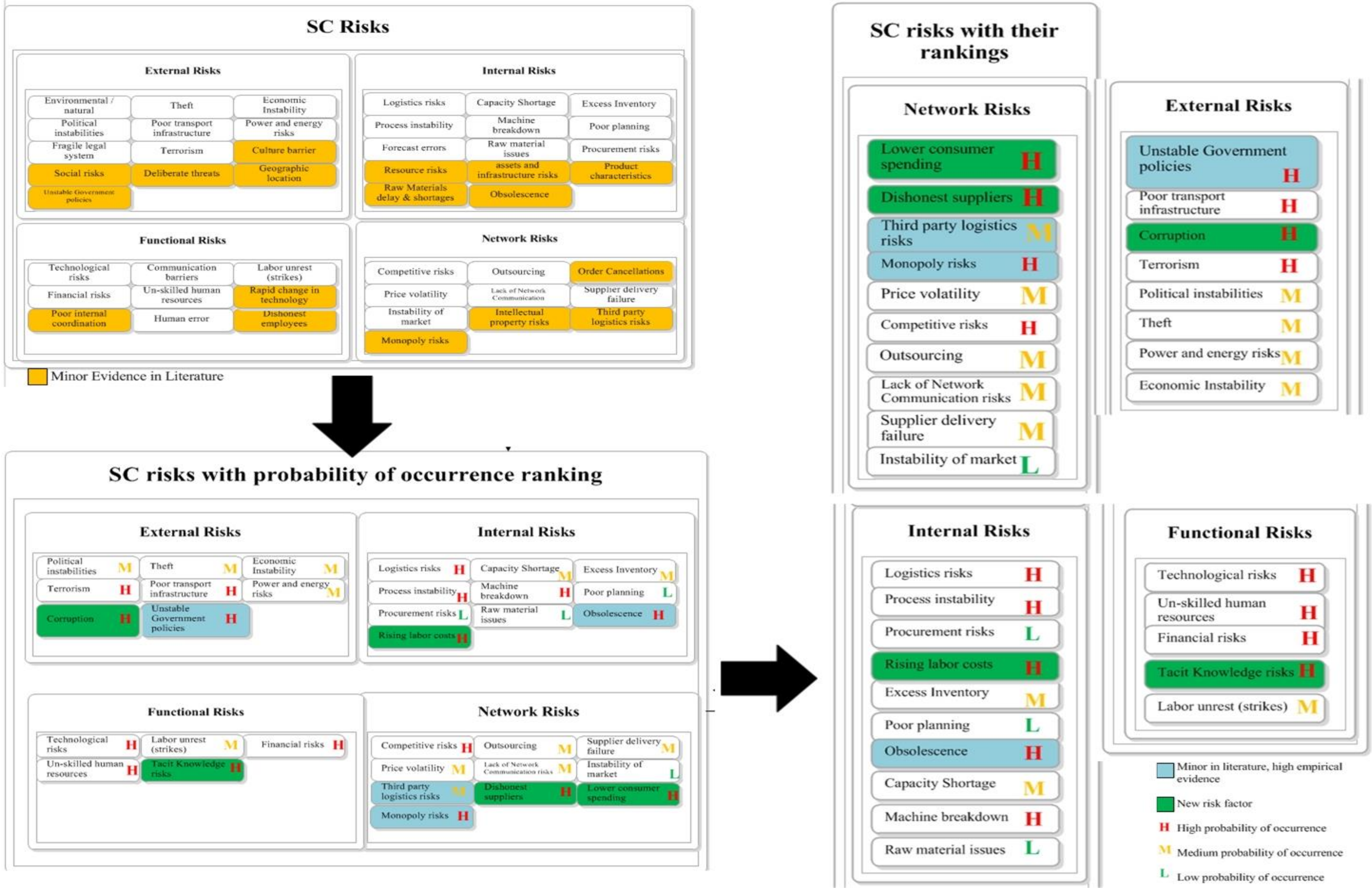

Figure 6.1: Evolution of SC risks across different research stages

As seen in Figure 6.1, during the conceptual stage, risks were categorized under the four categories; internal, external, network, and functional risks. Under the internal risks, 14 risk factors (sub-risks) were identified, 5 of the 14 risk factors were slightly expressed in the literature as shown with yellow colour in Figure 6.1. Moreover, there were 13 risk factors identified under the external risks, five of them were minorly stated in the literature as shown with yellow colour in Figure 6.1. Furthermore, 10 risk factors were considered under the network risk category, four of them were expressed minorly in the literature as shown with yellow colour in Figure 6.1. Finally, the functional risks, 9 risk factors were considered during the conceptual stage, 4 of them were expressed minorly in the literature as shown with yellow colour in Figure 6.1.

The empirical evidence from the MER context was based on interviewing 30 companies from the FMCG industry. Moreover, a holistic view of the entire chain was considered while choosing the sample based on few studies recommendations (Scholten and Schilder, 2015; Tukamuhabwa Rwakira et al., 2015; Tukamuhabwa Rwakira, 2015) to view risks with a holistic view rather than considering one entity in the chain as the analysis unit. Furthermore, the MER has not been considered in the SC resilience context. However, only a research conducted by Tukamuhabwa Rwakira et al. (2015) explored the SC threats in Uganda which has slight similar conditions to the MER.

Accordingly, as shown in Figure 6.1, the MER context has provided different findings than studies conducted in the developed countries (Jüttner and Maklan, 2011; Scholten et al., 2014; Pettit et al., 2010). Table 6.1 provides a summary of changes in risk categories from the conceptual model to the refined model (1) based on data collected from stage one in the empirical study.

Table 6.1: risk factors changed (conceptual vs. refined)

	Risk factor changed	Included in conceptual model	Literature support	Empirical support	Included in refined model
Internal risks	Forecast error	√	√	√ **Low**	**X**
	Resources risks	√	√ **Minor**	√ **Low**	**X**
	Product characteristics	√			**X**
	Assets and infrastructure risks	√			**X**
	Raw materials delay and storage	√			**X**
	Obsolescence	√	√ **Minor**	√	√ **(blue colour)**
	Rising labour cost	**X**	**-**	√	√ **(green colour)**
External risks	Environmental / natural risks	√	√	√ **Low**	**X**
	Fragile legal system	√			**X**
	Culture barriers	√	√ **Minor**	√ **Low**	**X**
	Social risks	√			**X**
	Geographic location	√			**X**
	Deliberate threats	√			**X**
	Unstable government policies	√	√ **Minor**	√	√ **(blue colour)**
	Corruption	**X**	**-**	√	√ **(green colour)**
Network risks	Order cancellation	√	√	√**Low**	**X**
	Intellectual property risks	√	**Minor**	√ **Low**	**X**
	Third party logistics risks	√	**Minor**	√	√ **(blue colour)**
	Monopoly	√	**Minor**	√	√ **(blue colour)**
	Dis-honest suppliers	**X**	**-**	√	√ **(green colour)**
	Lower consumer spending	**X**	**-**	√	√ **(green colour)**
Functional risks	Communication barriers	√	√	√ **Low**	**X**
	Human error	√			**X**
	Rapid change in technology	√	√ **Minor**	√ **Low**	**X**
	Poor internal coordination	√			**X**
	Dis-honest employees	√			**X**
	Tacit knowledge risks	**X**	**-**	√	√ **(green colour)**

Table legend: (√) included, (X) not included

Several changes have taken place in the risk factors based on the data revealed from interviews. Some risk factors were supported from the literature, but when they did not get much support empirically, such as: forecast errors, environmental risks, fragile legal system, order cancellations, communication barriers, and human error (Chopra and Sodhi, 2004; Juttner, 2005; Tang and Tomlin, 2009; Tang, 2006; Rice and Caniato, 2003; Pettit et al. 2010).

On the other hand, there were some risk factors that were included in the conceptual model during the conceptual phase that had minor evidence from the literature, and further, they did not get much support empirically too, such as: resources risks, product characteristics, assets and infrastructure risks, raw materials delay and storage, culture barriers, social risks, geographic location, deliberate threats, intellectual property risks, rapid change in technology, poor internal coordination, and dis-honest employees (Chopra and Sodhi, 2004; Finch, 2004). Eventually, all risk factors that did not gain high empirical evidence were removed from the refined model to provide a set of risk factors that were empirically supported from the industry.

Moreover, some risk factors did not get much support in the literature on SC risks, such as: obsolescence, unstable government policies, third party logistics risks, and monopoly risks (Manuj and Mentzer, 2008; Zsidisin et al., 2000; Meulbrook 2000). However, based on the empirical study, they were highly supported from the practitioner's perceptions. Although these risk factors were in in the conceptual model with yellow colour (minor evidence from literature) as seen in Figure 6.1, they remained in the refined model with blue colour with high empirical evidence.

Finally, there are few risks factors, that were not well-thought-out in the literature; such as, corruption, rising labour cost, lower consumer spending, tacit knowledge risks, and dis-honest supplier. These risk factors were added to the refined model (1) with green colour as seen in Figure 6.1.

In my opinion, the revealed risk factors specifically reflect the FMCG industry in the MER context, where not all risk factors that was investigated in the developed countries are identified in the developing countries. An example of this is the natural disasters risks which occur very frequently because of the bad weather conditions in this context, while the MER natural environment is much more stable. Thus, although this risk was perceived high in the literature, it did not get much support in the MER context.

6.2.2 Evolution of resilience capabilities across different research stages

It has been argued in the SC resilience assumed literature that capabilities considered the building block of the concept of SC resilience (Tukamuhabwa Rwakira et al., 2015; Tukamuhabwa Rwakira, 2015; Pettiti et al., 2010; Caravalho et al., 2012). Thus, the literature attempted to define different capabilities that can manage to reduce SC vulnerabilities, and it return enhance SC resilience (Christopher and Peck, 2004; Chopra and Sodhi, 2004; Juttner and Maklan, 2011; Pettit et al., 2010; Caravalho et al., 2012; Ponomarov and Holcomb; 2009). However, some researchers used the word strategies rather than capability (Zsidisin and Wagner, 2010; Tukamuhabwa Rwakira et al., 2015; Tang, 2006; Agigi et al., 2016; Manuj and Mentzer, 2008). These capabilities; such as, flexibility, capacity, efficiency, visibility, adaptability, anticipation, recovery, robustness, dispersion, Collaboration, organisation, market position, security, and financial strength would separately create a lot of value to the organisation. However, not all of these capabilities are essential, and some of them can be grouped together as one capability. Consistent with previous studies, this research aimed to identify the set of capabilities that can help anticipate and overcome risks.

After analysing the literature on capabilities that supports resilience, there were four capabilities included in the conceptual model; visibility, flexibility, Collaboration, and control as shown in Figure 6.2. Based on stage one in the empirical study, the findings revealed new capability category emerging from the findings called learning and innovation highlighted in red colour. In addition, the sub-capabilities identified are considered a novel contribution, not because they are new to the literature, but because they were identified either in different contexts other than SC resilience highlighted in yellow colour, or they were identified as main capabilities required to be resilient highlighted in purple colour.

This was consistent with Pettit et al. (2010) and Kamalahmadi and Parast (2016) recommendations for further exploration is essential on different sub-levels in industry-specific studies. Moreover, few empirical studies attempted to examine the outcomes of implementation of resilience strategies (Tukamuhabwa Rwakira et al., 2015).

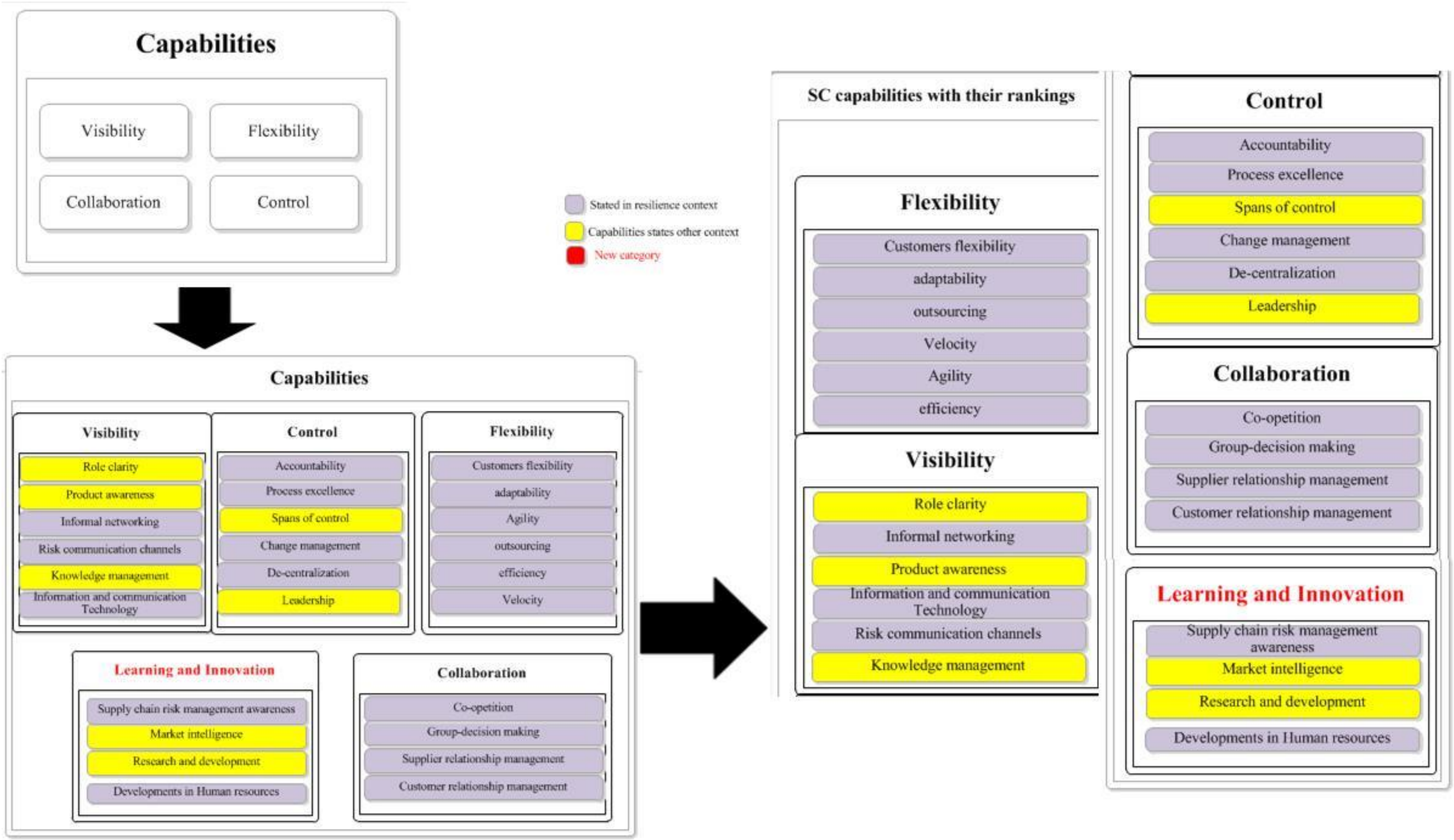

Figure 6.2: Evolution of resilience capabilities across different research stages

Thus, the findings revealed from this research should be considered in future research to consider the outcomes of their implementations on the resilience of SCs. To extend the findings revealed in stage one, AHP method was used to rank the five capability groups according to their relative importance to attain superior SC performance based on the five attributes discussed earlier. Furthermore, the flexibility was ranked the most important attribute and the visibility comes next. Apparently, these results are consistent with the literature since both capabilities were considered the most cited within the SC resilience capabilities literature (Rice and Caniato, 2003; Pettit et al., 2010; Sheffi, 2005). Thus, to make more explanation of these findings, the sub-capabilities under the flexibility and visibility were ranked too based on judgements of practitioners as shown in Figure 6.2.

Although previous studies (Pettit et al., 2010; Sheffi, 2005) provided a comprehensive set of capabilities, they did not provide their rankings based on their importance in enhancing SC resilience. For this reason, this research attempted to provide SC mangers with the most important set of capabilities. Hence, SC managers can avoid implementing capabilities that is less important before focusing on the most important first.

6.2.3 Evolution of supply chain KPIs across different research stages

Several performance measurement systems in the SC context have been proposed in the literature (Kaplan and Norton, 2001; Neely et al., 2002; Council, 2010). However, selecting the most appropriate KPIs for all the entire SC activities is not an easy task (Caravalho et al., 2012). Yet, choosing the KPIs that ensure resilience is much more difficult and needs high managerial awareness specially in an unexplored environment like the MER.

Although several researches identified the need to identify resilience metrics (Carpenter et al., 2001; Caravalho et al., 2012), they did not indicate particularly what KPIs can be used to measure resilience in SCs.

Consistent with previous research by Gaudenzi and Borghesi (2006), who argued that two principles from measurement of performance could be used in managing SC risks, it was firstly conducted that the way of measuring performance has to be connected to all members in the chain (Neely et al., 2002) Secondly, they argued that that there has to be a standardized reference model for all entities in the chain. Accordingly, this could occur by having standard KPIs to measure the SC members' processes using SCOR model or the SC Integrated Management Analysis Method (SCIMAM) (Signori, 2001). From this notion, SCOR model has been used as a reference model for the identification of the resilience KPIs. To do this, the resilience definition used in this research along with the data collected from the interviews have been considered to be able to refine and shortlist them to be transformed to their most equivalent SCOR level two KPIs instead of having different names to SC KPIs although some of them have similar calculations but different naming. Based on the transformation of the companies' SC KPIs to level two SCOR KPIs, the data revealed 27 level two KPI considered to be resilient KPIs.

Arguably, only few studies adopted SCOR model in the SC risks context, such as a study conducted by Diehl and Spinler (2013) who adopted the SCOR model to map the risks in each SC process in FMCG based on the five processes that SCOR define (plan, source, make, deliver, and return). However, this research is considered different than the research conducted by Diehl and Spinler (2013), since the main reason of adopting the SCOR was to find a reference model that provides standard KPIs to measure how resilient is the SC.

The SC performance attributes and SC level one KPIs were prioritized using AHP interview based in stage two of the empirical study. Prioritizing of the SC performance attributes, and level one SC KPIs has extended the findings of stage one. Though, prioritizing SC KPIs is not a new concept (Elgazzar, 2013), it is a new concept in the SC resilience context.

Moreover, there are several researches that have adopted AHP method for prioritisation of SC measures using multi-criteria to enable decision-makers to meet their strategic objectives (Chan and Qi, 2003; Perera et al., 2013; Elgazzar, 2013).

This research was able to prioritize the five SC performance attributes and the 10 level one SC KPIs discussed earlier. Thus, SC managers know preciously what attribute is more important to ensure resilience in SCs. Moreover, the findings of the AHP hierarchy to rank the level one KPIs in respect to their importance to the five SC attributes revealed that there are new links discovered between an attribute and a KPI, which are not decomposed from this attribute although these links were not considered in the SCOR literature as seen in Figure 6.3.

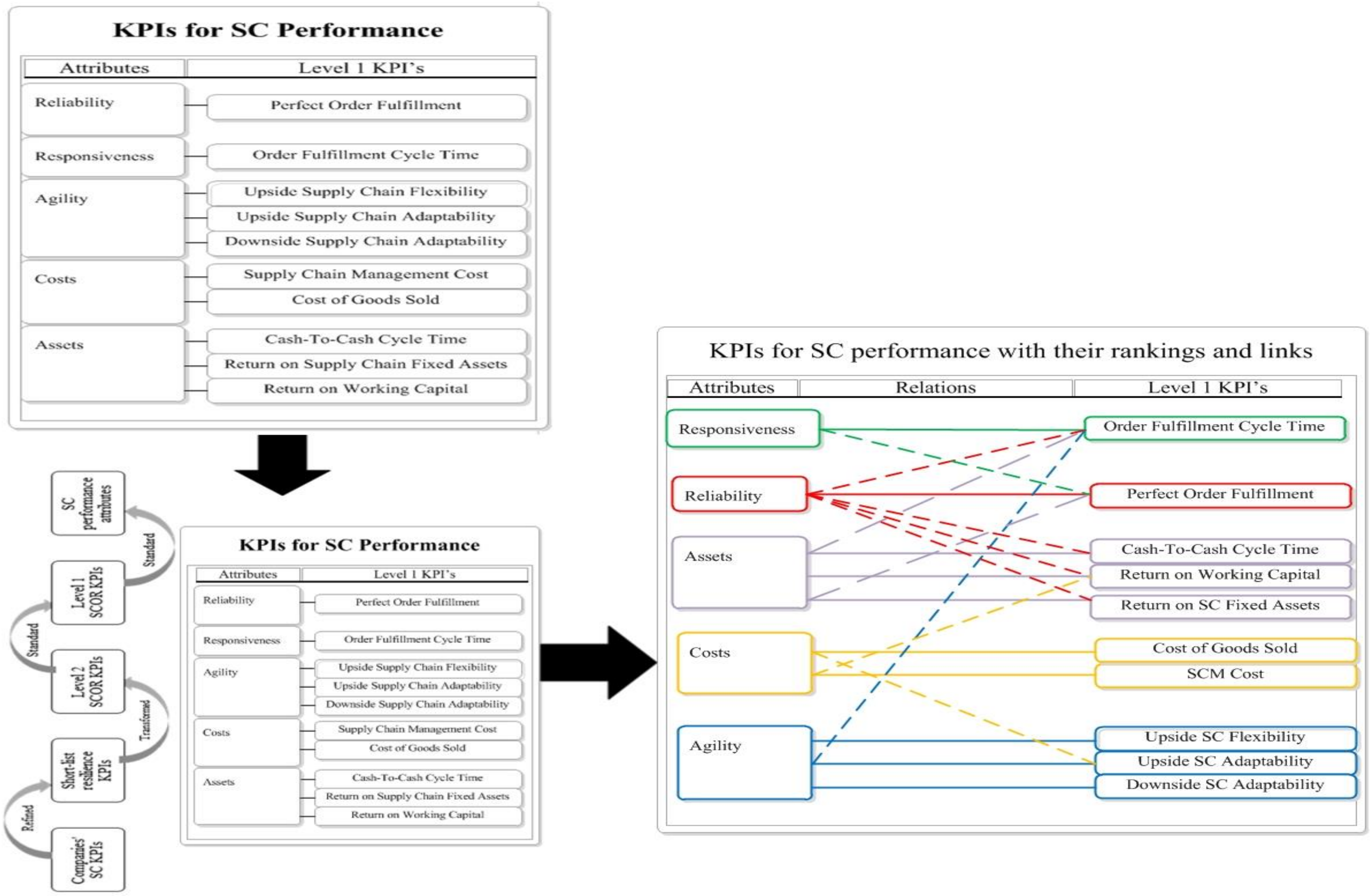

Figure 6.3: Evolution of SC KPIs across different research stages

6.3 Supply chain resilience constructs prioritisation

Several authors used AHP methodology as a decision tool in SC risk management literature. Badea et al. (2014) used AHP to assess risks and the alternatives that assists SC managers. Gaudenzi and Borghesi (2006) used AHP to rank the risk factors relative to the SC objectives for a medical company SC case. Liu (2014) applied AHP to create a risk assessment framework carrying the characteristics of chemical SCs. Wu et al. (2006) created an AHP structure to give ranking to inbound risks that faces suppliers in the SC. Rajesh and Ravi (2013) used AHP to identify and rank the important factors that enhance SC coordination. Thus, consistent with previous studies that acknowledged the using of AHP method to rank multi-criteria in supporting decision makers, this research used AHP to select the most important risks, capabilities, and SC KPIs for enhancing resilience.

This research was able to prioritize the five SC attributes (reliability, responsiveness, agility, cost, and assets), the four main risks categories (internal, network, external, and functional), the five capabilities (visibility, flexibility, Collaboration, control, and learning and innovation), and the ten level one SC KPIs adopted from SCOR model (perfect order fulfilment , order fulfilment cycle time, upside SC flexibility, upside SC adaptability, SCM cost, cost of goods sold, cash-to-cash cycle time, return of SC fixed assets, and return on working capital).

Furthermore, the results from ranking the level one SCOR KPIs revealed a novel contribution to this research in identifying new links between the SC performance attributes and their relevant level one SC KPIs adopted from SCOR model. However, these findings are based on subjective inputs that need to be further tested quantitively to give more support to the discovered links.

6.3.1 Interrelations between risks, capabilities, and KPIs

Several researches proposed a proposition that there is a relation between capabilities and risks (Pettit et al., 2010; Carvalho et al., 2012), and that SC managers are exerting efforts to reduce vulnerabilities that cause deterioration in the entire chain performance (Hendricks and Singhal, 2003). However, Sheffi (2005) argued that identifying risk factors and capabilities are not enough because the disruptions occur brings unexpected negative consequences on SC performance. Thus, Tukamuhabwa Rwakira et al. (2015) drew a conclusion remark based on the research findings that risks and capabilities are interrelated in the sense that the capabilities employed may produce negative consequences in the form of new vulnerability in any point in the entire chain. Pettit et al. (2010) went a step forward by proposing certain propositions assuring that when extreme risks exceed the capabilities employed, this in turn will increase SC vulnerabilities, which will affect profitability. Thus, when the risks and capabilities are managed, improvements will be significant on SC performance.

Following the assumptions discussed by Pettit et al. (2010), this research attempted to explore the interrelation between risks, capabilities, and KPIs specifically in the FMCG industry in the MER context by developing matrices to investigate these relations. The first matrix is the risks/KPIs matrix to demonstrate the interrelations between different risk factors investigated during the data collection and the SC KPIs that ensure resilience. While the second matrix is the capabilities/KPIs matrix to demonstrate the effect of implementing the identified capabilities on enhancing performance is measured by SC KPIs to ensure resilience. Whereas the third matrix is the capabilities/risks matrix, which is designed to investigate the effect of implementing the identified capabilities on eliminating risks that causes SC vulnerabilities to ensure resilience.

The findings revealed from the matrices enable SC managers to understand which capability attempts to improve which risk factor, which risk factor affect specifically which KPI, and also, which KPI can be used to measure which risk factor, and finally, which capability can be employed to enhance which KPI. Table 6.2 provides a comparison between the conceptual model, refined model (1), and refined model (2) for SC resilience in the MER.

Table 6.2: Comparison between conceptual model, refined model (1), and refined model (2)

	Point of Comparison	Conceptual model	Refined model (1)	Refined model (2)
1	**Starting point**	- The un-stable conditions facing MER - Literature review on SC resilience constructs	Conceptual model	Refined model (1)
2	**Road-map**	Literature review main areas: • SCM • SC risk management • SC resilience • SC resilience constructs • SC performance measurement systems	- Assign companies - Develop interview template - Conduct semi-structured interviews - Data analysis: thematic and comparative analysis. - Refining the conceptual model - Constructing matrices to investigate relations between risks, capabilities, and KPIs. - Validate matrices	- AHP hierarchies developed for risks, capabilities, and KPIs - AHP interview template developed -Pairwise comparisons conducted - AHP steps conducted - AHP results verified using Expert Choice - AHP hierarchies developed for top 2 ranked risks and capabilities. - AHP interview template developed - Pairwise comparisons conducted - AHP performed using Expert Choice - Developing final version of the model
3	**Methodology used**	literature review	- Semi-structured interviews - Thematic analysis - Comparative analysis	- Structured interviews - AHP method
4	**Sample**		30 FMCG companies in MER	30 FMCG companies in MER
4	**Gaps**	Investigate SC resilience constructs in MER context	Setting priorities to extend the findings	Refer to limitations and recommendation for future research in Chapter 7
	Risks	**- 4 categories:** • Internal risks: • External risks: • Network risks: • Functional risks:	**- 4 categories with sub-risks ranked based on their probability of occurrences** • Internal risks: • External risks: • Network risks: • Functional risks:	**- 4 categories ranked based on finding of AHP.** 1. Network risks 2. External risks 3. Internal risks 4. Functional risks **- Sub-risks of the top 2 risks ranked based on AHP.**
	Capabilities	**- 4 categories:** • Visibility • Flexibility • Collaboration	**- 4 categories with sub-capabilities:** • Visibility • Flexibility • Collaboration	**- 4 categories ranked based on finding of AHP.** 1. Visibility 2. Flexibility

		• Control	• Control • Learning and Innovation	3. Collaboration 4. Control 5. Learning and Innovation **- Sub-capabilities of the top 2 risks ranked based on AHP.**
	KPIs	**- Adopted SCOR SC performance attributes: Reliability, responsiveness, agility, cost, and assets.** **- Adopted SCOR level 1 KPIs that measures SC performance attributes:** • Reliability: perfect order fulfilment. • Responsiveness: order fulfilment cycle time. • Agility: upside SC flexibility, upside SC adaptability, and downside SC adaptability. • Cost: SCM cost and cost of goods sold. • Assets: cash-to-cash cycle time, return on SC fixed assets, and return on working capital.	**- Collected companies' SC KPIs.** **- Refine collected KPIs based on resilience definition** **- Transform refined KPIs to relevant SCOR level 2 KPIs.** **- Place level 2 KPIs under every level 1 KPI** Level 2 KPIs adopted:	**- SC performance attributes ranked based on practitioner's judgements using AHP:** 1. Responsiveness 2. Reliability 3. Assets 4. Costs 5. Agility - SC level 1 KPIs ranked based on practitioner's judgments in relation to SC performance attributes:
	findings		- Exploring SC risks from MER context specifically in FMCG industry - Ranking risk factors based on its probability of occurrence - Investigating different capabilities that ensure SC resilience - Investigating companies' KPIs that ensure resilience - Using SCOR model as a standard reference model to define SC KPIs for resilience	**- Providing:** • Ranking to the 5 SC performance attributes based on their importance in enhancing resilience. • Ranking to the 4 main risks categories • Ranking the risk factors (sub-risks) for the top 2 ranked risk categories • Ranking to the 5 capabilities categories

				• Ranking to the sub-capabilities for the top 2 ranked capabilities categories. • Ranking to the 10 level 1 KPIs based on their relative importance to the 5 SC performance attributes. **- Discovering new links between SC performance attributes and the level 1 KPIs**
	Outputs	Conceptual model for SC resilience in the MER for FMCG industry	Refined SC resilience model (1) for SC resilience in the MER for FMCG industry	Refined SC resilience model (2) for SC resilience in the MER for FMCG industry

The foregoing table attempts to give a summary to the evolution of the model between the different stages of this research in respect to: the starting point, roadmap, methodology used, sample size, gaps, risks, capabilities, KPIs, and findings.

6.4 Validation

Throughout the research conducted, it has been possible to validate the SC resilience model for FMCG in MER. Enumerating all SC resilience constructs (risks, capabilities, and KPIs) and the interrelations between them – based on the empirical data collected and analysed – is considered a step forward in the SC resilience area of research. Nevertheless, once the analysis was completed, the researcher prepared a validation set of questions – including the final version of the SC resilience model for FMCG companies in MER – (see **Appendix 14**) and interviewed five SC managers – from the previously selected companies – who were chosen based on the researcher's experience with the interviewees within the data collection process. The five SC managers agreed with the findings of the research presented in the SC resilience model and also provided three important recommendations to be considered. First, the model have to be implemented be able to measure the impact of implementing the proposed capabilities on eliminating risks that causes vulnerabilities which will in turn enhance the resilience of SCs. Second, the interrelations between risks, capabilities, and KPIs have to be tested during the implementation process on the SC resilience model to monitor any relations that needs to be considered. Third, the new links between the SC performance attributes and level 1 KPIs adopted from the SCOR model have to be tested quantitively to give further validation to these links. Thus, due to the research limitations, there is a great potential to shift them into further research recommendations.

6.5 Conclusion

This chapter discussed how far the literature is consistent or not with the findings revealed from the empirical study which is conducted in this research. It also demonstrates how the three SC resilience constructs have been changing during different phases of the research; from conceptualization phase, to stage one, and then to stage two of empirical study. Exploring the risk factors that cause SC vulnerabilities in the FMCG industry in the MER context is considered a novel addition to the SC resilience field of research (see Figure 6.1). Nevertheless, introducing certain managerial capabilities from different contexts will give more enhancements in improving resilience (see Figure 6.2). Moreover, having a standard set of resilience KPIs adopted from a standard validated model (SCOR) would help SC managers to measure the negative effects caused affecting each process in the entire chain (see Figure6.3). Additionally, discovering new links based on practitioners' perceptions can be arguably considered a novel contribution of the present thesis. Owing to the concept established in the literature that risks, capabilities, and performance are interrelated with each other, matrices were developed to investigate these relations. Finally, it discussed the idea of prioritizing risk, capabilities, and KPIs and illustrates the use of these priorities for enhancing SC resilience.

Chapter seven: Conclusions

7.1 Introduction

The main aim of this research was to create a resilience model for SC in the FMCG industry in the MER context. The motivation behind this aim was the lack of empirical researches on SC resilience in the literature compared to those conducted concentrating on the resilience concept from the developed countries perspective. However, the MER has a significant role in the global economy and in sequence has a role in the global SCs. Therefore, there has been an urgent need to explore the main constructs to build resilience in SCs from the MER context. This would be achieved by investigating all the risks that face FMCG companies in the MER and rank them. Moreover, important capabilities are also being investigated and ranked. Finally, KPIs that can be used to measure FMCG SC resilience are examined. This chapter offers an overview across all stages of the research, drawing a conclusion across all stages of the research, put differently, how the research questions were answered through the empirical findings from stage 1 and stage 2 of empirical study, and how the research gaps were filled and supported. Furthermore, the theoretical and managerial implications of the research findings, the limitations of the research and the further areas of research will be deliberated.

7.2 Conclusions across all stages of the research

Looking at the whole research in one picture is very important to discuss how the research addressed the research questions and tie the gaps found in the literature by contributing to the SC resilience knowledge. Figure 7.1 authenticates conclusions of all the phases of this research.

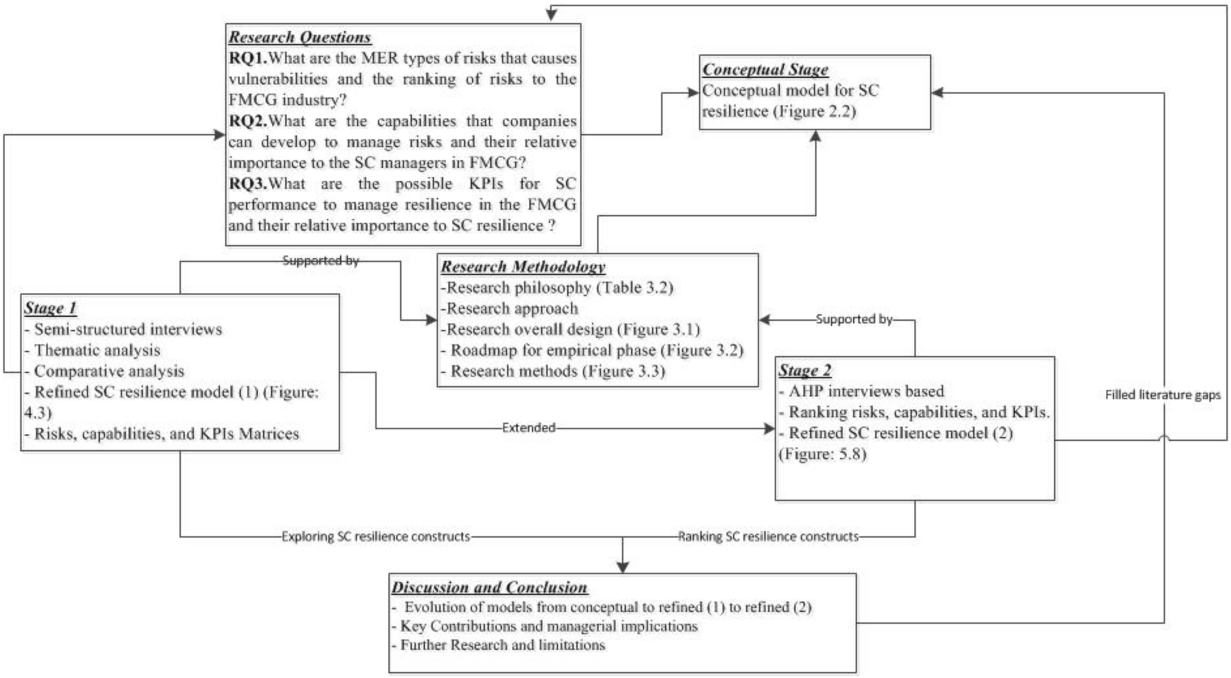

Figure 7.1: Conclusions of all phases of this research

The contributions of this research are based on three research questions formulated to fill the gaps in the literature identified earlier:

1. What are the MER types of risks that cause vulnerabilities and the ranking of risks to the FMCG industry?
2. What are the capabilities that companies can develop to manage risks and their relative importance to the SC managers in FMCG?
3. What are the possible KPIs for SC performance to manage resilience in the FMCG and their relative importance to SC resilience?

At the beginning of the research, after reviewing the literature review, a conceptual model for SC resilience was developed as a base to start the empirical study. A qualitative approach was taken to assess the conceptual model in the FMCG industry in the MER. The empirical study was supported by the research overall design (see Figure 3.1), roadmap for empirical phase (see Figure 3.2), and the research methods (see Figure 3.3) addressed and justified in chapter 3 (research methodology chapter).

Stage one of empirical study aimed at answering the first part in the three research questions by exploring the SC resilience constructs in FMCG industry in the MER context. Those constructs are: risks that cause vulnerability (see Table 4.2), capabilities to enhance resilience (see Table 4.4), and SC KPIs to measure risks and enhance entire SC performance (see Table 4.6). An initial ranking of SC risks was conducted based on a qualitative ranking which was developed based on the interviewees opinions concerning the probability of occurrences of those risks that will be extended in the next stage in empirical study to present reliable results (see Table 4.3). Each interviewed manager identified the risk factors that affect the processes performed by his company. This evaluation helped in understanding the impact of these risk factors based on its probability of occurrence inside the company and along the entire chain.

Furthermore, the analysis performed on the SC KPIs addressed how the SCOR model was used as a reference model to standardize the SC KPIs (see Figure 4.2). The key output of this stage is the refined SC resilience model (1) (see Figure 4.3). Further, three matrices were developed based on the empirical data to identify the interrelations between the three constructs (see section 4.7).

Stage two of empirical study was considered an extension of the findings of stage one. All the three SC resilience constructs investigated were ranked based on perceptions of SC managers working in FMCG industry in MER. AHP method was adopted to rank the four risk categories, five main capabilities and ten level one SC KPIs based on the five SC performance attributes (reliability, flexibility, agility, cost, an assets) to specify a preference for each decision alternative using each criterion. Each SC manager interviewed showed different standpoints in the evaluation, depending on the scope of SC processes performed in the company and the company's role in the entire SC involved.

The findings of the AHP analysis were extended by ranking the sub-risk factors of the top two risk categories (network and external risks), and ranking the two-most important capabilities categories (flexibility and visibility) based on pairwise judgements of interviewees. Moreover, the findings from the AHP revealed new relations between the five SC performance attributes defined by SCOR (reliability, responsiveness, agility, cost, and assets) and level one SCOR KPIs that has been used as a standard for SC resilience KPIs.

Finally, a new version of the SC resilience model was developed based on the findings of stage two of empirical study to answer the second part of the three research questions addressed by providing definite guidance to SC resilience with the relative importance of all factors under the three SC resilience constructs (see Figure 5.16)

The next section will provide a pinpoint on both the key theoretical contribution and managerial implications based on findings of this research.

7.3 Theoretical contributions

The current research findings revealed several theoretical contributions that will be addressed under the following propositions:

First, the findings discovered that the most important SC resilience constructs that will have a great impact on enhancing SC resilience for the FMCG companies operating in the MER. These findings were empirically evidenced from developing countries context based on analysis of the SC risks, capabilities, and KPIs with a holistic view from all SC members, rather than focusing in a single firm or entity as the scope of analysis. Among the 28 risk factors identified from the findings, five were new from the MER context. They are corruption, lower consumer spending, rising labour cost, tacit knowledge risks, and dis-honest suppliers. A new capability category emerged from the findings, called learning and innovation. In addition, the sub-capabilities identified are considered to be a novel contribution, not because they are new to the literature, but because they were identified either in different contexts other than SC resilience, or because they were identified as main capabilities required to be resilient.

Second, it has been argued that there is a direct relation between risk and performance (Knight, 1921; Lonsdale and Cox, 1998). However, having a standard performance measurement system with standard SC KPIs to measure the risks were still ambiguous. This research overcome this draw-back by adopting the SC KPIs from the SCOR model as standard KPIs as being resilience KPIs to monitor the performance of KPIs related to the company itself, and the performance of other SC partners (such as: suppliers, third-party logistics). By monitoring those SC KPIs and comparing the results of the values within a particular time horizon, the company can trigger the risk in case of any noteworthy deviation appears than the pre-defined values designated. This can be achieved by deciding the associated process that is diagnosed with the relevant level 2 KPIs (Council, 2010). For example, if there is a problem in the perfect order fulfilment KPI, this means that there is something wrong, thus, a risk is approaching one of the SC activities. For this reason, by being able to detect those KPIs that ensure resilience would change them from being normal KPIs measuring the SC processes to predictive KPIs to sense any change for the entire SC processes across all chain partners.

Third, this research developed a SC resilience model for SC resilience in the MER context which assembles the risk factors causing vulnerabilities, the capabilities required to be resilient, and the SC KPIs that would ensure SC resilience. Most of the previously conducted studies in the literature (Zsidisin and Wagner, 2010; Pettit et al., 2010; Sheffi, 2005; Ponomarov and Holcomb, 2009; Christopher and Peck, 2004) focused only on identifying the risk factors, and enhancing the SC capabilities. While other studies (Sevensson, 2002; Juttner, 2005; Zsidisin,and Ellram, 2003; Juttner and Peck, 2003) showed that risks causing vulnerabilities affect SC performance. However, the SC resilience models proposed did not address the three factors together in a single model (risks, capabilities, and KPIs), and the interrelations between them. Thus, the model proposed in this research and the matrices developed attempted to explore the relationships between risks, capabilities, and KPIs from practitioners' perspective. The reason behind this is that SC resilience cannot be attained by focusing on the individual perspectives and concepts without considering the interactions between them (Ponomarov and Holcomb, 2009).

Fourth, even though risk factors ranking is not a new concept in the SC risk management context (Gaudenzi and Borghesi, 2006; Levary, 2007), it is a new concept in the SC resilience context. Moreover, ranking the capabilities that enhance SC resilience is a new concept in the SC resilience construct. Several studies that addressed capabilities did not propose any ranking to these capabilities, in other words, which capabilities should the company focus on attaining first based on their importance to mitigate risks that cause SC vulnerabilities, and in return, enhance SC overall performance for the entire chain. As for the risks, several studies (Gunasekaran et al., 2001; Bigliardi and Bottani, 2010; Bhagwat and Sharma, 2007) attempted to prioritize SC KPIs, moreover, several studies (Chan and Qi, 2003; Perera et al., 2013; Elgazzar, 2013) used AHP to rank SC KPIs with the multi-criterion nature in them. However, non-of these studies strived to rank SC KPIs in the SC resilience context that involves SC managers in creating a thorough reflection of the interdependencies while exerting efforts to enhance resilience. Hence, the empirical findings reveal precisely all relevant decision priorities that need to be adopted to enhance SC resilience in the MER context, in other words, what are the KPIs needed to be monitored, what are the capabilities exactly needed to be enhanced, and what risks exactly have to be considered rather than focusing on the least important.

Fifth, following the assumptions discussed by Pettit et al. (2010), this research attempted to explore the interrelation between risks, capabilities, and KPIs specifically in the FMCG industry in the MER context by developing three matrices to investigate these relations. The three matrices (risks versus KPIs, risks versus KPIs, and capabilities versus KPIs) will enable SC managers to understand which capability attempts to improve which risk factor, which risk factor affect specifically which KPI, and, which KPI can be used to measure which risk factor, and finally, which capability can be employed to enhance which KPI.

Sixth, as stated earlier, identified five SC performance attributes (reliability, responsiveness, agility, cost, and assets) that consist of a group of level one KPIs for measuring the performance of SC processes. Moreover, the SCOR indicates that every level one KPI under any of the five attributes is considered to be the most important KPI to achieve this attribute. In other words, under the reliability attribute, there is one level one KPI named perfect order fulfilment that is considered the most important KPI for this attribute. However, the findings revealed – after setting an AHP hierarchy to rank the level one KPIs with respect to their importance to the five SC performance attributes – that is, there are new links discovered between an attribute and a KPI, which are not decomposed from this attribute. These findings were supported from practitioners' point of view. However, the links discovered were variable, some were high and some were low. For this reason, only relations revealed from the AHP pairwise comparison over 10% were considered and embedded in the final version of the SC resilience model (see Table 5.23). These links would enable SC managers to focus on the new contribution to improve the standard metrics adopted from the SCOR model. For example: to improve responsiveness, SC managers should monitor and improve "Perfect Order Fulfilment" (new contribution) beside "Order Fulfilment Cycle Time" (the main matric by SCOR model) to enhance the SC performance of the entire chain.

7.4 Managerial implications

Besides the theoretical contributions discussed, this research has a number of contributions to SC managers in the FMCG industry in the MER who are looking forward to making their SCs more resilient.

First, the research classifies the risk factors under four main risk categories to enhance the understanding of them based on empirical evidence from the industry and context where they operate. Moreover, the findings reveal different risks with a holistic view, rather than focusing on a company, or a specific activity as a base of analysis as suggested by Tukamuhabwa Rwakira et al. (2015). Thus, managers and practitioners can easily understand different risks that their partners in the chain face to be able to take any actions proactively rather than just responding to the threat when the risk is migrated within the SC.

Second, consistent with Pettit et al. (2010), the findings enlighten SC managers with the most important capabilities that should be employed to enhance resilience in their SCs. To achieve this, the research proposed sub-capabilities under each of the 5 main capabilities groups to present a clear road map for practitioners to cope with different risk factors, and in return, maintain a competitive advantage over the SCs that are less resilient (Kamalahmadi and Parast, 2016; Pettit et al., 2010).

Third, the research attempted to provide a standard set of SC KPIs with different levels (level 2, level 1) based on a well-known, pre-defined, and validated standard, which is the SCOR model. Nevertheless, this in turn will help to overcome any overlap in SC KPIs serving the same needs but from different standpoints (Signori, 2001).

Fourth, the proposed SC resilience model for FMCG in the MER is considered to be the first model dedicated to resilience context in the MER operating in a specified industry. The model proposes the interrelations between risks, capabilities, and KPIs based on the matrices developed (risks versus capabilities; risks versus KPIs; KPIs versus capabilities) rather than focusing on risks or capabilities in an isolated matter (Pettit et al, 2010). As an example, the risks vs. KPIs matrices show specifically which risk affect which KPI based on empirical study conducted on 30 FMCG companies. Furthermore, SC managers can link the capability to the main risks causing vulnerability to the SC processes.

Thus, the research contributions have several potential real-life impacts on the FMCG SCs in MER that can be concluded under four noteworthy arguments: (1) Increasing visibility between all SC partners that will assist SC managers to take proactive decisions regarding SC risks that causes vulnerabilities. (2) Enhancing the velocity and flexibility of SCs will enable SC managers to rapidly detect causes of SC risks by monitoring the resilience KPI and in turn enhancing the appropriate capability to overcome any disruption. (3) Standardization of SC resilience KPIs – by adopting the SCOR model standard metrics as resilience KPIs to sense any change for the entire SC processes across all chain partners – will have a significant impact on increasing the resilience of SCs. (4) Enumerating all SC resilience constructs (risks, capabilities, and KPIs) in FMCG with their relative importance to SC managers in a one stop model, which practitioners can adopt to enhance decision making in the MER.

7.5 Research limitations

Though this research makes significant theoretical contributions to theory, as well as the managerial implications to SC managers and practitioners, the limitations of the research also need to be well-thought-out. The limitations of this research are as follows;

- Even though the qualitative approach, which is adopted to conduct the empirical study of this research, was seen more relevant than a quantitative approach owing to the exploratory nature of the research conducted, the findings revealed from the empirical study is restricted to MER FMCG industry. Its research findings; as a result, may not be directly applicable to any other industries in the region or in the FMCG industry in a different region.
- The interrelation between the SC resilience constructs was based on subjective inputs, which can be further validated by employing objective inputs to be quantitatively tested to provide further validation to the revealed results.
- The new links discovered between the SC attributes and the level 1 SC KPIs were based on the subjective opinions of the interviewees who participated in the empirical study. Thus, these links need more analysis based on quantitative approaches to test whether these links are significant or not.
- Although this research aimed at developing a model of SC resilience in the MER, the

findings after implementation this model need further investigations. This is due to the cross-sectional disposition of the research, which limits the understandings of the implementation of the SC resilience model. Thus, a longitudinal research may be useful to further investigation on the implementation of such model to enhance resilience.

- The AHP interview sample consisted of 30 companies in total. If the sample included more companies, this may have changed the rankings of the resilience constructs.

7.6 Recommendations for further research

Based on the limitations highlighted above, there is a great potential to shift them into further research recommendations as follows:

- Quantitively testing the impact of implementing the SC resilience model proposed on enhancing the resilience of FMCG SCs in the MER.
- Quantitatively testing the interrelations revealed between the three SC resilience constructs would help in giving further validation to this research findings.
- Investigating the applicability of the SC resilience model in either a different industry in the same region, or on the same industry in another region. This can be done using the same interview template by conducting semi-structured interviews to compare and contrast the findings with the findings revealed from the research.
- The rankings of the applied to the resilience constructs can also be performed based on the findings that will reveal from applying the model in other region or on other industry. Accordingly, there will be an opportunity to compare and contrast the ranking of risks, capabilities, and KPIs in different disciplines.
- The new links discovered between the SC attributes and the level 1 SC KPIs need to be tested quantitatively.

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Appendices

Appendix 1: Interview questions

General questions:

- What is the scope of your business? Tell me about your work in general.
- Can you tell me about your products?
- What is the company's current situation in the market?
- What is the company's main field of production?
- What is the size of your company?
- What is your job title?
- Where is the company's production plants located? (Which countries?)

Supply chain questions:

- Do you have supply chain department in your company? If no, then why?
- If yes, how was your company's supply chain activities developed historically?
- Do you have a supply chain map encompassing all the different activities? Can you give me an overview of the supply chain map of the company?
- What is your supply chain strategy? (Cost leadership- differentiation)
- What is your SC network consisting of? (Material flow, info flow, supplier's network)
- Is your SC vulnerable both upstream and downstream? How?
- What are the causes of vulnerabilities?

Purchasing questions

- Do you prefer to single or multiple sources?
- Do you dual source? And if yes for which parts, and the reasons that you choose dual sourcing?

- Do you have a list of alternative suppliers you can refer to in case a supplier becomes idle?
- Do you reserve extra capacity or redundancy in certain supplier's plants so you can handle demand variations?
- How to you distinguish a critical from a non-critical part?

Warehousing

- How many warehouses are there; Reasons for this?
- If a warehouse catches on fire or it is destroyed partly by a storm or flooding, what are the contingency plans?
- During the weather changing which areas were affected and how did you respond? Was it a reactive response, or you already had proactive plans in place?

Planning

- Which are the critical capacity constraints in the supply chain and how do you deal with them
- Do you implement stockpiling (maintain inventory of critical parts and equipment) in order to succeed quick response if a disruption happens?

Logistics questions

- Transportation used from suppliers to the company; Transportation providers?
- When a disruption occurs, how do you normally act and difficulties dealing with it?

Supply chain risks questions

- What are the sources of risks that affect your SC?
- Is there is any contingency plans or personnel responsible for dealing with those risks? How?

- What are the managerial capabilities and strategies employed (or should be employed) to avoid risks and build a resilient supply chain?
- What are the tools used to identify SC risks? (Brain storming, SWOT, scenario analysis…)
- What is the risk management plan the company follows? (Avoidance, mitigation, transfer, acceptance)
- How does the company assess SC risks?
- What do you see as the biggest risk/s to your supply chain? Can you rank them?
- How often do you review your Business Continuity requirements with key suppliers and their capability to meet them?
- How do you seek minimize our supply chain risks and spread these amongst our supply chain stakeholders? Do we use insurance to reduce risk?

Risk questions

- How do you conceptualize risk? Do you perceive any distinctions between risk and disruption?
- What types of disruptions your company is mostly concerned with?
- Do you categorize risks? If yes, what type of categorisation and why?
- What approaches do you use in identifying, assessing (cost-benefit, risk-map matrix), managing and monitoring risks?

Resilience

- Are you aware about the concept of supply chain resilience? What do you know about it?

- How do your company work on improving the response to the external disturbances, the detection time of risks and maintaining Supply Chain performance, and Supply Chain resilience?
- What are the company Capabilities that may ensure the resilience of a Supply Chain?
- What KPIs you employ to manage you supply chain?
- What are the KPIs in your company that can ensure the resilience of a Supply Chain?
- What are the proactive resilient KPIs that would be implemented or already implemented by the company?
- What are the obstacles that faces the companies operating in the MER to be resilient? (What do you think different in MER that USA, Europe, etc.)

Appendix 2: Companies background

SN	Company	Category	Country	Company Size	Level of Experience	Type	Logo
1	Americana – Olives (ECC)	Food	Multinational	Medium-sized Form 50 to 249 Emplyee	More than 10 yeares	Manfacture	
2	Americana – Cake	Food	Multinational	Medium-sized Form 50 to 249 Emplyee	More than 10 yeares	Manfacture	
3	ARMA	Food	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
4	P&G	Home and Personal Care	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
5	Unilever	Food and Personal Care	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
6	Farm Frites	Food	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
7	HAMA	Agriculture	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
8	Carrefour	Retail	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Retailer	
9	Ragab Sons	Retail	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Retailer	
10	Al-Otaim	Retail	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Retailer	

11	SEKEM Group	Agriculture and Medicinal Herbs	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
12	Edita Food Industries	Food and Bakery	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
13	The Coca-Cola Bottling Co. of Egypt	Beverage	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
14	Juhayna Food Industries	Dairy	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
15	Kraft Foods Egypt	Dairy	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
16	ISIS For Food Industries	Medicinal Herbs	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
17	Cook Door	Fast Food	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
18	Mo'men	Fast Food	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
19	Pepsi Egypt	Beverage	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
20	Almarai	Dairy	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
21	*President Cheese*	Dairy and Cheese	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
22	Beyti	Dairy	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	

23	La vache qu rit	Dairy and Cheese	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
24	Hyper One	Retail	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Retailer	
25	Chipsy	Food	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
26	Domty	Dairy and Cheese	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
27	Lactel	Dairy	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
28	Savola Group	Food	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
29	Cadbury	Food	Multinational	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	
30	Al Watanya	Food	Local	Large-sized Greter than 249 Emplyee	More than 10 yeares	Manfacture	

Appendix 3: Risks data structure table

Risks Data Structure		
First Order Codes	Second Order Themes	Aggregate Dimensions
"...sometime, the factory is totally stopped because a small ingredient of the final product is missing…" *"…. we usually send to our suppliers the purchase orders a time ahead. However, when the agreed time of delivery isn't met, our purchasing manager starts expediting the order"*	Raw delays and shortages	**Internal**
… the quality department inspects any raw materials enter the warehouse strictly in order to eliminate any potential quality risk from the origin…"	Raw materials issue	
"…we may discover that the shipment is in the port waiting for our customs department to clear it out for more than 2 weeks and he isn't aware…" *"...we don't have any mean to trace our trucks."* *"…the mistake we fail in is that we select our 3PL without gaining much information about this company, we only want to go for the lowest cost………......then find ourselves paying more costs later…"*	Logistics risks	
"…we are working based on the sales and operations plan…. we may find by accident that a lot of changes have been made to the plan without any prior notice to us…. because we have limited capacity, in most cases we cannot fulfil many customer's orders on time..."	Capacity shortages	
"…doing everything in the last minute is the worst thing in management……….so orders are placed late, as a result materials arrive late, and this affects production and ………."	Poor planning	
"usually multi-national companies don't have the control over a great percent of our core materials used in the manufacturing process. We have to send to the head office in the home country the purchase order and they complete with the process…". *"it happens very often to find a specific packing material ordered by the two-line managers in the factory. It ends with having piles un-used in the stocks……… However, if there has been some sort of communication, we would cut unnecessary expenses and we can get quantity discounts too"*	Procurement risks	
"…we try always to minimize our inventory level specially for finished products………as a result, we faced a big trouble during the last 3 months when we weren't able to get raw materials from our supplier abroad due to the lack of foreign currency problem…… I think we have to learn from this and at least keep 3 months' stock for any uncertainty that may happen…"	Excess inventory	
"…there are several reasons of having machine breakdowns, such as: electricity shutdown, poor maintenance, lack of spare parts, bad fuels……. this will lead to at least 10 days till we get the spare part from suppliers outside…" *"…machine breakdown is one of the toughest risks that we may face….it affects our production schedule for long time and consequently affects adversely the entire chain…"*	Machine break down	
"...our internal SC processes are affected by any delay in raw materials delivery, any spare part shortages, any breakdown or failure to any of the production lines..."	Process instability	
"…sometimes, your product it self oblige you with a specific packaging and storing conditions, which is not cost efficient…"	Product characteristics	
	Assets and infrastructure risks	

"… 2 years ago, we had a problem in the production, we had a bottle neck in the production line caused by an old, small capacity machine; The machine was too slow so it reduced the quantity produced and increased the cost per unit…"	Resources risks	
"…As an international organisation, in order to try to reduce our costs, we headed to some countries which have a lower labour wages, but this affected our logistics costs…"	Rising labour costs	
"… In FMCG industry, we have to be as quick as possible in every step or move we make, because we have an endless challenge which is the short expiry date of the products; we have to get the product to the shelves in the market as soon as it is ready…"	Obsolescence	
"…before the start of the year, we set the manufacturing plan for the whole year based on a forecast made by marketing department. However, in some cases, the forecast is un-accurate……if the forecast is higher than the actual demand, we will have a pile of excess inventory that in most cases can get obsolete due to the perishable nature of the food components. And if the forecast is lower than the actual demand, this will lead to shortages due to lack of resources and limited capacities..."	Forecast errors	
"…late delivery of shipments to the customers due to congestion or raining weather causes in return cost us more money." *"all cars and truck are stuck in rainy days……. You can see all the city as a big garage for cars"*	Environmental / natural risks	
"Personally, I didn't see ever this amount of theft cases to our trucks as in those days". Obviously, the reason behind this was the security flaw due to the political events happening. "	Theft	
how can the government give companies 10 years' exemption from taxes, and at the end of the 10th year the company changes the ownership, name, or even the activity, and the government grants him then a new tax exemption period!!! It's un-fair." *"multi-national companies can't go to the government and change the ownership or the type of activity every ten years. But local companies do this more frequent such as X company, Y company. Of course, they grab a lot of profits from this manipulation given as a gift from the government"*	Fragile legal system	
every time any truck pass by the Cairo-Alexandria highway pays different tax amount every time, although at most cases the truck load is the same". *"…………. till a frozen chicken reach the final customer, it costs the local producer 25 Egyptian pounds, and the imported chicken costs the importer 15 Egyptian pounds after tax exemption. And after two days of implementing the exemption, we discover that X (one of the decision makers in the Ministry of Foreign and Trade) have a relative who is one of the largest chicken importers in the country………"*	Unstable government policies	**External**
"…government officers won't make your job easy without taking bribes. Imagine that the supplier of raw material sends to me a confirmation that the shipment has delivered to Alexandria port, and when the logistics manager goes and check he is told that the shipment isn't yet in delivered. After the port officer took the bribe, the shipment was cleared in less than one hour…" *"……because if we didn't pay bribes to port staff, we may wait for ages to get our imported raw materials released"*	Corruption	
"you can be going through a way for 3 hours in the dark without any light on both sides or even an emergency or police ambushes to give any confident signs that the way is safe" *"our country has one of the highest accidents record in the area. However, not all the accidents are due to driver's mistake, but because the road is poorly paved and lack any lights or signs"*	Poor transport infrastructure	

"till now, we manage all rail crosses with roads manually...and in most cases, the stuff responsible is sleeping or not even found in his place to manage the crossing" *"we may have a problem in setting the transportation schedule for our shipments, because we cannot predict or estimate how long the journey from the farm to the factory would take. The roads are unpaved…….so in most cases, the plan does not materialize"*		
"the Arab Spring was a nightmare to all business aspects in the region, starting by Tunisia, then Egypt, then Syria, Libya, Yemen, and no one knows who's next" *"several political conflict is taking place in the last 5 years between the Muslim brothers and the Military Council that gives bad messages to the whole globe especially our foreign partners (i.e. suppliers)"* *"even when the political conditions in Egypt started to be better, the condition in Syria, Libya, and Yemen is getting worse. This has very big impact on our SC"*	Political instabilities	
"…we actually don't have a pack-up plan to our operation facility (i.e. factory), so when the electricity goes off, everything is on-hold till electricity comes back…"	Power and energy risks	
"… and after we put the commercial on streets, it didn't make a boom because it was in English, so we realized that mistake and switch it in Arabic"	Cultural barriers	
"… nowadays, government forces extreme laws and policies focused on how green is your production, and how do you protect environment from pollution …"	Social risks	
"…how can we work in a region with every day having terroristic attacks every Friday!!!" *"here in …., terrorist attacks disrupt everything; So we make a plan B for every move we take in order to avoid…"*	Terrorism	
"…it was before I join the company, some dissatisfied, dis-honest employees managed to steal sensitive data from the company and sell it to a competitor. It caused much damage to the us, so wanted compensations."	Deliberate threats	
"…. we read in the official newspaper that the dollar price is…., and when we ask for foreign currency to pay for our suppliers, the banks refuses to give us because they don't have currency to cover all their clients"	Economic instability	
"… our consumption of power almost doubles to keep the temperature of raw material in summer day"	Geographic location	
"Good communication channels would solve everything. It will allow us to solve any problem before it getting worse. I just remembered a case, when the marketing manager knew that there is un-planned promotional campaign in one of the biggest retailers. He approved the sales plan without even sharing it with me till we found the factory send us an urgent purchase order……." *"due to a cut in the main internet line for the whole country..."* *"Good communication channels would solve everything. It will allow us to solve any problem before it getting worse. I just remembered a case, when the marketing manager knew that there is un-planned promotional campaign in one of the biggest retailers from the SC manager of this retailer…he approved the sales plan without even sharing it with me till we found the factory send us an urgent purchase order…"*	Lack of network communication	**Network**
"…. there have to be some government intervention to limit the monopoly for core irreplaceable raw materials and semi-finished goods. In most cases, if we import those materials from the Far East we get it more cheap"	Monopoly risk	
"…if the customers didn't find our products on shelves, we are losing because customers won't wait for us………..... and it will take us time to get back to our position" *"...the FMCG market is an open market, with many companies offering similar products. We are always looking for increasing our market share, however, it is not easy as any one can imagine…"*	Competitive risks	

"Facebook now is the most effective tool to either transfer a positive message or even a negative message to the customer…and of course, it is always used negatively by our competitors in either a direct or in-direct way…". *"…. social media marketing indirectly affects the customers' preferences"*		
"how can we plan for our production with a new dollar price everyday morning!!!" *"...the prices of everything is increasing in a dramatic way…"*	Price volatility	
"…sometime, we need to make few amendments in our distribution schedule, but due to the lack of control we have on our transportation agent, we miss these opportunities" *"…. when it comes to 3rd party sourcing, a lot of risks arises. In these cases, we usually cancel the contract with the company and try to find another reliable 3rd party..."* *"…. that's why we use two different (3PL) companies for the distribution process. Because if at any time one of them didn't fulfil its obligation, the second one is always there….then after our commitment with our customers are fulfilled, we ask them for the penalty clause as per the contract between both of us…"* *"…the mistake we fail in is that we select our 3PL without gaining much information about this company, we only want to go for the lowest cost………......then find ourselves paying more costs later…"*	Third party logistics risks	
"… I think that the reason of this could be the difficulty of predicting customers' needs…" *"…the political and economic conditions has made the market very cloudy….. no one can understand what's going on…."* *"…we know amend the production plan nearly every week"*	Instability of market.	
"...even large retailers and wholesalers cancels the order..." *"…either they ordered wrong items so they modify the order, or they ordered extra quantities than they need so they cancel all the order…"*	Order cancellations	
"…. we usually send to our suppliers the purchase orders a time ahead. However, when the agreed time of delivery isn't met, our purchasing manager starts expediting the order" *"…with no doubt we have to fulfil our orders on time. But some time it's out of our hands, we get our raw materials from suppliers abroad, and the raw materials are in the port waiting for clearance".*	Supplier delivery failure	
"… no doubt in these unstable economy, the consumer is afraid to buy more, he would rather save money for any unexpected…"	Lower consumer spending	
"… it gets rid of many unfavourable efforts and headaches but the problem is you don't have any control on his standard of performance, so you risk your reputation in the market depending on his performance…"	Outsourcing	
"it often happens, we order a particular material with determined specs, when we receive the shipment, we don't find the material with the specs we ordered, why, because the supplier wants to widen his profit margin so he cut from the materials…"	Dis-honest suppliers	
"…innovation is one of the most attribute we have here in the company, but there is a challenge which is how to keep your achievement safe, you can invent something new but others steal it from you so at the end you didn't benefit from it…"	Intellectual property risks	

"...I can admit that we are not good at hunting staff with the needed qualifications..."	Un-skilled human resources	**Functional**
"...we paid about 30 million to buy the SAP software. And still we don't have more than 10% knowledge about how to use it" *"no one wants to change the way he is doing the job. The purchasing staff still want to make the PO manually, however it may take them seconds to use Oracle in sending the PO to the suppliers,*	Technological risks	
"...during the past 3 months as a near example, we had more than 4 strikes from the workers in the factory that refused to complete their job until they are paid more…. Of course the political instabilities due to the revolution changed the mentality and behaviour of the people. Anyone needs anything, just shout and make a strike…. accordingly, this always leads to partial closure of the factory and reduced finished product productivity, which will affect company's' image and stability in the market."	Labour unrest (strikes)	
"we face some problems while dealing with suppliers abroad due to time difference…our day is their night and vice-versa…"	Communication barriers	
"…. the only way to get foreign currency is through the money brokers to provide us with the required amounts with a rate that no one has even expected……"	Financial risks	
"… we keen on sharing knowledge with our employees, because if the employee doesn't know the reason behind what he is doing, he won't make it right, or he will simply ignore it…"	Tacit knowledge risks	
"we plan how we are going to finish the paper work required more than we plan how we are going to handle our shipments…"	Poor internal coordination	
"...due to the huge amount of work, the employee may send a false delivery date to the supplier, so the shipment…"	Human error	
"… I remember those days when we had to wait months to bring an urgent shipment, today with one click you can get what you need in less then 24 hours"	Rapid change in technology	
"…human resources are the core of our company, HR department tries to increase our employees' loyalty by keeping them happy, invest on them, etc.… If you managed to keep your employees happy, they will do their work efficiently, effectively, honestly…"	Dis-honest employees	

Appendix 4: Empirical evidence for SC risks

Second-order themes	Support from the 30 companies																														Aggregate dimensions
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
	Americana – Olives (ECC)	Americana –Cake	ARMA	P&G	Unilever	Farm Frites	HAMA	Carrefour	Ragab Sons	Al-Otaim	SEKEM Group	Edita Food Industries	The Coca-Cola Bottling Co.	Juhayna Food Industries	Kraft Foods Egypt	ISIS for Food Industries	Cook Door	Mo'men	Pepsi Egypt	Almarai	President Cheese	Beyti	La vache qu rit	Hyper One	Chipsy	Domty	Lactel	Savola Group	Cadbury	Al Watanya	
Logistics risks	✓	✓	✓	✓	✓			✓			✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Internal Risk
Process instability	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	
Forecast errors	✓			✓	✓				✓	✓				✓	✓		✓			✓			✓	✓		✓					
Excess Inventory	✓		✓		✓	✓	✓	✓				✓	✓		✓	✓		✓	✓			✓		✓	✓	✓	✓	✓			
Capacity Shortage	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓				✓	✓	✓			✓	✓			✓	
Machine breakdown	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓			✓	✓	✓				✓	✓	
Raw material issues	✓		✓	✓	✓	✓		✓				✓	✓	✓	✓	✓		✓				✓		✓	✓	✓	✓	✓			
Poor planning	✓	✓		✓	✓			✓	✓	✓	✓			✓	✓			✓	✓	✓		✓	✓				✓	✓	✓	✓	
Procurement risks	✓	✓	✓				✓	✓		✓	✓	✓	✓			✓	✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓	
Resource risks	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓			✓	✓			✓										
assets and infrastructure risks		✓	✓			✓			✓	✓		✓	✓			✓				✓					✓		✓	✓			
Product characteristics	✓				✓		✓			✓					✓	✓		✓					✓	✓		✓	✓		✓	✓	
RM delay and shortages	✓	✓	✓	✓		✓		✓	✓			✓				✓		✓		✓	✓		✓				✓				
Rising labour costs	✓	✓	✓	✓	✓						✓		✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Obsolescence	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓			✓	

Competitive risks	✓	✓	✓		✓	✓			✓			✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**Network Risk**
Price volatility	✓		✓		✓	✓	✓	✓		✓		✓	✓		✓	✓		✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	
Instability of market	✓		✓	✓		✓	✓			✓	✓	✓			✓	✓	✓			✓	✓	✓	✓	✓		✓			✓	✓	
Outsourcing	✓	✓	✓					✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	
Lack of Network Communication	✓	✓		✓	✓				✓	✓				✓	✓		✓		✓	✓	✓			✓	✓	✓	✓		✓	✓	
Supplier delivery failure	✓				✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓			✓	✓	
Order Cancellations	✓		✓						✓	✓				✓	✓				✓							✓	✓	✓	✓	✓	
Intellectual property risks	✓	✓	✓	✓		✓							✓				✓	✓		✓	✓				✓		✓			✓	
Third party logistics risks	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓			✓	✓	✓	✓	
Dis-honest suppliers	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓		✓	
Lower consumer spending	✓	✓	✓		✓	✓	✓	✓				✓	✓	✓	✓	✓	✓		✓	✓	✓	✓				✓	✓			✓	
Monopoly risks	✓	✓	✓			✓	✓			✓	✓	✓	✓	✓	✓	✓	✓			✓	✓			✓	✓	✓	✓	✓	✓	✓	
Environmental /natural		✓		✓	✓				✓									✓		✓	✓		✓		✓	✓		✓	✓	✓	**External Risk**
Political instabilities	✓	✓		✓	✓	✓		✓	✓	✓				✓		✓	✓				✓	✓	✓		✓	✓			✓	✓	
Fragile legal system	✓	✓		✓	✓								✓			✓	✓			✓		✓					✓		✓	✓	
Theft	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓								✓		✓	✓	✓	✓	
Poor transport infrastructure	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Terrorism					✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	
Economic Instability		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓	✓				✓	✓				✓		✓	✓	
Power and energy risks	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓		✓	✓	✓	
Social risks	✓		✓	✓	✓	✓		✓	✓	✓							✓	✓		✓			✓	✓	✓	✓			✓	✓	
Deliberate threats	✓			✓	✓				✓	✓	✓		✓	✓										✓	✓	✓		✓			
Geographic location	✓			✓	✓	✓		✓	✓	✓				✓				✓							✓					✓	
Culture barrier	✓			✓	✓								✓				✓		✓									✓	✓	✓	
Unstable Government policies	✓							✓		✓	✓			✓	✓	✓						✓			✓					✓	

Unstable Government policies	✓	✓			✓	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓				✓	✓		✓	✓	✓	✓	✓	
Corruption	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	
Technological risks	✓					✓		✓					✓		✓	✓	✓	✓		✓	✓		✓	✓			✓	✓	✓	✓	**Functional Risk**
Financial risks	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓					✓			✓	✓						✓	
Communication barriers			✓	✓	✓		✓	✓		✓		✓		✓	✓		✓						✓						✓	✓	
Un-skilled human resources	✓		✓	✓				✓		✓	✓				✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	
Labour unrest (strikes)							✓							✓			✓	✓				✓		✓	✓		✓			✓	
Poor internal coordination				✓	✓	✓	✓				✓	✓									✓	✓	✓							✓	
Human error	✓				✓	✓	✓					✓	✓	✓				✓						✓	✓		✓		✓		
Dis-honest employees	✓					✓	✓	✓	✓	✓			✓	✓					✓	✓	✓										
Rapid change in technology	✓						✓	✓	✓	✓			✓	✓						✓					✓			✓	✓	✓	
Tacit Knowledge risks	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓		✓		✓	✓	✓	

Appendix 5: Risks rankings based on their probability of occurrence

Aggregate Dimensions	Second Order Themes	Company																														Numbers			Weighted Sum
		Americana – Olives (ECC)	Americana – Cake	ARMA	P&G	Unilever	Farm Frites	HAMA	Carrefour	Ragab Sons	Al-Otaim	SEKEM Group	Edita Food Industries	The Coca-Cola Bottling Co. of Egypt	Juhayna Food Industries	Kraft Foods Egypt	ISIS For Food Industries	Cook Door	Mo'men	Pepsi Egypt	Almarai	President Cheese	Beyti	La vache qui rit	Hyper One	Chipsy	Domty	Lactel	Savola Group	Cadbury	Al Watanya	High	Medium	Low	
Internal	Logistics risks	Low	Low	Medium	Low	High	Low	Medium	Low	Medium	Low	High	High	Medium	Medium	Medium	Low	Low	Medium	Low	High	High	Medium		Low	High	High	Medium	High	High	High	10	9	10	58
	Process instability	Low	Medium	Medium	Low	High	High	High	High	High	Low	Medium	High	High	Medium	Medium	Medium	Medium	High	Low	Low	Medium	High	High	Low	High	Low	Medium	Low	Low	Low	11	9	10	61
	Forecast errors	Medium	Medium	High	Low	Low	Low	High	Medium	Medium	Low	Low	Low	Low	Medium	Low	High	Low	High	Low	Low	Low	Medium	Low	High	Low	High	Low	Medium	Medium	Medium	6	9	15	51
	Excess Inventory	Medium	Low	Low	Medium	Low	Medium	Low	High	Medium	Medium	Medium	Medium	Medium		Low	High	Low	Low	Medium	Low	Medium	High	Low	High	Medium	Low	Medium	Medium	Medium	Medium	4	15	10	52
	Capacity Shortage	High	Low	Medium		Medium	Medium	Low	Low	High	High	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	High	Low	Medium	Low	Medium	High	High	High	7	15	7	58
	Machine breakdown	Low	Medium	Medium	High	Medium	High	High	Medium	Medium	Low	Low	Medium	Low	Medium	High	High	High	High	High	High	High	High	High	Medium	Low	Medium	High	Low	Medium	High	14	10	6	68
	Raw material issues	Low	Medium	Medium	Low	High	High	Medium	High		High	Medium	Medium	High	Low	Low	Medium	Low	Low	Low	High	Medium	Medium	Low	Medium	Low		Low	Low	Low	Low	6	9	13	49
	Poor planning	Low	High	High	Low	Medium	High	High	Low	Low	Low	Medium	Medium	Low	Low	Medium	High	Low	Low	Medium	Low	High	High	Low	High	Medium	Medium	Medium	Low	Low	Low	8	8	14	54
	Resource risks	Medium	Low		Medium	Low	Medium		Low		Low	Low	Low	Medium	Low	Medium		Low	Low	Medium	Low	Low	Low	Low	Low	Low	Low	Medium	Medium	Medium	Medium	0	10	16	36
	assets and infrastructure risks	Medium	Low	Low	Medium	Low	Medium		Medium		Medium	Medium		Medium		Medium	Low		Low	Medium	Low	Low	Low	Low	Medium	Low	Low	Low	Low	Medium	Medium	0	12	13	37
	Product characteristics	Medium	Low			Low	Low		Medium	Low		Medium	Medium	Medium	Medium		Medium		Low	Medium	Low	Medium	Low	Low	Medium	Medium	Low	Medium	Low	Medium	Medium	0	14	10	38
	RM delay and shortages	Medium	Low	Low	Low	Low		Low		Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Low	Medium	Medium	Low	Medium	Medium	Low	Medium	Medium	Medium	Medium	0	10	18	38
	Rising labor costs	High	Low	High	Medium	Medium	High	Low	High	Low	High	High	High	Low	Medium	Medium	High	Low	Low	Low	Medium	Low	High	High	Low	Medium	Medium	Low	High	High	High	13	7	10	63
	Procurement risks	Low	Low	Low	Medium	Medium	Low	Medium	Low	Medium	Low	Low	High	High	Medium	Medium	Low	Medium	Low	High	High	Medium	Medium	Low	High	High	High	High	Low	Low	Low	8	9	13	55
	Obsolescence	Medium	Medium	Medium	High	High	Low	High	High	High	High	High	Medium	Low	High	High	Low	Medium	Medium	Low	Low	High	High	High	Low	Low	Low	Low	Medium	Medium	Medium	12	9	9	63
Network	Competitive risks	Low	Medium	High	Low	Low	Low	High	Medium	Medium	High	Low	Medium	Low	Low	Low	Low	Medium	High	Low	High	High	High	Medium	Low	High	High	High	Low	Low	Low	10	6	14	56
	Price volatility	Medium	Medium	High	High	Low	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low	Low	Medium	Medium	Medium	Medium	Low	High	Low	Medium	Medium	Medium	3	20	7	56
	Instability of market	Medium	Low	Low	Low	Medium	Low	Low	High	High	Low	High	High	High	Low	Medium	Low	Low	Low	Medium	Low	Low	Low	Medium	High	Medium	Low	Low	Low	Low	Low	6	6	18	48
	Outsourcing	High	Low	Medium	High	High	Medium	Low	Low	Medium	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Medium	Low	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium	4	14	12	52
	Lack of Network Communicati	Low	Medium	Medium	High	Low	High	Medium	Low	Low	Low	Low	Medium	High	High	Low	Low	Low	Low	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High	5	13	12	53
	Supplier delivery failure	Low	Medium	Medium	Low	Medium	Medium	Medium	High		High	Medium	Medium	High	Low	Low	Medium	Low	Low	Low	High	Medium	Medium	Low	Medium	Medium	Medium	Low	Low	Low	Low	4	13	12	50
	Order Cancellations	Low	Medium	Medium	Low	Medium	Low	Low	Low	Low	Low	Medium	Medium	Low	Low	Medium	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Medium	Medium	Low	Low	Low	0	10	20	40
	Intellectual property risks	Low	Low	Medium	Low	Medium		Medium	Low	Medium	Low	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Medium	Medium		Medium		Medium	Medium	Low	Low	0	11	16	38
	Third party logistics risks	Low	High	Low	High	High		Medium	Low	Medium	Low	Medium	Low	Low	Medium	Medium	Low	Medium	Low	Low	Medium	Medium		Medium	Medium	Medium	Medium	Low	Low	Medium	Low	3	13	12	47
	Lower consumer spending	High	Low	High	Medium	Medium	High	Low	High	Low	High	High	High	Low	Medium	Medium	High	Low	Low	Low	Medium	Low	High	High	Low	Medium	High	High	High	High	High	15	6	9	66
	Monopoly risks	Low	Low	Low	Medium	Medium	Low	Medium	Medium	Low	High	Low	High	High	Medium	Medium	Low	Medium	Low	High	High	Medium	Medium	Low	High	High	High	High	High	High	Low	11	9	10	61
	Dishonest suppliers	High	High		Low	High	High	Low	Low	Low	Medium	High		High	Low	High	High	High	Medium	High	High	Low	Low	Low	High	High	High	Medium	Medium	Medium	Medium	14	6	8	62

Aggregate Dimensions	Second Order Themes	Company																														Numbers			Weighted Sum
		Americana – Olives (ECC)	Americana – Cake	ARMA	P&G	Unilever	Farm Frites	HAMA	Carrefour	Ragab Sons	Al-Otaim	SEKEM Group	Edita Food Industries	The Coca-Cola Bottling Co. of Egypt	Juhayna Food Industries	Kraft Foods Egypt	ISIS For Food Industries	Cook Door	Mo'men	Pepsi Egypt	Almarai	President Cheese	Beyti	La vache qu rit	Hyper One	Chipsy	Domty	Lactel	Savola Group	Cadbury	Al Watanya	High	Medium	Low	
External	Environmental /natural	Low	Low	Low	Low		Low	Medium	Medium	Low	High	Low	High	Low	Medium	Medium	Low	Medium	Low	High	High		High	Low	Low	Low	Low	Low	Low	Low	Low	5	5	18	43
	Political instabilities	Medium	Medium	Medium	Medium	Medium	Medium	High		High	Low		High	High	High	High	Low	Medium	Medium	Low	Low	Low	Low	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	6	15	7	55
	Fragile legal system	Medium	Medium		Medium	Medium	Medium	Low	Low	Low	Medium	Low	Low	Low	Low	Medium	Low	Low	Medium	High	High	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Medium	2	10	17	43
	Theft	Low	Low	High	High	Low	Low	High	Low	High	High	Medium	Medium	Medium	Medium	Medium	Low	High	High	Low	Low	Medium	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	7	14	9	58
	Poor transport infrastructure	Low	Low	Medium	Low	High	High	Low	Medium	Low	Low	Medium	Medium	Medium	High		High	Low	Medium	Medium	High	High	Medium	High	High	High	High	Medium	High	High	High	13	9	7	64
	Terrorism	Low	Medium	High	Low	High	Low	High	High	Medium		Low	Medium	High	Low	Low	Low	Medium	High	Low	High	High	High	High	Low	High	High	High	High	Low	Low	14	4	11	61
	Economic Instability	Medium	Medium	High	Low	Low	Low	High	High	High	High	Medium	Medium	High	High	Low	High	High	High	Low	Low	Low	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	10	11	9	61
	Power and energy risks	Medium	Low	Low	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Medium	Low	Low	Medium	Low	High	High	Medium	Medium	Medium	High	Low	High	High	High	High	High	High	Medium	9	11	10	59
	Social risks	Medium	Medium	Low			Medium	Low		Medium	Low	Medium		Low		Low	Low	Low	Medium	Low	Medium		Low	Low	Medium	Low	Low	Low	Low	Low		0	8	15	31
	Deliberate threats	Medium	Low	Low	Medium	Low	Medium	Low	Medium	Low		Medium	Low	Medium	Low	Low		Low	Low	Low	Medium	Low	Medium		Low	Low	Medium	Low	Low	Low	Low	0	9	18	36
	Geographic location	Medium	Low	Low	Medium	Low	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Medium	Medium		Medium	Medium		Medium		Medium	Low		Low	Medium	Low	Low	Low	Medium	0	14	12	40
	Culture barrier	Medium	Low	Medium	Medium	Low	Medium	Low	Medium	Low			Low	Low		Medium	Low		Medium	Medium	Medium	Medium		Medium		Low	Medium	Low	Medium	Low	Medium	0	14	10	38
	Corruption	High	Low	Medium		Medium	Medium	Low	Medium	High	Low	High	High	Low	High	High	Medium	High	Low	Medium	Medium	Medium	High	High	High	Medium	High	Medium	High	High	High	14	10	5	67
	Unstable Government policies	Low	Medium	Medium	High	Medium	Medium	Medium	Medium	High	Low	Low	High	High	High	High	High	High	High		Medium	Medium	Low	Medium	Medium	High	High	High	High	High	High	15	10	4	69
Functional	Technological risks	Low	Low	High	High	Low	Low	Low	Low	Low	Low	High	High	High	Medium	Medium	Low	High	High	Low	Low	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	7	3	20	47
	Financial risks	Low	Low	Medium	Low	High	High	High	High	High	Medium	Low	Low	Medium	High		High	Low	Medium	Low	High	High	Medium		Low	High	High	Medium	High	High	High	14	6	8	62
	Communication barriers	Low	Medium	High	Low	High	Low	Low	Low	Low	Medium	Low	Medium	High	Low	Low	Low	Medium	High	Low	High	High	High	High	Low	High	High	High	Low	Low	Low	11	4	15	56
	Un-skilled human resources	Medium	Medium	High	Low	Low	Low	Medium	Low		High	Medium	Medium	High	Medium	Low	High	Low	High	Low	Low	Low	Medium	Low	High	Low	High	Low	Medium	Medium	Medium	7	10	12	53
	Labor unrest (strikes)	Medium	Low	Low	Medium	Low	Medium	High	Low	High	High	Medium	Medium	Low		Low	High	Low	Low	Medium	Low	Medium	High	Low	High	Medium	Low	Medium	Medium	Medium	Medium	6	12	11	53
	Poor internal coordination	Low	Low	Medium	Low	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Medium	Low		Low		Medium	Low	Low	Medium	Low		Low		Medium	Low	Medium		Low	0	10	15	35
	Human error	Low	Low		Medium	Low	Low	Medium	Low	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Medium	Low		Low		Medium		Low	Medium	Low		Medium	Low	Medium	0	11	14	36
	Dishonest employees	Low	Low	Low	Medium	Low	Medium	Medium	Low	Medium	Low	Low	Medium	Low	Medium	Medium	Low	Medium	Low	Low	Low	Low	Low	Low	Low	Medium	Low	Low	Medium	Low	Medium	0	11	19	41
	Rapid change in technology	Medium	Low			Low	Low				Low			Low	Low		Low	Medium	Low		Medium	Medium	Low	Medium	Low	Medium	Low			Low	Low	0	6	13	25
	Tacit Knowledge risks	High	Low	Medium		Medium	Medium	High	Low	Low	Low	High	High	Low	Low	High	Low	Low	Low	Medium	Medium	Medium	High	Low	Low	Medium	Low	Medium	High	High	High	9	8	12	55

Appendix 6: Capabilities data structure table

Capabilities Data Structure		
First Order Codes	Second Order Themes	Aggregate Dimensions
"…here, the management keen on clarifying roles and responsibilities to everyone to avoid duplication or any sort of clash"	Role clarity	Visibility
"…we have this problem in the company, procurement department doesn't know technical information about the product, so it often happens that the ordered specs for materials are wrong"	Product awareness	
"sometimes, we recognize that there is a forgotten order than need to be prepared and delivered very soon…………. I have a personal relation with almost all wholesalers and retailers we deal with, so we contact the customer explaining the situation and that the order would be late and they accept the situation if they can…" *"we usually follow up our orders using phone calls", "I can ask my supplier about other suppliers' prices too"*	Informal networking	
"…traceability is the key to discover the risk prior happening…this wouldn't be effective without finding the way to inform our partners with the current situation to be prepared."	Risk communication channels	
"…about five years ago, we had a problem with delivering information and knowledge to the right individuals/departments in the company to use it…"	Knowledge management	
"…ERP system helped sharing data and information among different departments in the company, this enhanced the overall performance of the company	Information and Communication technology	
"we may agree with the retailer to make some changes in the quantities of each type of potatoes ordered, while the total remains the same. And in the next order we manage to deliver the rest of the undelivered quantity of a certain type…"	Customers flexibility	Flexibility
"At no time in our history has adaptability been so critical. Products, services, organisations, companies, and even whole industries come and go in a heartbeat"	Adaptability	
"We are good at making important changes rapidly. Speed refers to the organisation's ability to recognize opportunities and act quickly, whether to exploit new markets, create new products, establish new employee contracts, or implement new business processes".	Agility	
"although we have our own trucks, but also we hire nearly about 35% of the trucks from a transportation agency to fulfil our delivery schedules" *"…companies such as Agility and Logic that offers storage service based on a contract have solved a lot of our storage problems..."*	Outsourcing	
"…it is difficult to find a local supplier providing us with the required specifications…the only way that we had to change the design of the packing for all our products to be able to find an alternative supplier…of course this would cut a lot of transportation cost..."	Efficiency	
"…speed is the core of our operations, if you are late one or two days from delivering products to the market, you lose the season…"	Velocity	

"…the characteristics of the industry give us the opportunity to do some sort of deals with other competitors……I remember one incident, big retailers were forcing us to increase the credit period for them……after we analysed the situation, we and Coca-Cola SC manager agreed not to do so……...and finally nothing changed in our credit terms with them……however I think if the economic situation is getting worse…" *"…. we always maintain good relation with our competitors, we also may be having the same suppliers for raw materials…………"*	Co-opetition	**Collaboration**
"…here, anyone in the company can contribute in the decision making so we can reach the best solution…"	Group-decision making	
"…. long term contracts with our suppliers make us always confident that if we faced any shortage in materials or any unpredicted increase in the demand we will find them in our back…" *"…we do have strategic partnerships with our main suppliers to be prioritized if they faced any shortages…."* *"…. involvement of our suppliers in the product design rarely happens…. but when we started to think about the idea we realized that we were too late……sharing knowledge and experience with them (supplier) improve Collaboration to be able to respond any sudden changes in the customers' preferences…"* *"…to achieve successful implementation of our internal improvement strategy, we send members of our staff to monitor the production process of the suppliers to reduce the probability of having quality issue in the materials at the suppliers' premises…."*	Supplier Relationship Management	
"…we usually have sales staff in the big retailers to be in a direct contact with customers…. they explain to them the new offers…. they take notes about the missing SKUs that customers asked about…" *"…we now have Hyper one loyalty cards…all customer's information is kept on our database; we are able to trigger customers' preferences……we send to them all promotions especially on the items they regularly buy…."* *"…it is very important to have a link with the customers in a way or another...this help us to improve our products and create more value to them"*	Customer relationship management	
"…during the high season, we have too many orders to deliver which may cause some sort of a chaos and employees begin to forget tasks, so they through responsibilities to each others"	Accountability	**Control**
"… we seek to get rid of any non-value added operations in the process by using tools such as lean, six-sigma, etc.…"	Process excellence	
"…we try to have control over every operation in the business, but in some situations, you can't have this privilege especially when it comes to your supplier…"	Spans of control	
"…I remember when the company purchased the SAP software, employees were very stubborn and preferred to work manually as before…"	Change management	
"…we have many warehouses in several locations across the country, this puts us in a challenge which is the lack of control over the flow of materials and finishes products from and to the warehouses"	De-centralization	

We often think of leadership as a set of people at the top of the organisation but it is actually a skill that can, and should, exist at every level. Leadership is the capability to inspire and motivate people to fulfil a mission. At the top of the organisation leadership includes directing others while at lower levels it is accomplished through influencing others. Your company's leadership performance has a lot to do with how much the organisation can accomplish in a given amount of time.	Leadership	
"…it is not the matter of a system that bind us (SC members) together. It is all about understanding the importance of transferring the information when any unplanned activity happens."	SC risk management awareness	**Learning and Innovation**
"market intelligence is the all about how to understand all success factors of the business"	Market intelligence	
"...because of the nature of our products – milk, yogurt, etc.- the product life cycle is not a threat, as these products are fixed since they were introduced, but we invest mainly on new packing techniques to reduce cost and to be environment friendly…"	Research and development	
"… the management always invests in employees to keep them up to date with the new trends in business in order to enhance the performance"	Development in human resources	

Appendix 7: Empirical evidence for capabilities

Second-order themes	1 Americana – Olives (ECC)	2 Americana –Cake	3 ARMA	4 P&G	5 Unilever	6 Farm Frites	7 HAMA	8 Carrefour	9 Ragab Sons	10 Al-Otaim	11 SEKEM Group	12 Edita Food Industries	13 The Coca-Cola Bottling	14 Juhayna Food Industries	15 Kraft Foods Egypt	16 ISIS for Food Industries	17 Cook Door	18 Mo'men	19 Pepsi Egypt	20 Almarai	21 President Cheese	22 Beyti	23 La vache qu rit	24 Hyper One	25 Chipsy	26 Domty	27 Lactel	28 Savola Group	29 Cadbury	30 Al Watanya	Aggregate dimensions
	Support from the *30 companies*																														
Role clarity	✓	✓	✓		✓	✓			✓			✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Visibility
Product awareness	✓	✓	✓	✓	✓	✓			✓	✓		✓		✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	
Informal networking	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	
Risk communication channels	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	
Knowledge management	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓			✓	✓			✓	✓	✓	✓	✓			✓	✓		✓	✓	
Information and communication Technology	✓				✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓			✓	✓	
Customers flexibility	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓		✓	✓	**Flexibility**
Adaptability	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓			✓	✓	✓	✓			✓	

Agility	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓		✓		✓	✓	✓	✓		✓	✓	✓				✓	✓	
Outsourcing	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓			✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	
Efficiency	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓			✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	
Velocity	✓		✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓			✓	✓	
Co-opetition	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓								✓		✓	✓	✓	✓	
Supplier relationship management	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Customer relationship management					✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	
Group-decision making		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓	✓				✓	✓				✓		✓	✓	**Collaboration**
Accountability	✓	✓	✓		✓	✓	✓		✓		✓		✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Process excellence	✓		✓		✓	✓	✓	✓		✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓	✓		✓	
spans of control	✓		✓	✓	✓	✓			✓	✓		✓		✓	✓	✓		✓	✓	✓		✓			✓	✓	✓	✓			
De-centralization	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓		✓	✓	✓	✓			✓	
Change management	✓	✓			✓	✓	✓		✓		✓		✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		✓		✓	
Leadership	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	**Control**

SCRM awareness	√		√		√		√		√	√		√	√	√		√		√		√		√	√		√	√	√		√	√	**Learning and Innovation**
Market intelligence	√	√	√	√	√	√		√	√		√		√	√	√	√	√		√	√	√	√	√		√	√	√			√	
Research and development	√	√		√	√	√	√	√		√	√	√		√	√	√		√		√	√	√		√		√	√		√	√	
Developments in Human resources			√	√	√	√	√		√		√	√	√		√	√		√	√	√	√			√	√		√		√	√	

Appendix 8: SC KPIs data structure table

KPIs Data Structure			
First Order Codes	Second Order Themes	Aggregate Dimensions	
		Level 1 KPIs	SC attribute
" We measure Reliability by KPI's: Actual Delivered Vs. Actual orders Production plan conformance Export On Time In Full Suppliers OTIF On Time In Full & Supplier performance " we measure these KPI's to insure perfect order: Scrap value Percentage Manufacturing Schedule Adherence Percentage lost manufacturing capacity	Percentage of Orders Delivered in Full	Perfect Order Fulfilment	Reliability
" The company order fulfilment KPI's are: Customer Complains Manufacturing Schedule Adherence	Delivery Performance to Customer Commit Date		
"I think perfect order should focus on the KPI's: On time ship rate Perfect Order Measure / Fulfilment	Documentation Accuracy		
"…traceability is the key to discover the risk prior happening…this wouldn't be effective without finding the way to inform our partners with the current situation to be prepared."	Perfect Condition		
" We measure the following KPI's for Order Cycle time: total import lead time FG Stock level FG inventory days	Source Cycle Time	Order Fulfilment Cycle Time	Responsiveness
" Company measure responsiveness by the KPI's Volume Performance Packaging Materials Yield Manufacturing cycle time	Make Cycle Time		
" KPI's list contain Order fulfilment cycle time : Inventory replenishment cycle time Supply chain cycle time Percentage of standard tender/bid procedures	Delivery Cycle Time		
" KPI's measure responsiveness Average time to procure	Delivery Retail Cycle Time		

Percentage of (preferred) suppliers not used in last 12 months			
Velocity/ Capacity Acceleration % *# of Stories/ Capacity* *Cycle Time*	Upside Supply Chain Flexibility	Upside Supply Chain Flexibility	Agility
Release Overhead % *Standard Deviation/ Variability*	Upside Supply Chain Adaptability	Upside Supply Chain Adaptability	
Due Date Performance *Escaping Defects/ Size of work*	Downside Supply Chain Adaptability	Downside Supply Chain Adaptability	
" KPI's that related to supply chain management cost *Current Purchase Budget Plus Adjustment for all categories* *% Actual vs. Estimated Savings* *Delayed Spot purchase = % of payable invoices without purchase order* *Repair & Maintenance Cost Per Unit Volume* *" Cost KPI's that related to supply chain management cost :* *Non-Moving / Slow Moving Inventory:* *Saving Performance* *Early receipts to MRP date (required date)* *Independent demand ratio*	Cost to Plan	Supply Chain Management Cost	Cost
" Supply chain management cost KPI's *Total Recordable Frequency Rate* *Number of tags per employee* *% of slow moving products* *% of time spent picking back orders* *Inventory Carrying Costs* *Customer order promised cycle time*	Cost to Make		
" We measure Supply chain management cost by KPI's: *Material value add* *Average production costs of items* *Customer order cycle time* *Inventory Accuracy* *Percentage Actual vs. Estimated Savings* *Travel & entertainment costs as Percentage of gross margin*	Value At Risk (VAR $, Percentage of Sales)		
" Our company KPI's that related to Supply chain management cost : *Early PO Receipts to PO due date* *Average age of fleet* *Total negotiated cost reduction savings* *Average size of discounts of items*	Mitigation Cost (Cost to Mitigate Supply Chain Risk)		

COGS KPI's *Labour Cost Per Unit Volume* *Other Production Cost Per Unit Volume*	Direct Material Cost	Costs of Goods Sold	
Measuring COGS KPI's *Unit Cost per batch* *Inventory service level*	Indirect Cost Related to Production		
Labour Cost Per Unit *Labours Hours* *Over time percentage*	Direct Labour Cost		
Cash to cash cycle time related KPI's *Inventory Turnover*	Cash-to-Cash Cycle Time	Cash-To-Cash Cycle Time	Assets
Customer order promised cycle time *Material value add*	Inventory Days of Supply		
Company measure the following KPI's for Cash cycle *Average production costs of items*	Days Sales Outstanding		
Inventory turnover *Days payable outstanding = {account payables / (total purchased a year /365)}*	Days of Payable Outstanding		
Saving Levels Due to Improvement Efforts *Return on Innovation Investment*	Supply Chain Management Costs	Return on Supply Chain Fixed Assets	
# of Key Capital Investments that Meet or Exceed ROI Expectations *Customer Lifetime Value* *Customer Lifetime Value / Customer Acquisition Cost*	Supply Chain Fixed Assets		
Operating Cash Flow *Cash Rotation (365/cash cycle)* *Cash Flow from Investing Activities* *Cash Flow from Financing Activities* *Cash Flow*	Supply Chain Management Costs	Return on Working Capital	
Cash Conversion Cycle *Accounts Receivable Turnover* *Accounts Receivable*	Inventory		
Accounts Payable Turnover *Accounts Payable*	Supply Chain Revenue		

Appendix 9: SC KPIs empirical evidence

Second-order themes	Support from the 30 companies																														Aggregate dimensions	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
	Americana – Olives (ECC)	Americana –Cake	ARMA	P&G	Unilever	Farm Frites	HAMA	Carrefour	Ragab Sons	Al-Otaim	SEKEM Group	Edita Food Industries	The Coca-Cola Bottling Co.	Juhayna Food Industries	Kraft Foods Egypt	ISIS for Food Industries	Cook Door	Mo'men	Pepsi Egypt	Almarai	President Cheese	Beyti	La vache qu rit	Hyper One	Chipsy	Domty	Lactel	Savola Group	Cadbury	Al Watanya		
Percentage of Orders Delivered in Full	✓		✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	**Perfect Order Fulfilment**	**Reliability**
Delivery Performance to Customer Commit Date	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		
Documentation Accuracy		✓	✓		✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓			✓	✓	✓			✓		✓			
Perfect Condition		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓				✓	✓	✓		✓	✓	✓	✓		✓	✓	✓				
Source Cycle Time	✓	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	**Order Fulfilment Cycle Time**	**Responsiveness**
Make Cycle Time	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓			✓	✓	✓	✓		✓		
Delivery Cycle Time		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓				✓	✓	✓		✓	✓	✓		✓	✓			
Delivery Retail Cycle Time	✓		✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓				✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		

Upside SC Flexibility	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓		✓		✓		✓	✓		✓		✓	✓	**Upside SC Flexibility**	**Agility**
Upside SC Adaptability	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓		✓	✓		✓		✓				✓	✓	✓	✓		✓	**Upside SC Adaptability**	
Downside SC Adaptability	✓	✓		✓	✓	✓	✓	✓		✓		✓	✓	✓		✓		✓	✓		✓	✓	✓	✓			✓	✓		✓	**Downside SC Adaptability**	
Cost to Plan	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓		✓		✓	✓	**SCM Cost**	**Costs**
Cost to Make		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓		✓		✓		
Value at Risk (VAR $, Percentage of Sales)	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓		✓	✓	✓	✓	✓					
Mitigation Cost (Cost to Mitigate SC Risk)	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓				✓		
Direct Material Cost	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		**Cost of Goods Sold**	
Indirect Cost Related to Production	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓		
Direct Labour Cost		✓	✓	✓	✓		✓	✓	✓	✓		✓		✓			✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓			
Cash-to-Cash Cycle Time	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		**Cash-To-Cash Cycle Time**	**Assets**
Inventory Days of Supply	✓			✓			✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			
Days Sales Outstanding	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓			✓	✓	✓		✓	✓	✓		✓	✓				

Days of Payable Outstanding	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	
SCM Costs	✓	✓		✓	✓		✓		✓	✓		✓	✓		✓		✓	✓		✓	✓		✓		✓	✓	✓	✓	✓		**Return on SC Fixed Assets**
SC Fixed Assets	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	
SCM Costs		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓		✓	**Return on Working Capital**
Inventory	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	
SC Revenue	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓				✓	✓	✓		✓		✓	✓		✓	✓	

Appendix 10: KPIs/risks matrix

Level 2 (resilience KPIs)	Level 1 KPIs (strategic KPIs)	SC performance attributes	Risk																																
			Internal risks										Network risks										External risks								Functional risks				
			Logistics risks	Process instability	Excess Inventory	Capacity Shortage	Machine breakdown	Raw material issues	Poor planning	Procurement risks	Rising labour costs	Obsolescence	Competitive risks	Price volatility	Instability of market	Outsourcing	Lack of Network	Supplier delivery	Third party logistics	Dis-honest suppliers	Lower consumer	Monopoly risks	Political instabilities	Theft	Poor transport	Terrorism	Economic Instability	Power and energy risks	Unstable Government	Corruption	Technological risks	Financial risks	Un-skilled human	Labour unrest (strikes)	Tacit Knowledge risks
Percentage of Orders Delivered in Full	Perfect Order Fulfilment	Reliability															17		28		29			21	23		23								
Delivery Performance to Customer Commit Date	Perfect Order Fulfilment	Reliability	24				16		30						30					21		18	22			19									
Documentation Accuracy	Perfect Order Fulfilment	Reliability								22					25	26		30					20			18									
Perfect Condition	Perfect Order Fulfilment	Reliability							25		27	21					27		22		19			28	22		22								

Upside SC Adaptability	Upside SC Flexibility	Delivery Retail Cycle Time	Delivery Cycle Time	Make Cycle Time	Source Cycle Time
Upside SC Adaptability	**Upside SC Flexibility**	**Order Fulfilment Cycle Time**	**Order Fulfilment Cycle Time**	**Order Fulfilment Cycle Time**	**Order Fulfilment Cycle Time**
Agility	**Agility**	**Responsivene**	**Responsivenes**	**Responsivene**	**Responsiveness**
					29
	28				
	19			16	
	22			20	
				30	19
	26				
					17
	21				
	23				
		24		30	
25					25
28		20			
17		19			
			16		
17		22			21
			25		
			19		27
			30		22
	19				
19		19			
21	21	16			
					19
26	25	28			
19	26	25			29
					25
			23	22	
			17	28	

Mitigation Cost (Cost to Mitigate	Value At Risk (VAR $, Percentag	Direct Labour Cost	Indirect Cost Related to Productio	Direct Material Cost	Cost to Make	Cost to Plan	Downside SC Adaptability
SCM Cost	SCM Cost	SCM Cost	SCM Cost	SCM Cost	SCM Cost	SCM Cost	Downside SC Adaptability
Costs	Costs	Costs	Costs	Costs	Costs	Costs	Agility
29							
			22	26		16	
24							
					26		
					25		
							25
25					17		18
16				30	29	20	19
							25
	24	25	27				26
	16	27	18	22		25	
28	19	30	25	22	24	23	
	28	18	28	25		18	
21	29	21	23	28	25		
	19	30	23	23			
	16	29	27	22			
30					30		
24					25	27	
27					19		
						18	

SCM Costs	Days of Payable Outstanding	Days Sales Outstanding	Inventory Days of Supply	Cash-to-Cash Cycle Time	Direct Labour Cost	Indirect Cost Related to Productio	Direct Material Cost
Return on SC Fixed Assets	Cash-To-Cash Cycle Time	Cash-To-Cash Cycle Time	Cash-To-Cash Cycle Time	Cash-To-Cash Cycle Time	Cost of Goods Sold	Cost of Goods Sold	Cost of Goods Sold
Assets	Assets	Assets	Assets	Assets	Costs	Costs	Costs
17							
16							
	17						20
	23						22
	22						22
23	25						28
			28			30	
22							
	19	19		30	25		
			26			24	
	20	18		17	18		
		30	21				
20		16	25				
				17	29	27	
		29	23				
				22	19	17	
				18	18	18	
				23	28	19	
28		24	27				
		30	19				
				25	26	16	
		30	17				
28							
24							
20	24						27

Inventory	Accounts Payable (Payables Outstandi	Accounts Receivabl e (Sales Outstandi	Cost of Goods Sold	SCM Costs	SC Revenue	Cost of Goods Sold	SC Fixed Assets
Return on Working Capital	Return on Working Capital	Return on Working Capital	Return on Working Capital	Return on Working Capital	Return on SC Fixed Assets	Return on SC Fixed Assets	Return on SC Fixed Assets
Assets	Assets	Assets	Assets	Assets	Assets	Assets	Assets
	18						27
20							
	21						30
	26			29			
				28			
				17			
				17			25
	27			21			
					25		20
30		17	23				
	26			20			
21		19	29				
18					20		
29					26		22
	16	30	26			23	
28					19		
	25	18	27			25	
	28	22	27			29	
	26	25	19			16	
27					22		20
20					16		
	19	28	16			20	
19					16		
							23
							29
				16			21

SC Revenue
Return on Working Capital
Assets
17
18
25
16
18
20
26
26
21

Appendix 11: Capabilities/KPIs matrix

Level 2 (resilience KPIs)	Level 1 KPIs (strategic KPIs)	SC performance attributes	Capability																									
			Visibility						Flexibility						Collaboration				Control						Learning and Innovation			
			Role clarity	Product awareness	Informal networking	Risk communication channels	Knowledge management	Information and communication	Customers flexibility	Adaptability	Agility	Outsourcing	Efficiency	Velocity	Co-opetition	Supplier relationship management	Customer relationship management	Group-decision making	Accountability	Process excellence	spans of control	De-centralization	Change management	Leadership	SC risk management awareness	Market intelligence	Research and development	Developments in Human resources
Percentage of Orders Delivered in Full	Perfect Order Fulfilment	Reliability	21					23					28					29				17					18	
Delivery Performance to Customer Commit Date	Perfect Order Fulfilment	Reliability	29					18					28					20				29					28	
Documentation Accuracy	Perfect Order Fulfilment	Reliability	20		26		29	21		22		17	24		22		18	16	24		17	21		20		27	24	
Perfect Condition	Perfect Order Fulfilment	Reliability				17					23					23				19					17			
Source Cycle Time	Order Fulfilment Cycle Time	Responsive ness	27					25					23					20				29					24	

Make Cycle Time	**Order Fulfilment Cycle Time**	**Responsiveness**	16					29					27					22				24					17	
Delivery Cycle Time	**Order Fulfilment Cycle Time**	**Responsiveness**			24		21			29		20			29		21		20		22			19		28		
Delivery Retail Cycle Time	**Order Fulfilment Cycle Time**	**Responsiveness**	29		21		20	18		24		28	21		18		22	17	19		18	30		26		17	19	
Upside SC Flexibility	**Upside SC Flexibility**	**Agility**				30					30					25				16					22			
Upside SC Adaptability	**Upside SC Adaptability**	**Agility**	24					21					19					25				25					20	
Downside SC Adaptability	**Downside SC Adaptability**	**Agility**					28					18					23				26							
Cost to Plan	**SCM Cost**	**Costs**	27					20					25					17				18					29	
Cost to Make	**SCM Cost**	**Costs**	30					16					29					28				17					20	
Direct Material Cost	**SCM Cost**	**Costs**	18					29					28					26				19					29	
Indirect Cost Related to Production	**SCM Cost**	**Costs**		26					16					22									28					23
Direct Labour Cost	**SCM Cost**	**Costs**	23					26					27					21				27					18	
Value at Risk (VAR $, % of Sales)	**SCM Cost**	**Costs**	23					30					27					23				30					29	
Mitigation Cost (Cost to Mitigate SC Risk)	**SCM Cost**	**Costs**		18					26					28									19					25
Direct Material Cost	**Cost of Goods Sold**	**Costs**	20					24					24					27				18					30	

Indirect Cost Related to Production	**Cost of Goods Sold**	**Costs**	17					29					22					25				16					20	
Direct Labour Cost	**Cost of Goods Sold**	**Costs**	16		20		21	25		20		17	22		26		19	24	16		27	24		30		23	17	
Cash-to-Cash Cycle Time	**Cash-To-Cash Cycle Time**	**Assets**				23					22					25				22					19			
Inventory Days of Supply	**Cash-To-Cash Cycle Time**	**Assets**	30					16					28					25				23					21	
Days Sales Outstanding	**Cash-To-Cash Cycle Time**	**Assets**	28					20					26					21				16					16	
Days of Payable Outstanding	**Cash-To-Cash Cycle Time**	**Assets**			22		24			20		19			19		16		25		27			20		29		
SCM Costs	**Return on SC Fixed Assets**	**Assets**	21		28		24	17		29		17	18		19		19	17	27		19	30		23		28	30	
SC Fixed Assets	**Return on SC Fixed Assets**	**Assets**				30					19					21				17					23			
Cost of Goods Sold	**Return on SC Fixed Assets**	**Assets**	23					27					29					28				26					19	
SC Revenue	**Return on SC Fixed Assets**	**Assets**	24					22					22					16				16					17	
SCM Costs	**Return on Working Capital**	**Assets**	18					25					26					20				17					27	
Cost of Goods Sold	**Return on Working Capital**	**Assets**	22					25					20					29				24					26	

Accounts Receivable (Sales Outstanding)	**Return on Working Capital**	**Assets**		**21**					**21**					**22**									**21**					**24**
Accounts Payable (Payables Outstanding)	**Return on Working Capital**	**Assets**	**18**					**19**					**30**					**21**				**16**					**29**	
Inventory	**Return on Working Capital**	**Assets**	**23**					**24**					**30**					**24**				**30**					**24**	
SC Revenue	**Return on Working Capital**	**Assets**		**25**					**30**					**23**									**19**					**27**

Appendix 12: Capabilities/risks matrix

Risks		Capability																									
		Visibility						Flexibility						Collaboration				Control						Learning and Innovation			
		Role clarity	Product awareness	Informal networking	Risk communication channels	Knowledge management	Information and communication	Customers flexibility	Adaptability	Agility	Outsourcing	Efficiency	Velocity	Co-opetition	Supplier relationship management	Customer relationship management	Group-decision making	Accountability	Process excellence	spans of control	De-centralization	Change management	Leadership	Supply chain risk management	Market intelligence	Research and development	Developments in Human resources
Internal Risk	Logistics risks							19						22											26		
	Process instability							21						16											18		
	Excess Inventory	21								17						27			18								29
	Capacity Shortage							30						24											28		
	Machine breakdown							24						27											22		
	Raw material issues							23						26											17		
	Poor planning							20						19											28		
	Procurement risks	22								27						28			16								27
	Rising labour costs							21			18						19								21		
	Obsolescence										30						23										

Network Risk	**Competitive risks**		**21**				**25**				**22**						**24**							**30**			
	Price volatility						**21**							**27**										**29**			
	Instability of market	**19**								**27**						**21**			**26**								
	Outsourcing	**30**								**20**						**17**			**29**								**25**
	Lack of Network Communication							**18**						**23**											**23**		
	Supplier delivery failure							**26**						**30**											**30**		
	Third party logistics risks							**24**						**26**											**26**		
	Dis-honest suppliers	**28**								**26**						**29**			**21**								**21**
	Lower consumer spending		**2**								**2**						**2**						**2**				
	Monopoly risks	**27**								**28**						**18**			**16**								**27**
External Risk	**Political instabilities**	**21**								**19**						**21**			**22**								**26**
	Theft						**17**																	**22**			
	Poor transport infrastructure	**24**								**28**						**20**			**26**								**25**
	Terrorism		**25**								**29**						**19**								**17**		
	Economic Instability																**28**								**28**		
	Power and energy risks						**20**												**26**								**16**
	Unstable Government policies						**30**									**17**		**24**						**24**			
	Corruption								**21**						**16**	**26**								**23**			

Functional Risk	**Technological risks**		**27**					**29**			**24**								**30**								**23**
	Financial risks		**26**								**21**								**27**								**28**
	Un-skilled human resources								**21**						**16**				**26**								**26**
	Labour unrest (strikes)								**25**						**18**	**23**								**27**			
	Tacit Knowledge risks						**30**									**28**								**27**			

Appendix 13: AHP interview template

What are the important for each of the following against the others?

Item Description	Reliability	Responsiveness	Agility	Costs	Assets
Reliability	1.000				
Responsiveness		1.000			
Agility			1.000		
Costs				1.000	
Assets					1.000

Reliability				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000			
Network Risk		1.000		
External Risk			1.000	
Functional Risk				1.000
Responsiveness				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000			
Network Risk		1.000		
External Risk			1.000	
Functional Risk				1.000
Agility				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000			
Network Risk		1.000		
External Risk			1.000	
Functional Risk				1.000
Costs				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000			
Network Risk		1.000		
External Risk			1.000	
Functional Risk				1.000
Assets				
	Internal Risk	Network Risk	External Risk	Functional Risk
Internal Risk	1.000			
Network Risk		1.000		
External Risk			1.000	
Functional Risk				1.000

Reliability					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000				
Flexibility		1.000			
Collaboration			1.000		
Control				1.000	
Learning and Innovation					1.000

Responsiveness					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000				
Flexibility		1.000			
Collaboration			1.000		
Control				1.000	
Learning and Innovation					1.000

Agility					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000				
Flexibility		1.000			
Collaboration			1.000		
Control				1.000	
Learning and Innovation					1.000

Costs					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000				
Flexibility		1.000			
Collaboration			1.000		
Control				1.000	
Learning and Innovation					1.000

Assets					
	Visibility	Flexibility	Collaboration	Control	Learning and Innovation
Visibility	1.000				
Flexibility		1.000			
Collaboration			1.000		
Control				1.000	

Learning and Innovation					1.000

Reliability										
	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside SC Flexibility	Upside SC Adaptability	Downside SC Adaptability	SCM Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on SC Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.00									
Order Fulfilment Cycle Time		1.00								
Upside SC Flexibility			1.00							
Upside SC Adaptability				1.00						
Downside SC Adaptability					1.00					
SCM Cost						1.00				
Cost of Goods Sold							1.00			
Cash-To-Cash Cycle Time								1.00		
Return on SC Fixed Assets									1.00	
Return on Working Capital										1.00
Responsiveness										
	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside SC Flexibility	Upside SC Adaptability	Downside SC Adaptability	SCM Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on SC Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.00									
Order Fulfilment Cycle Time		1.00								
Upside Supply Chain Flexibility			1.00							
Upside SC Adaptability				1.00						
Downside SC Adaptability					1.00					
SCM Cost						1.00				
Cost of Goods Sold							1.00			
Cash-To-Cash Cycle Time								1.00		
Return on SC Fixed Assets									1.00	
Return on Working Capital										1.00
Agility										
	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside SC Flexibility	Upside SC Adaptability	Downside SC Adaptability	SCM Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on SC Fixed Assets	Return on Working Capital

Perfect Order Fulfilment	1.00									
Order Fulfilment Cycle Time		1.00								
Upside SC Flexibility			1.00							
Upside SC Adaptability				1.00						
Downside SC Adaptability					1.00					
SCM Cost						1.00				
Cost of Goods Sold							1.00			
Cash-To-Cash Cycle Time								1.00		
Return on SC Fixed Assets									1.00	
Return on Working Capital										1.00

Costs

	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside SC Flexibility	Upside SC Adaptability	Downside SC Adaptability	SCM Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on SC Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.00									
Order Fulfilment Cycle Time		1.00								
Upside SC Flexibility			1.00							
Upside SC Adaptability				1.00						
Downside SC Adaptability					1.00					
SCM Cost						1.00				
Cost of Goods Sold							1.00			
Cash-To-Cash Cycle Time								1.00		
Return on SC Fixed Assets									1.00	
Return on Working Capital										1.00

Assets

	Perfect Order Fulfilment	Order Fulfilment Cycle Time	Upside SC Flexibility	Upside SC Adaptability	Downside SC Adaptability	SCM Cost	Cost of Goods Sold	Cash-To-Cash Cycle Time	Return on SC Fixed Assets	Return on Working Capital
Perfect Order Fulfilment	1.00									
Order Fulfilment Cycle Time		1.00								
Upside SC Flexibility			1.00							
Upside SC Adaptability				1.00						
Downside SC Adaptability					1.00					
SCM Cost						1.00				
Cost of Goods Sold							1.00			
Cash-To-Cash Cycle Time								1.00		
Return on SC Fixed Assets									1.00	
Return on Working Capital										1.00

Reliability										
	Lower consumer spending	Dis-honest suppliers	Third party logistics risks	Monopoly risk	Price volatility	Competitive risk	Outsourcing	Lack of network communication	Supplier delivery failure	Instability of market
Lower consumer spending	1.00									
Dis-honest suppliers		1.00								
Third party logistics risks			1.00							
Monopoly risk				1.00						
Price volatility					1.00					
Competitive risk						1.00				
Outsourcing							1.00			
Lack of network communication								1.00		
Supplier delivery failure									1.00	
Instability of market										1.00
Responsiveness										
	Lower consumer spending	Dis-honest suppliers	Third party logistics risks	Monopoly risk	Price volatility	Competitive risk	Outsourcing	Lack of network communication	Supplier delivery failure	Instability of market
Lower consumer spending	1.00									
Dis-honest suppliers		1.00								
Third party logistics risks			1.00							
Monopoly risk				1.00						
Price volatility					1.00					
Competitive risk						1.00				
Outsourcing							1.00			
Lack of network communication								1.00		
Supplier delivery failure									1.00	
Instability of market										1.00
Agility										

	Lower consumer spending	Dis-honest suppliers	Third party logistics risks	Monopoly risk	Price volatility	Competitive risk	Outsourcing	Lack of network communication	Supplier delivery failure	Instability of market
Lower consumer spending	1.00									
Dis-honest suppliers		1.00								
Third party logistics risks			1.00							
Monopoly risk				1.00						
Price volatility					1.00					
Competitive risk						1.00				
Outsourcing							1.00			
Lack of network communication								1.00		
Supplier delivery failure									1.00	
Instability of market										1.00
Costs										
	Lower consumer spending	Dis-honest suppliers	Third party logistics risks	Monopoly risk	Price volatility	Competitive risk	Outsourcing	Lack of network communication	Supplier delivery failure	Instability of market
Lower consumer spending	1.00									
Dis-honest suppliers		1.00								
Third party logistics risks			1.00							
Monopoly risk				1.00						
Price volatility					1.00					
Competitive risk						1.00				
Outsourcing							1.00			
Lack of network communication								1.00		
Supplier delivery failure									1.00	
Instability of market										1.00
Assets										
	Lower consumer spending	Dis-honest suppliers	Third party logistics risks	Monopoly risk	Price volatility	Competitive risk	Outsourcing	Lack of network communication	Supplier delivery failure	Instability of market
Lower consumer spending	1.00									
Dis-honest suppliers		1.00								
Third party logistics risks			1.00							
Monopoly risk				1.00						
Price volatility					1.00					
Competitive risk						1.00				

Outsourcing							1.00			
Lack of network communication								1.00		
Supplier delivery failure									1.00	
Instability of market										1.00

Reliability								
	Political instabilities	Theft	Poor transport infrastructure	Unstable taxation	Power and energy risks	Terrorism	Corruption	Unstable Government policies
Political instabilities	1.000							
Theft		1.000						
Poor transport infrastructure			1.000					
Economic Instability				1.000				
Power and energy risks					1.000			
Terrorism						1.000		
Corruption							1.000	
Unstable Government policies								1.000

Responsiveness								
	Political instabilities	Theft	Poor transport infrastructure	Unstable taxation	Power and energy risks	Terrorism	Corruption	Unstable Government policies
Political instabilities	1.000							
Theft		1.000						
Poor transport infrastructure			1.000					
Economic Instability				1.000				
Power and energy risks					1.000			
Terrorism						1.000		
Corruption							1.000	
Unstable Government policies								1.000

Agility								
	Political instabilities	Theft	Poor transport infrastructure	Unstable taxation	Power and energy risks	Terrorism	Corruption	Unstable Government policies
Political instabilities	1.000							
Theft		1.000						
Poor transport infrastructure			1.000					
Economic Instability				1.000				
Power and energy risks					1.000			
Terrorism						1.000		
Corruption							1.000	
Unstable Government policies								1.000

Costs								
	Political instabilities	Theft	Poor transport infrastructu re	Unstable taxation	Power and energy risks	Terrorism	Corruption	Unstable Governmen t policies
Political instabilities	1.000							
Theft		1.000						
Poor transport infrastructure			1.000					
Economic Instability				1.000				
Power and energy risks					1.000			
Terrorism						1.000		
Corruption							1.000	
Unstable Government policies								1.000
Assets								
	Political instabilities	Theft	Poor transport infrastructu re	Unstable taxation	Power and energy risks	Terrorism	Corruption	Unstable Governmen t policies
Political instabilities	1.000							
Theft		1.000						
Poor transport infrastructure			1.000					
Economic Instability				1.000				
Power and energy risks					1.000			
Terrorism						1.000		
Corruption							1.000	
Unstable Government policies								1.000

Reliability						
	Customers flexibility	Adaptability	Outsourcing	Velocity	Agility	Efficiency
Customers flexibility	1.000					
Adaptability		1.000				
Outsourcing			1.000			
Velocity				1.000		
Agility					1.000	
Efficiency						1.000
Responsiveness						
	Customers flexibility	Adaptability	Outsourcing	Velocity	Agility	Efficiency
Customers flexibility	1.000					
Adaptability		1.000				
Outsourcing			1.000			
Velocity				1.000		
Agility					1.000	

Efficiency						1.000
Agility						
	Customers flexibility	Adaptability	Outsourcing	Velocity	Agility	Efficiency
Customers flexibility	1.000					
Adaptability		1.000				
Outsourcing			1.000			
Velocity				1.000		
Agility					1.000	
Efficiency						1.000
Costs						
	Customers flexibility	Adaptability	Outsourcing	Velocity	Agility	Efficiency
Customers flexibility	1.000					
Adaptability		1.000				
Outsourcing			1.000			
Velocity				1.000		
Agility					1.000	
Efficiency						1.000
Assets						
	Customers flexibility	Adaptability	Outsourcing	Velocity	Agility	Efficiency
Customers flexibility	1.000					
Adaptability		1.000				
Outsourcing			1.000			
Velocity				1.000		
Agility					1.000	
Efficiency						1.000

Reliability						
	Role clarity	Informal networking	Product awareness	Information and communication Technology	Risk communication channels	Knowledge management
Role clarity	1.000					
Informal networking		1.000				
Product awareness			1.000			
Information and communication Technology				1.000		
Risk communication channels					1.000	
Knowledge management						1.000
Responsiveness						

	Role clarity	Informal networking	Product awareness	Information and communication Technology	Risk communication channels	Knowledge management
Role clarity	1.000					
Informal networking		1.000				
Product awareness			1.000			
Information and communication Technology				1.000		
Risk communication channels					1.000	
Knowledge management						1.000
Agility						
	Role clarity	Informal networking	Product awareness	Information and communication Technology	Risk communication channels	Knowledge management
Role clarity	1.000					
Informal networking		1.000				
Product awareness			1.000			
Information and communication Technology				1.000		
Risk communication channels					1.000	
Knowledge management						1.000
Costs						
	Role clarity	Informal networking	Product awareness	Information and communication Technology	Risk communication channels	Knowledge management
Role clarity	1.000					
Informal networking		1.000				
Product awareness			1.000			
Information and communication Technology				1.000		
Risk communication channels					1.000	
Knowledge management						1.000
Assets						
	Role clarity	Informal networking	Product awareness	Information and communication Technology	Risk communication channels	Knowledge management
Role clarity	1.000					
Informal networking		1.000				
Product awareness			1.000			
Information and communication Technology				1.000		

Risk communication channels					1.000	
Knowledge management						1.000

Appendix 14: Validation interview template

Dear Participant,

At the beginning, I would like to thank you for your time, cooperation and effort in providing me with valuable information during the data collection to investigate the all the risks that face FMCG companies in the MER and rank them, in addition to the important capabilities and their relative importance to SC resilience, and finally, the KPIs that can be used to measure FMCG SC resilience. Based on the valuable information provided, I was able to develop a SC resilience model for FMCG industry SCs operating in the MER. However, for part of the conclusion, I am required to validate the model by reporting back to some key participants to get feedback regarding the model developed.

Validation interview questions:

- Could you please provide me with any comments regarding the risk factors and their rankings?
- Could you please provide me with any comments regarding the SC resilience capabilities and their relative importance in enhancing SC resilience?
- Could you please provide me with any comments regarding the SC resilience KPIs?
- What do you think about the new links discovered between the SC performance attributes and level 1 KPIs?
- Could you please provide me with any comments regarding the matrices developed that demonstrates the interrelations between risks, capabilities, and KPIs?
- Do you have any other suggestions for how to make the model more relevant to practice?