

An Investigation into Risk and Vulnerability in the UK Food Supply Network

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ABSTRACT

PURPOSE: The aim of the thesis was to investigate the constructs of risk and vulnerability at a network level for the UK food supply system. Through a deeper re-examination of data collected for the Chatham House project, the objectives of the thesis were to understand actors' perceptions of threats within UK food networks and how these relate to the constructs of risk and vulnerability.

METHOD: Using a grounded analysis approach, the research re-examined data from case studies in the UK dairy and wheat supply networks, from a supply chain risk management (SCRM) and supply chain vulnerability (SCV) perspective. While not in the tradition of a true grounded theory method, the study looked to support theory building through comparison of findings to key literature in the SCRM and SCV fields.

FINDINGS: The study revealed that risk, vulnerability and resilience are highly interrelated. How actors perceived risk, along with their willingness or capability to act, were core dynamics of SCV. Innovation was also identified as a major influence on resilience and adaptive capacity. At a network level, vulnerability can be characterised as system change. Thus the research highlights convergences between the fields of ecological resilience, system transition, SCV and supply chain resilience (SCRES) for supply networks.

RESEARCH IMPLICATIONS: There has been very little research into SCRM, SCV and SCRES at a network level. This thesis presents a conceptualisation of these constructs for the UK food supply network, along with their interconnections, and therefore provides a contribution to these fields.

PRACTICAL IMPLICATIONS: Wider socio-economic and environmental outcomes of the UK food network are at risk and there needs to be more cohesive, network-based policies and approaches to support greater resilience. This will require a stronger lead from government and collaborative approaches from policy makers and supply actors.

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List of Abbreviations

CAP	Common Agricultural Policy
CCC	Committee on Climate Change
CCRRC	Coca Cola Retailing Research Council
CH	Chatham House
EC	European Commission
EU	European Union
EFRA	Environment, Food and Rural Affairs Committee
DEFRA	Department for the Environment, Farming and Rural Affairs
FAO	Food and Agriculture Organisation of the United Nations
FEC	Food Ethics Council
FFPI	FAO Food Price Index
GCA	Groceries Code Adjudicator
GM	Genetic modification
IGD	Institute of Grocery Distribution
NGO	Non-governmental Organisation
R&D	Research and Development
RBV	Resource Based View
SC	Supply Chain
SCRES	Supply Chain Resilience
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
SCV	Supply Chain Vulnerability
SKU	Stock Keeping Unit
TCE	Transaction Cost Economics
TSB	Technology Strategy Board

Chapter One: Introduction

1.1 Background to the thesis

1.1.1 Supply Chain Risk and Vulnerability

Modern supply chains are facing increased risk and uncertainty, driven by the prevailing supply chain strategies of globalisation, outsourcing, lead-time reduction, reduced inventory holding and increasing integration. (Sheffi and Rice, 2005, Zsidisin et al., 2005). This uncertainty manifested itself in a number of high profile disruptions, notably the period post the 9/11 attacks and the outbreak of SARS in South-East Asia. As with food chains, these disruptions served to underline the interconnectedness of supply chains with growing appreciation of how sudden shocks within one area can spread to cause disruption in directly connected chains. This sparked an impetus for supply chain managers to mitigate for both everyday demand-supply co-ordination risks but also for these types of high impact, low probability disruption risks (Faisal et al., 2006, Zsidisin et al., 2005, Kleindorfer and Saad, 2005, Norrman and Jansson, 2004, Zsidisin et al., 2004). Despite this, supply chain risk management still remains pre-dominately focused on shock-based contingent risks , sourced within the immediate supply chain rather than within the wider supply or other interconnected networks.

From an academic perspective, while there has been significant interest in SCRM in the last 10 years, the conceptualisation of systemic risks and uncertainties within the wider environment is under-developed. These risk sources are often exogenous to the supply network but have the potential to create severe consequences for the competitive future of organisations (Christopher and Holweg, 2011, Trkman and McCormack, 2009). These risks are manifested either through incidents of sudden shocks but also through systemic change [rate of change here is an issue too] which affect the economic, political and social space within which organisations operate. As supply chains become more complex, there is more of an

imperative to understand risks from both an internal perspective (to the firm and network) and the external environment (Christopher and Holweg, 2011, Ritchie and Brindley, 2007) To date, there have been no previous studies which have examined the convergence of global and local (exogenous and endogenous) factors and their implications for UK food supply vulnerability from either a systemic or network-based perspective.

Despite these growing pressures, at the time of the thesis, the concepts of supply risk and vulnerability were still considered to be in their infancy (Juttner, 2005, Juttner and Maklan, 2011, Ponomarov and Holcomb, 2009). Despite a significant increase in interest in this area, there still remains insufficient understanding of these concepts to date (Hohenstein et al., 2015). In particular there has been little research as to how these concepts apply across supply networks (Greening and Rutherford, 2011) and how the interplay between exogenous global factors and endogenous, internal structural and relational factors impacts on supply vulnerability. Previous studies have mirrored organisational approaches in their tendency to deal with more narrowly based definitions of risk, more easily quantifiable, focused either at single or dual organisational levels. The SCRM literature in general tends to be narrowly focused (not multi-disciplinary) and without a more holistic understanding of the dynamics across networks. While SCV is characterised as the interdependency and the interactions between organisations, there is also little research into how actors' perception of risk impact on these interactions. There is also a tendency for research to be in the 'positive' tradition, focusing on strategies and actions for mitigation, rather than normative i.e. why supply chains may be vulnerable to disruptions (Peck, 2005). From an academic perspective, this signals significant gaps in this arena.

1.1.2 Food supply chain disruptions

Food supply chains have seen a rise in disruptions and the UK agri-food system has seen a number of well publicised crises over the last decade. These include the outbreak of BSE during the 1990s, the occurrence of foot and mouth disease in 2001 and food contamination scares (e.g. Sudan 1). The food chain has

also seen wide-spread disruption from seemingly unconnected events such as the fuel protests strikes in 2000 (Peck, 2005), the Buncefield oil depot fire in 2005 (Gardner, 2007) and the floods of 2007 (BBC, 2010). These crises served to underline that agri-food chains are vulnerable to both shock type risks, both external and internal (e.g. disease, terrorism, natural disasters) but also to ‘creeping’ systemic crises (e.g. fuel protests) where one small event can escalate throughout the whole system (Peck, 2005).

1.1.3 Context 2006-2008

The vulnerability of the food system was underlined in the period 2007-2008 by the food price shocks which demonstrated how external, global events can flow through to affect the business environment in the UK. The FAO food price index (FFPI) reached a record 219 points in June 2008, 51% higher than seen over the previous year (FAO, 2008a). These price rises triggered a ‘food crisis’ in developing countries – an estimated extra 73-105 million people globally were catapulted into poverty as a direct result (World Bank, 2008). Developing countries were faced with civil and political unrest, culminating in a series of trade restricting or distorting measures such as export restrictions, reduction in food related taxes and price controls (World Bank, 2008).

While increased prices had a devastating effect on developing countries, the price shocks also affected developed countries. In the UK, the rise in prices flowed through to the retail shelf; food price inflation peaked at 12.8% in August 2008 (ONS, 2008). Consumers in the UK, as well as agri-food businesses, saw a sudden reversal in a 26-year trend of year on year price reductions, challenging expectations of sources of ever-cheaper food. Retailers, suppliers and producers alike were caught by surprise by the sudden price rises. The events triggered wide-spread concerns over the global interdependency of modern food supply chains and demonstrated the political and social importance of affordable food.

Prior to 2006, the concept of UK national food security had seemed an anachronism. Post 2006, this had started to change with a number of government based discussion documents being produced (see Peck, 2006 and DEFRA, 2006).

However, these studies were pre-dominantly policy based with no real analysis of the implications for supply chains or agri-businesses. Only Peck (2006) examined specific impacts on the resilience of the wider food supply system. There was still complacency at the potential levels of threats facing the UK food system and a lack of understanding of the systemic nature of these threats. The spectre of a period of continued food inflation, rather than deflation, forced the issue of UK national food security back onto the political agenda; the debate over national food security for the UK (and for other EU countries) has only re-emerged over the last few years.

1.1.4 The Chatham House study

In late 2006, in response to rising concern over UK food security, Chatham House initiated a research program to examine the impact of global trends, particularly resource constraints, on food supply. The impetus for the work was built on the need to bridge the absence of systemic analysis and potential strategic and policy blind-spots, particularly in the face of potential threats to national food security. This two-year programme, entitled 'UK food supply in the 21st Century: The New Dynamic', was established to explore how combination of global factors could affect the UK food supply system over the next decade. The research objectives were to identify the strategic options open to stakeholders across the supply networks and highlight policy implications and gaps. To illuminate the issues, two sectors were chosen as exploratory cases – that of the wheat and dairy sectors. The programme revolved around the development of four globally-based scenarios. These explored the systemic inter-linkages between global factors and the range of potential outcomes for global food production. At the time the scenarios were developed, the food price crisis had fully manifested itself and actors were concerned as to whether price rises heralded a step change in food supply. The scenarios therefore depicted a range of possible outcomes in the global arena – namely, *Just a Blip* (that prices would fall back to pre-crisis levels), *Food Inflation* (cost pressures would see ongoing food inflation), *Into a New Era* (higher food prices and scarcity would trigger a transformational system change) and *Food in Crisis* (acute prices would trigger shortages). To assess how these global scenarios could impact UK supply, a series of workshops were held with senior representatives from within the dairy and wheat

supply networks, and those who had wider food-based interests from both governmental and non-governmental sectors.

The study formally started in late 2006, with data collection taking place between 2007 and early 2008, with the report published in 2009. The researcher was the Principal Investigator for the project and undertook a lead role in the research project; being responsible for the research design, much of the data collection, all of the analysis and overall delivery of the research objectives. The researcher was also responsible for the majority of the drafting of the final report which outlined the key research findings (see Ambler-Edwards et al., 2009). The data set gathered as part of this wider project forms the core of this thesis.

1.1.5 Food system vulnerability post 2008/09

Post 2008-2009, food prices started to reduce (although even now in 2015, they are still higher than pre-2007 levels). While the immediate shock has passed, the Chatham House research revealed significant issues which could continue to impact food supply chains in the future. These included population growth, global switching to more resource intensive foods (e.g. meat), competition over land use, water and energy constraints and the threat of climate change (Ambler-Edwards et al., 2009). The raft of protectionist measures taken in light of the 2007-2008 food price rises, indicate that the future robustness of and access to global markets may not always be relied on. The increasing exposure of the UK food system to these global markets (particularly agriculture) has the potential to create more price shocks and market volatility.

All of these factors could continue to increase uncertainty within the marketplace. While this global supply serves to deliver a greater range of choice and availability of products to the UK market, it in turn creates increasing exposure to complex political, social and economic effects that have not been considered in their entirety. The complex nature of food supply itself, its interdependencies and resource-heavy usage point to increasing vulnerability from more exogenous, systemic sources of risk and uncertainty. These wider uncertainties and the resultant vulnerability of the food system will take on increasing importance, prompting

questions over how concepts of supply chain vulnerability will need to be framed in the future.

1.2 Aims and objectives of the thesis

While the CH report articulated the pressures faced by the UK food system, the research was conducted from a policy perspective rather than a supply chain vulnerability perspective. The study did not specifically examine the data to understand how global effects interacted with the inherent properties of the UK food supply network to create vulnerabilities (and/or the opposite, resilience). While the data gathered did encompass the likely actions behaviours by actors across the supply network, this data was not used extensively to understand how these interactions contributed to the vulnerability of the network. It therefore did not address the questions raised by the SCRM and vulnerability literature.

From a food system perspective, there are a number of studies and reports which examine single-point issues that have relevancy to agri-food chains. These have majored on either the environmental aspects (e.g. Manning, 2008, Vasileiou and Morris, 2006) or food safety risks (e.g. Manning et al., 2007, Roth et al., 2008). A few studies have examined the impacts of global, external factors but these again are pre-dominantly single-issue in focus (e.g. Manning et al., 2007), with a heavy bias towards animal disease and food safety issues. However, there have been relatively very few studies which examined the vulnerability of the UK food system when faced with the impacts of the combination of globally-sourced, systemic risks.

This PhD therefore arose from the need to bridge the gaps, both in terms of understanding further the systemic vulnerability of the UK food system but also in terms of the contribution to the body of knowledge on SCRM and vulnerability. The data collected during the Chatham House project was numerous and rich, encompassing actors' perceptions right across the wheat and dairy supply networks, and other stakeholders such as consumer groups, government and NGOs (over 70

actors were involved in the study). The data collected also contained significant information on how actors might respond in light of the four scenarios, with potential insight into how they evaluated the potential threats and risks and their perceptions of likely impacts. This data therefore had the potential to support a more normative, grounded study of risk and vulnerability phenomena. This thesis therefore undertook a fresh examination and analysis of this data, taking a more explicit supply chain risk management perspective. The objectives for the thesis took guidance from the identified gaps in previous supply risk and vulnerability studies; principally to:-

- undertake research which examines risk and vulnerability at a network level for the UK food system
- to re-examine and provide a deeper analysis of the data collected through the Chatham House research project from a supply chain risk and vulnerability perspective
- to understand actors' perceptions of risks and vulnerabilities within the UK food supply system

The research questions that guided the study were as follows:

RQ1: How do actors conceptualise risk and vulnerability within the UK food supply system?

RQ2: How do the endogenous characteristics of the UK food supply system, in terms of its structure and dynamics, contribute to the perceived level of vulnerability in light of global, exogenous uncertainties?

RQ3: How adequate are these conceptual frameworks of vulnerability, resilience and adaptive capacity in light of global phenomena?

RQ4: What are the implications for stakeholders and policy makers in their aims to reduce vulnerability and encourage a more robust UK food system

RQ5: What are the implications for future research into concepts of vulnerability, resilience and adaptive capacity?

The first research question sets the scene to understand how actors perceived the threats and risks facing the food system (through the lens of the four CH scenarios), their core concerns and their potential blind-spots. The second question looks to address the need to understand the interplay between external threats and the internal, inherent characteristics of the UK food system and how these may combine to create vulnerability for the network. Question three supports exploratory theory building by comparing the existing concepts of vulnerability (from the literature) to the concepts that emerge from the data (Gill and Johnson, 2002). Research questions four and five are designed to critically evaluate the findings from the data and draw conclusions as to the contribution of the thesis, the potential impacts on stakeholders and the implications for future research in this field.

1.3 Thesis Approach

1.3.1 Level of analysis and scope

As the thesis re-examined data collected from the CH study, the scope and level of analysis was dictated by the structure of the CH study. In this respect, the level of analysis was at a supply network level. While supply networks are seen as the highest level of analysis for SCM research (Croom et al., 2000, Harland et al., 2001), research is often from the perspective of a focal firm and its respective supply chain (Miemczyk et al., 2012). In this instance, the supply network is described as the entire network for a particular industrial sector, known as the industrial network (Hakansson and Ford, 2002, Gadde et al., 2003, Ritter et al., 2004). The examination of these wider connections is particularly important when examining major disruptions to supply chain nodes, where there is a need for firms to seek new connections within the wider context of the market/industrial network (Greening and Rutherford, 2011).

The networks under consideration were those of the wheat and dairy industrial networks. The food system has two key routes through to the consumer – through food service or through retail. While some actors from the food service

industry made up a small proportion of the participants, in this instance, a decision was taken to focus predominately on the retail route to market, chiefly as this had the most political interest and acts as the front line in food provision in a food crisis. In addition these networks spread their tentacles into secondary support industries and beyond, therefore for the purpose of the study, the network was bounded to include only:-

- retailers
- general food manufacturers/processors
- mills/bakeries/dairy processors
- traders (predominately grain traders)
- dairy and wheat producers
- primary agricultural support organisations (e.g. agri-chemical suppliers)

1.3.2 Research methodology

The methodology for the thesis is in the case study tradition (Yin, 1994) with the two cases being the industrial networks of the UK wheat and dairy sectors. Case study methods are appropriate as exploratory devices in industrial networks where there is little knowledge in the field (Gill and Johnson, 2002) and are also consistent as a method for theory building (Bryman and Bell, 2003). While not in the tradition of a true grounded theory method (as theoretical sampling was not used and the data and analysis were not conducted simultaneously (Glaser and Strauss, 1967, Suddaby, 2006), it took a grounded approach to the re-examination and analysis of the CH data. In this sense, the approach took guidance from the development of new theory by contrasting the daily reality and how these phenomena are interpreted by those who interact with them (Glaser and Strauss, 1967). The thesis is in keeping with the interpretive, inductive tradition (Crotty, 2002) in developing a deeper understanding ('verstehen') of social phenomena and their interlinkage at an 'adequate causal' level (Weber, 1962). To employ a systemic approach to the analysis, a five phase approach was used (as described by Yin (2010):-

1. compiling of the data – organisation of data collected

2. disassembling of data – through formal coding
3. re-assembly of the data – to assemble emerging patterns
4. interpretation of the data – to develop meaning pertinent to the study
5. conclude – to show the broader significance of findings and challenge current thinking

Table 1.1 shows the original data collection instruments, the purpose they served in the CH study and how they were used in this thesis.

Data collection	Original purpose (Chatham House Project)	Thesis purpose
General interviews (Food system dynamics 2007-2008)	-To understand how actors perceived the dynamics of the food crisis in 2007 -To identify core global factors which could create changes in future dynamics -To develop the four scenarios	-To contextualise the dynamics of 2007/2008 period
Supply chain sector interviews (wheat and dairy actors)	-To understand actors' perceptions of key drivers of risk and vulnerability impacting their organisation	-Key responses by actors related to conceptions of risk of risk and vulnerability
Initial scenario workshops (1 x wheat actors, 1 x dairy actors)	-To test scenarios for plausibility -To gauge initial reactions from actors	-How wheat and dairy actors conceptualise risk -Thematic analysis to identify risk categories -How risk categories apply to the different echelons of the wheat and dairy networks
Main scenario workshops (1 x wheat actors, 1 x dairy actors)	-To identify the potential impact of scenarios on UK food system -To understand the likely actions, behaviours and strategies of actors across the food system	-To identify the core factors which impact on vulnerability of the wheat and dairy supply networks -To build a conceptual framework which shows how these factors interlink

Table 1.1 : Data collection and its usage

1.3.3 Timeline of the thesis

As this thesis was undertaken on a part-time basis, the literature review, the data analysis and synthesis and the writing process took place over a significant period of time with a number of hiatuses. The timeline for the thesis is shown in figure 1.1. The data was collected between 2007 and 2008 and the thesis looks to ground this in the context of the time and provide a snap shot of actors' perceptions during this period. As can be seen, the main literature review took place between 2009 and 2012 and this body of work formed the basis for the research questions and analysis. This was followed by an update covering developments within the fields of SCV and SCRES conducted in 2015, forming the latter part of the literature review chapter.

The extended writing period created an opportunity within the thesis to evaluate how the findings stand-up in light of events and changing contexts within the food system over the last four to six years. The thesis therefore includes a chapter which summarises the main changes in the food system since 2009 and assesses whether the findings have stood the test of time.

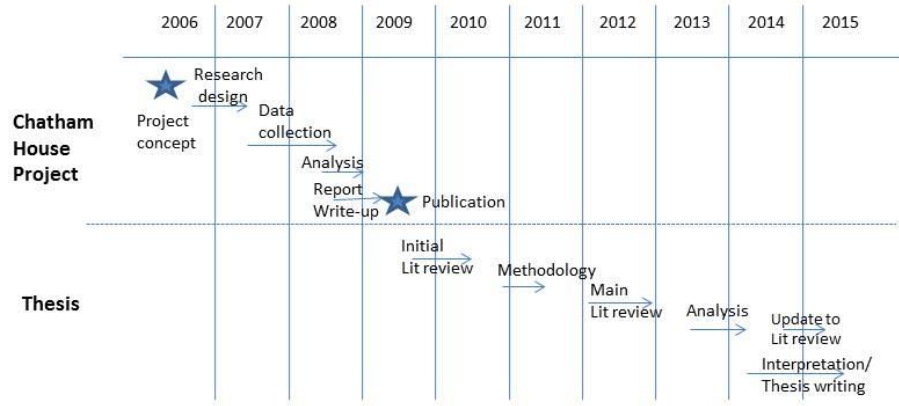


Figure 1.1 Timeline of the thesis

1.4 Structure of Thesis

This thesis is structured in ten chapters. Figure 1.2 shows how these chapters link together with table 1.2 summarising the purpose of each chapter.

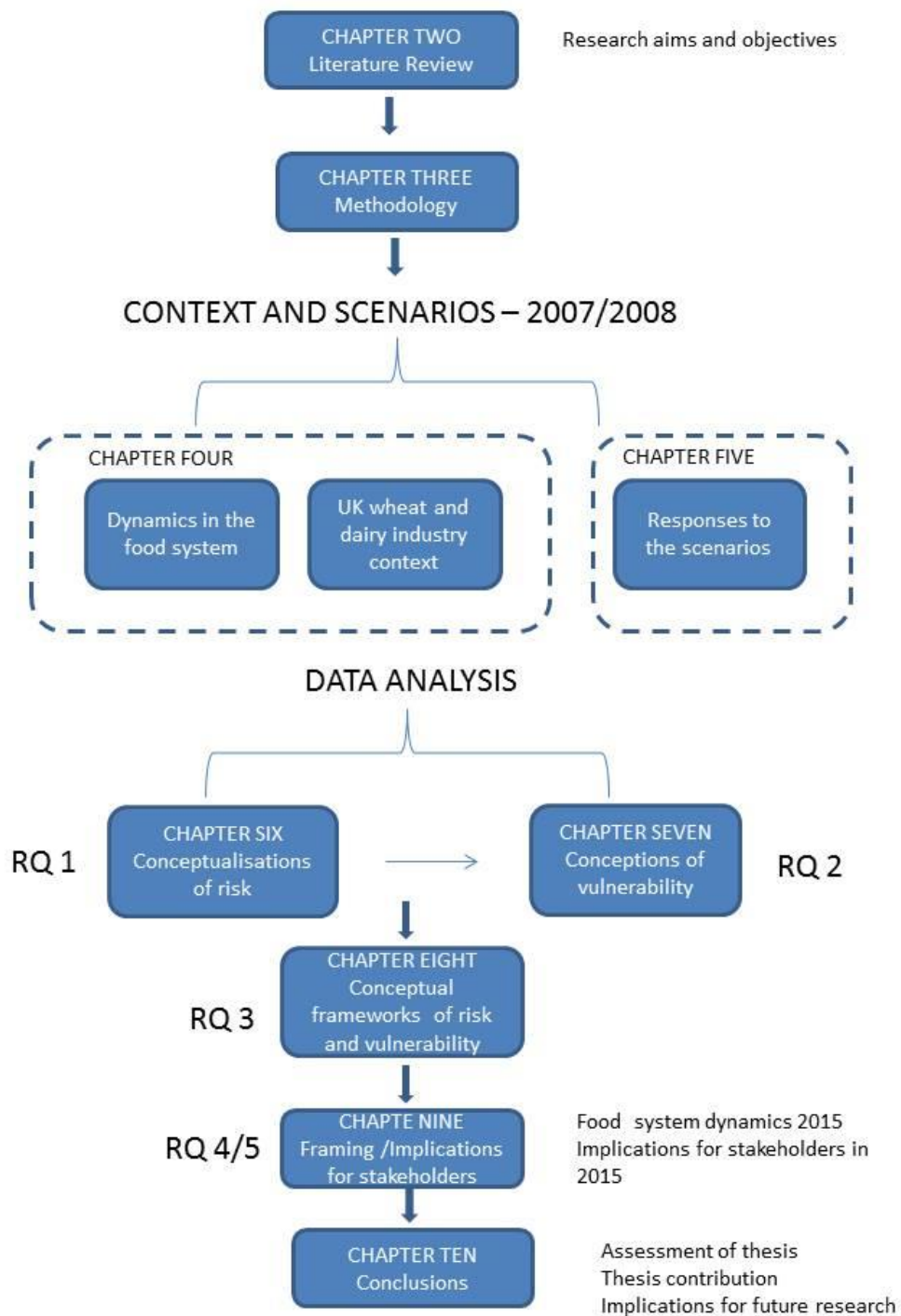


Figure 1.2 : Map of the thesis

Chapter	Title	Purpose
One	Introduction	-To introduce the theme and context of the thesis
Two	Literature Review	-Overview of SCM and SCRM literature up to 2012 -Update of SCV and SCRES literature 2012-2015 -Establishment of research gap and justification for research questions
Three	Methodology	-Explanation of research philosophy -Research approach and design including how data was re-examined and analysed
Four	The Dynamics of the UK Food System	-The context of the UK food system (dairy and wheat sectors) as of 2008-2009 -Key dynamics of period as perceived by actors
Five	Responses to the Chatham House Scenarios	-How actors responded to the four scenarios -Likely effects of the scenarios on the dairy and wheat sectors
Six	Conceptualisations of risk	-How actors perceive risk -Explanation of the risk categories derived from the data
Seven	Conceptions of vulnerability	-The exogenous and endogenous factors impacting on actors' perceptions of vulnerability - The interlinkages between factors and a conceptual framework of vulnerability
Eight	Conceptual frameworks of risk and vulnerability – towards new thinking?	-An assessment as to how well frameworks and concepts within the SCRM literature match thesis findings
Nine	Framing of the debate and implications for actors	-How the issues have been framed since 2008 -An update on the wheat and dairy sectors since 2008 -An evaluation as to how relevant the findings and conceptual frameworks from this research are now
Ten	Conclusions	-Contribution to the field of SCRM -Implications for future research

Table 2.1: Summary of chapters

Chapter Two is a review of the supply chain management, supply chain risk and vulnerability literature. It also maps out the research gap and provides justification for the five research questions which guided the thesis research. Chapter three establishes the research philosophy of the researcher. It also gives a description of the wider Chatham House project and how scenarios were developed to provide a way of conceptualising how global demand and supply dynamics could impact the UK food supply system. The chapter proceeds to explain how the data used within the thesis was collected. The research methodology for the thesis is explained along with how the data was re-coded and analysed afresh. The chapter ends by detailing how this data was used in the subsequent chapters to answer the five research questions.

Chapter Four sets the context for the UK food system, using the dairy and wheat sectors as examples, during the 2008-2009 period (the time of the data collection). It presents data from interviews conducted to understand how actors, both from within the food system and peripheral to it, perceived the key dynamics at that time and where their concerns lay. Chapter Five presents the narrative of the four scenarios that were pivotal in collecting subsequent data as to how actors perceived risk and vulnerability.

Chapter Six is concerned with the findings from the analysis as to how actors perceive and conceptualise risk. The chapter explores the different categories of risk that emerged from the empirical data and how these perceptions differed as to the position each actor has within the supply chain. Chapter Seven explores the conceptualisation of vulnerability. It presents a conceptual framework of exogenous and endogenous factors, emerging as core themes from the data, which impact on how actors view and think about vulnerability.

Chapter Eight critically examines how adequate current conceptualisations are in the field of SCRM and vulnerability. It compares the findings and conceptual frameworks developed from the empirical data in the thesis with other conceptions and theories and highlights potential gaps and contradictions.

Chapter Nine gives an update of the dynamics post the 2008 food crisis period and assesses the weakness in the current framing of the issues facing the food system. The chapter also assesses the relevance of the findings and conceptual frameworks derived from the data in this thesis and how well they have stood the test of time since the crisis. It also evaluates the validity of the research.

Chapter Ten presents the conclusions and summarises the contribution made by this thesis to the field of SCRM. It also sets out the implications for future research.

1.5 Conclusions

The thesis is concerned with the examination of risk and vulnerability in the UK food supply network. Through a fresh examination of data, previously collected as part of the Chatham House food study, it takes a grounded analytical approach to understand how risk and vulnerability is conceptualised by supply actors. It also looks to understand how global exogenous and supply network related endogenous factors impact on the vulnerability of the UK food system. The contribution therefore is to the field of supply chain risk and vulnerability.

Chapter Two: Literature Review

2.1 Introduction

As the research is to explore the concepts of supply chain risk and vulnerability in the context of the UK food supply system, the main focus of this chapter is to explore current thinking in the academic fields of supply chain risk and vulnerability, where there are potential gaps and where this thesis fits. Due to the timelines involved in this thesis, the main literature review was performed in 2012 and the majority of this chapter covers only literature up to this period. However a further review was conducted in 2015 to update developments in the SCV and SCRES fields and this is also included in this chapter.

Both supply chain risk and vulnerability have evolved from the field of supply chain management (SCM). The first part of this chapter therefore explores SCM itself, which forms the fundamental theoretical underpinning for any study into the interplay between organisations and their supply structures and dynamics. The chapter presents a summary of pertinent points from this field, covering how this field has been applied within a supply network context.

The chapter then proceeds to the core subject areas, that of risk, vulnerability and resilience. It first deals with the ideas of risk, and how these concepts have been incorporated into ideas of supply chain management. It then covers the related fields of supply chain vulnerability, resilience and adaptive capacity, exploring in some part definitions from other fields such as ecology.

The chapter follows with a discussion on recent studies into supply risk and vulnerability in relation to the UK food supply system. The next section presents the summary of the literature review as to the developments within the SCV and SCRES fields post 2015. The chapter concludes with an outline of the research gap that drove the methodological design and purpose of the thesis. It then details the research questions that guided the thesis, designed to help address this gap.

2.2. Supply Chain Management

2.2.1 Supply Chain management theory

Supply chain management emerged as a separate entity from that of operations management in the early 1980s (Croom et al., 2000, Cousins et al., 2006). It grew out of the development of logistics, in response to ever increasing complexities of supply-based processes and the need to co-ordinate inter-firm logistic activities. However supply chain management is considered to be a wider concept than just that of logistics-based activities. It was re-conceptualised during the early 1990s as the integration of key business processes, in addition to that of logistics processes. (Lambert and Cooper, 2000) :-

Supply chain management is the integration of key business processes from end users through original suppliers that provides products, services and information that add value for customers and other stakeholders. (Global Supply Chain Forum definition – from Lambert and Cooper(2000)).

Supply chain management is generally accepted to be have been led by business practice (Lambert and Cooper, 2000) rather than through theoretical means. The field therefore exhibits a strong alignment to actual SCM practice, but can suffer from the lack of theoretical rigour, in the development of supply chain specific theories (Harland et al., 2006, Burgess et al., 2006, Carter, 2011). There is therefore a need for development of normative and underpinning theoretical models (Burgess et al., 2006, Harland et al., 2006, Storey et al., 2006, Carter, 2011). However, the field is not without its theoretical foundations; these are based on existing theories from the disciplines of economics, strategic management and sociological disciplines (Burgess et al., 2006, Carter, 2011, Hitt, 2011). The most important of these are judged to be Transaction Cost Economics (TCE), the resource based view of the firm (RBV) and social exchange theory (Burgess et al., 2006, Hitt, 2011), which form the basis of many of the strands of supply chain management thinking and research.

SCM research has often been founded on a single discipline-based focus including those of purchasing, marketing, logistics, strategy, psychology/sociology, finance/economics, information technology and operations management (Cousins et al., 2006) although there is some evidence of multi-disciplinary studies. This range again indicates there is a very broad conceptual understanding of what SCM constitutes. The fragmentation and confusion concerning the definition of supply chains and the terms is an oft cited criticism (Croom et al., 2000, Storey et al., 2006) - Stock and Boyer (2009) identified 166 SCM definitions in their examination of the literature. Despite this, there is some convergence of opinion, particularly around the concepts of *integrated supply chain management*, as identified by Storey et al. (2006). These converging concepts are founded on the premise that the integration or increased co-ordination of processes and activities between actors and organisations within a chain (be it 2 or more echelons) will create increased efficiencies thus creating a level of competitive advantage (in this sense referencing TCE and social exchange theory). There is an inherent belief here that the combination of partnerships through the chain would result in better performance in the management of the flow of goods through the chain (Mentzer et al., 2001). The underpinning theory here, based on TCE is that there is an economic rationale and therefore benefit, to the integration of processes across the chain (Hakansson and Persson, 2004). This is the concept that it is supply chains that compete, rather than individual companies (Christopher, 1992).

2.2.2 Scope and ambition of SCM

SCM has developed as both a managerial and strategic function. From the management perspective, the goal is to organise and manage SC processes to meet consumer demand (Cousins et al., 2006). Responsibilities range from the management of information and product flows to the management of external relationships with suppliers and customers across the supply chain (Lambert and

Cooper, 2000, Mentzer et al., 2001). But it also encompasses decision making. At the top level this involves decisions on the planning of supply, what to source, what to make, how to meet customer demand and organise delivery channels (Storey et al., 2006).

Mentzer et al. (pg.18, 2001) define SCM as ‘the systemic, strategic co-ordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole’

There are strong interrelationships between supply chain structures, processes that operate across the supply chain and their strategic management (see figure 2.1). Supply chain management is therefore:-

- the integration of the processes to manage flows and information
- a set of management activities to strategically plan and structure flows
- the management of the network structure (Lambert and Cooper, 2000).

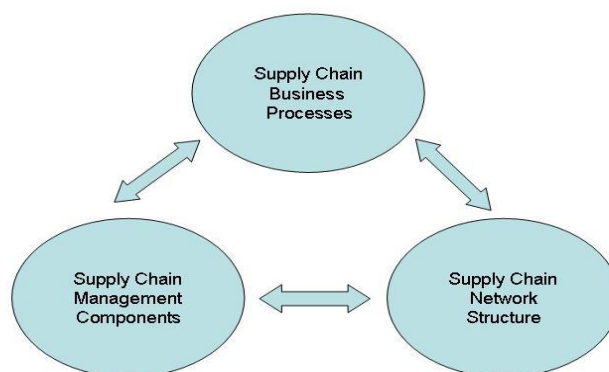


Figure 2.1 : Supply Chain Management Framework – from pg. 70, Lambert and Cooper (2000)

However, this conceptualisation does not recognise the important of inter-firm relationships. This emerged as a crucial element, vital in facilitating the ability of firms to co-ordinate product and information flows (Handfield and Nichols, 1999). A more comprehensive definition of supply chain is therefore provided by Handfield and Nichols (1999).

“The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage (extraction), through to the end user, as well as the associated information flows.....Supply chain management (SCM) is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage” (pg.2, Handfield and Nichols, 1999)

Thus SCM is conceptualised as the management of inter-organisational relationships (Lamming et al., 2001, Barratt, 2004, Cousins et al., 2006). Better relationships between suppliers and customers form the heart of this conceptualisation, partly based on the work by Deming (1986) from Wagner et al. (2002) and Porter (1980). Porter (1980), in particular, emphasized the economic advantages that could be gained by closer inter-firm alliances. The management of relationships therefore lies at the heart of successful supply chain management.

The theory underpinning integrated supply chains is often viewed as based on ‘idealised schema’ (pg. 760, Storey et al., 2006). This has led to the concept of the end-to-end integrated view of supply chain management being considered as a ‘philosophy’ of SCM (Lockamy and McCormack, 2004, Mentzer et al., 2001) rather than an actual achievable result. In practice this philosophical view of a fully integrated SCM remains just that; a philosophy. In practice, there is little empirical research to identify examples of supply chains where there is fully integrated management across the full supply chain or across the wider supply network. This

was recognised in research by Fabbe-Costes and Jahre (2008) and Kotzab et al. (2011) who note that 'there is a dearth of evidence in the relation to the extent to which SCM – as defined in the academic literature – is implemented or even understood in practice' (2011, pg. 233) There is therefore a level of pragmatism in some parts of the literature in recognising the difficulties in fully integrating processes. Here, the concept of integration is limited, in some cases to the alignment of value and strategic goals between partners rather than an integration of processes e.g. Stank et al. (1999), McAdam and Brown (2001). In others, the suggestion is for organisations to strategically pick and choose which processes and supply chain members should be integrated and co-ordinated (Lambert and Cooper, 2000).

2.2.3 Supply networks

These views of SCM are linked to perceptions about the nature of supply chains themselves. At the lowest level, supply chains are conceptualised as dyadic supplier/buyer relationships. Research focus on dyadic relationships forms a great part of the supply chain management literature – for example Fynes et al. (2005), Wagner et al. (2002) . However, there is a wider understanding of supply chains as the flow of goods and services through two or more organisations to customers/markets (Lambert and Cooper, 2000, Mentzer et al., 2001). However, the linear representation of the supply chain has come to be considered a little simplistic (Lambert and Cooper, 2000, Choi and Kim, 2008). In reality materials and information flow through a complex structure of organisations from initial raw materials to the end consumer; in effect a supply network.

A supply network is defined as 'interconnected entities whose primary purpose is the procurement, use and transformation of resources to provide packages of goods and services' (pg. 22 Harland et al., 2001). This is therefore the set of organisations who directly and indirectly produce products and services to support specific end-consumer markets (Harland et al., 2001). Lambert and Cooper (2000)

differentiate between primary members - those businesses that carry out direct value-adding activities for customers and end consumers – and supporting members – organisations who provide resources, knowledge or assets for the primary members.

In this definition, the network is viewed from the position of a focal firm – a single node into which flows products and information from multiple upstream suppliers out to downstream customers (Harland, 1996). This level of conceptualisation is often characterised as the highest for consideration by supply chain management (Croom, 2008) and most supply network research is from the perspective of a focal firm. However, this definition tends to neglect the interdependencies that operate between multiple suppliers and buyers in a supply network (Greening and Rutherford, 2011). Research into industrial networks emerged from the industrial marketing and purchasing fields (Möller and Wilson, 1995) and describes the complex interactions across a network embedded within a particular market. Often in the literature the use of supply network (focal firm) and industrial network (no focal firm) are used interchangeably (Miemczyk et al., 2012). However, the definition of the industrial network recognises the market context of the network and that organisations operate within a complex web of interconnected business relationships, some of which exist outside of the traditional supply chain linkages (Gadde et al., 2003, Ritter et al., 2004). This also extends to relationships with government, NGOs, the media and other non-business related organisations (Ritter et al., 2003). Figure 2.2 shows the structural differences between supply chains and industrial networks.

In this sense, no one relationship can be understood without reference to the wider network. Each company ‘gains benefits and incurs costs from the network in which it is embedded and from the investments and actions of all the other companies involved’ (pg.134, Hakansson and Ford, 2002). The examination of these wider connections is particularly vital when examining major disruptions to supply chain nodes, where there is a need for firms to seek new connections within the wider context of the industrial network (Greening and Rutherford, 2011). This level of analysis is also vital when examining the sustainability of practices, as the social

and environmental consequences of actors' behaviours expand further and impact a wider set of stakeholders than those contained within the immediate supply chain (Miemczyk et al., 2012). The inclusion of more actors in a supply network may uncover additional motives such as social, environmental and ethical considerations that may be missed using more isolated units of analysis (Pilbeam et al., 2012). The Chatham House project, by its nature, examined the food system from an industrial network perspective – there was no focal firm but examined different organisations and their perceptions across different points in the wheat and dairy industries. This thesis, therefore interprets the terms 'supply network' in terms of an industrial network; hence any reference to supply networks implies this definition.

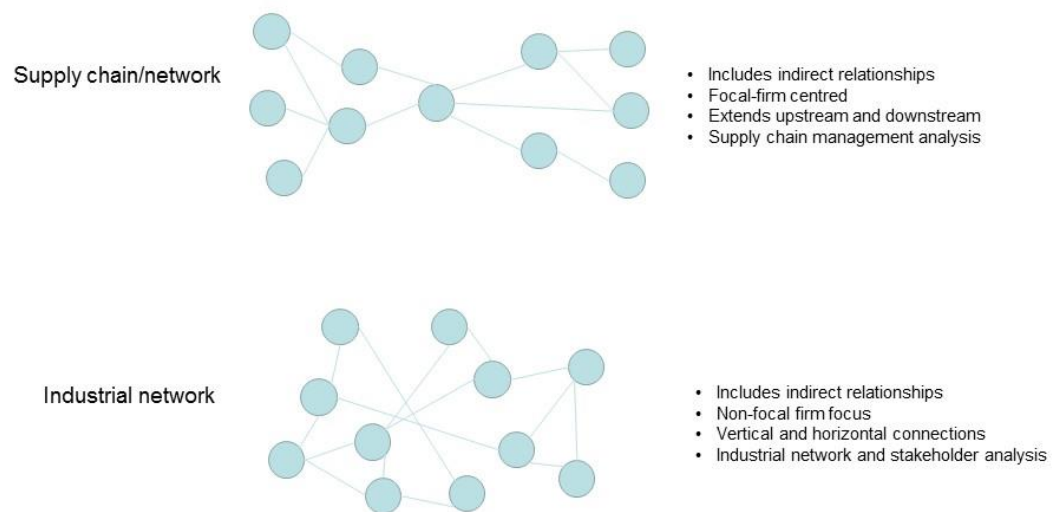


Figure 2.2: Levels of supply network analysis (adapted from Miemczyk et al, 2012)

2.2.4 Supply networks and SCM

How traditional SCM relates to the network setting, and how it needs to be adapted, presents an even more difficult challenge. From an industrial/supply network, it becomes virtually impossible for one firm to control and co-ordinate activities across the network in the traditional sense of SCM (Ritter et al., 2004). Gereffi et al. (2005) identify three key factors which impact on the extent to which networks can be successfully governed by lead firms :-

- the complexity of information required to sustain a transaction, especially in terms of product and process specifications
- the extent to which information can be codified and transmitted to parties without the need for transaction specific investment
- the capabilities of organisations and actors in the supply network to meet the requirements of the transaction

Gereffi et al (2005) identified five different types of governance, based on these factors. These are shown in figure 2.3.

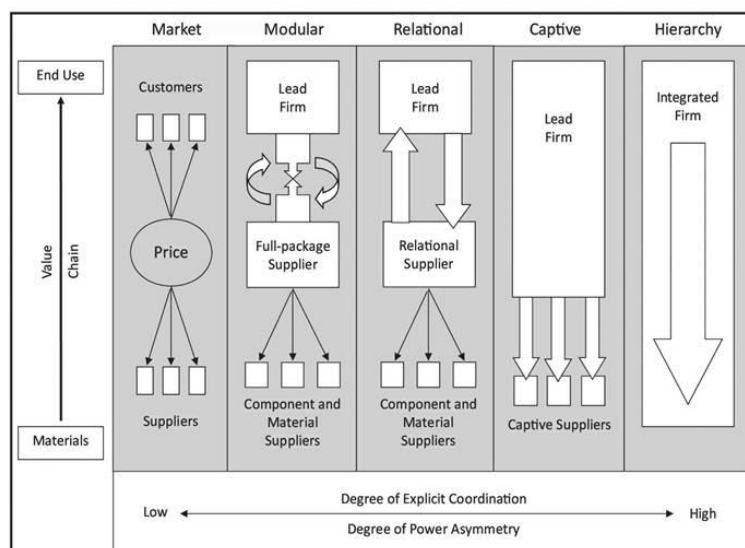


Figure 2.3 : Five global value chain governance types (Gereffi et al. (2005, pg.89)

More research has started to emerge with regards to supply networks – see Miemczyk et al. (2012), Pilbeam et al. (2012), Adenso-Diaz et al. (2012). While actors with greater power may have opportunities to control parts of the network, their span of control is limited or difficult where there are greater number of nodes/suppliers (Pilbeam et al., 2012). While the concepts of integrated SCM management hold, in that greater efficiency and effectiveness are the desired outcome, there is a need to focus on greater legitimacy and/or increasing flexibility (Pilbeam et al, 2012). Here, the concepts of SCM expand from managing serial interdependencies (direct relationships) to exploiting advantages arising from other interdependencies with a wider set of stakeholders across the network (Hakansson and Persson, 2004, Pilbeam et al., 2012). This has a subtle difference to the classic TCE underpinning in that, rather than developing relationships to guard against opportunistic behaviour and uncertainties, there are softer benefits from developing relationships outside of the traditional SCM model (Gadde et al, 2003). Gadde et al (2003) suggest therefore that while there is a need for supply chains to compete against competitors, there is also the need to develop complementary relationships (sometimes with competitors) in order to create the innovation and flexibility needed to survive within that particular market context. This gives rise to alternative mechanisms of governance, where trust and power emerge as important constructs along with more informal governance instruments (Pilbeam et al., 2012).

2.3 Risk, Vulnerability and Resilience

2.3.1 Risk definition and perceptions

The thesis' main topics are the concepts of SCRM and SCV. However it is useful to explore briefly the concept of risk itself. The term is an everyday concept but in reality its' meaning has evolved over time (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 (Bernstein, 1996). This probabilistic definition of risk was based on the values attached to all possible outcomes- both positive and negative – in conjunction with probability of each of these outcomes occurring. This definition of risk was known as the ‘expected value’ definition and can be summarised simply as :-

$$\text{Risk} = \text{probability of event} \times \text{impact}$$

Over time this quantifiable measure of risk became the prevailing definition in the fields of insurance and financial risk management through the 18th and 19th centuries. In many cases, the term ‘risk’ became synonymous with only the negative outcomes principally in terms of loss of capital or bankruptcy (Beaver, 1966). This loss based, probabilistic view of risk has perpetuated throughout the 20th century forming the basis of Health and Safety, environmental and financial risk management systems.

A continuing argument has raged over the validity of this mechanistic definition of risk, starting with the revised ‘expected utility’ definition as proposed by Daniel Bernouilli in 1738 (Bernstein, 1996). This definition indicated the subjective and context related element of risk taking; that a rational decision maker will take into account the ‘utility’ or benefit of the expected outcome to themselves personally. Further development of this argument has seen the emergence of a more subjective, social model of risk (The Royal Society, 1992), where risk is in effect non-quantifiable and wholly dependent on the perceptions of the decision maker (March and Shapira, 1987). This reflects the conceptualisation of risk in some management and psychology fields which emphasise an individual disposition to risk taking as a key factor in decision making (Manuj and Mentzer, 2008a). In this sense, the construct of risk is said to be socially constructed, and therefore contingent to different contexts and different actors (The Royal Society, 1992).

A further debate which characterises this field is the difference between the concepts of risk and uncertainty. The terms are often confused and used interchangeably and there is no agreed definition for either (Miller, 1992). In order to address this ambiguity, F.H. Knight, a 20th century economist, defined risk as a sub-

set of uncertainty, in effect the 'known' portion – 'It will appear that a measurable uncertainty, or "risk" proper ... is so far different from an un-measurable one that it is not in effect an uncertainty at all.' (p38, Knight, 1921) Knight went on to define uncertainty as the 'divergence of actual conditions from those that have been expected' (p38) introducing the idea that risk is effectively the variance from predicted outcomes. Interestingly, he associated this variance with the potential generation of profit. This view was echoed in part by Porter (1985) who indicated that competitive advantage can be gained through the better understanding and management of key uncertainties and their effect on industry structure and dependencies. This also reflects the concept of portfolio management, utilised within the financial management and investment field, which emphasises the need to balance risk with reward (Rao and Goldsby, 2009, Markowitz, 1962).

A number of recent developments have led to a widening of the concept of risk to encompass more uncertainty. In particular, the conception of the 'uncertainty principle', first mooted at the United Nations conference on environmental protection in 1992 (ILGRA, 2002), has re-opened the debate on the need to manage uncertainty. This principle was designed to create an impetus to take action independent of scientific uncertainty about the nature of the extent of risk and was initially used to generate the incentive to take action to prevent environmental damage. This placed the onus on the innovator or creator of potential risk to consider and assess the nature of the risk in the context of scientific uncertainty. This principle, which now underpins both European environmental and Health and Safety legislation, removed the 'ignorance factor' as an excuse for not managing unknown risks.

2.3.2 Risks in Supply Chains

There is a significant body of literature that is concerned with risk management from a business and managerial perspective (Khan and Burnes, 2007, Manuj and Mentzer, 2008a, Christopher et al., 2011). In addition, the concept of supply risk has a history of study in terms of buyer behaviour and supplier selection (Khan and Burnes, 2007) and most notably can be linked to the work by Williamson

on TCE and uncertainty avoidance in supplier contracting (Khan and Burnes, 2007, Williamson, 2008).

However, the field of supply chain risk management itself is considered to be in its infancy (Sodhi et al., 2012) although it has started to receive increase interest from academics (Rao and Goldsby, 2009, Colicchia and Strozzi, 2012). Literature in the field started to expand in the early 2000s and has seen a significant upswing from 2005 onwards (Tang and Musa, 2011, Colicchia and Strozzi, 2012). Interest in this area has been led predominately by practitioner concern (Sodhi et al., 2012) over the rise of supply chain risks. Modern supply chains have seen an increase in uncertainty, driven by the prevailing supply chain strategies of globalisation, outsourcing, lead-time reduction, reduced inventory holding and increasing integration (Sheffi and Rice, 2005, Zsidisin et al., 2005, Sodhi et al., 2012). This uncertainty has manifested itself in a number of high profile disruptions, such as 9/11, SARS and hurricane Katrina (Chopra and Sodhi, 2004, Manuj and Mentzer, 2008a). The increase in these phenomena, coined 'black swan' events (Taleb, 2008), have underlined the need to consider low probability and potentially unknown risks that could have catastrophic effects.

However, in addition, less wide-spread and contained events have had detrimental impacts on the performance of firms and their supply chains. A famous example of this is the fire at a single source supplier to Ericsson which caused immediate supply disruption and had a catastrophic effect on their market share (Norrman and Jansson, 2004). These events have served to underline the increasing complexity of modern supply chains (Colicchia and Strozzi, 2012, Sodhi et al., 2012) particularly those that stretch across the globe, their interconnections and growing exposure to externally generated uncertainty. This has sparked a growing impetus for supply chains to consider both demand-supply co-ordination risks and disruption risk management (Kleindorfer and Saad, 2005) and also to identify and mitigate against future potentially high impact, but low probability uncertainties and disruptions (Norrman and Jansson, 2004, Zsidisin et al., 2004, Zsidisin et al., 2005, Kleindorfer and Saad, 2005, Faisal et al., 2006)

Despite this increase of activity in the field of Supply Chain Risk management (SCRM), definitions and interpretations of both risk and SCRM are diverse and plentiful (Tang and Musa, 2011, Sodhi et al., 2012). However, from a risk perspective, the literature can be broadly split into those that view risk as a loss (e.g. Manuj and Mentzer, 2008a, Tang and Musa, 2011) or risk as a variance (e.g. Rao and Goldsby, 2009, Colicchia and Strozzi, 2012). Tang and Musa (2011) categorically state that risk is associated only with the negative outcomes and impacts. Losses are often conceptualised 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).

There is a small body of literature that conceptualises risk as variability in expected outcomes. For example, Zsidisin et al. (2005) define risk as 'variability in outcomes or results' (p3403). Rao and Goldsby (2009) turn to a financial definition of risk and identify two key elements to assessing whether risk is present – in that it is the exposure to an event and the uncertainty of possible outcomes (from Holton, 2004 in Rao and Goldsby, 2009). This is echoed in Juttner's definition, that risk is the variation in distribution of possible supply chain outcomes, likelihoods and their subjective values (Juttner, 2005). However, the predominant definition of risk still remains that of loss. This perhaps reflects the business impetus, and managerial tendency to focus on mitigating negative outcomes (Khan and Burnes, 2007, Rao and Goldsby, 2009).

Both Kleindorfer and Saad (2005) and Tang (2006) define two categories of risk:-

- operational risks
- disruption risks.

Operational risk is risk associated with uncertainty in the co-ordination of supply-demand while disruption based risk is event driven through crises or disasters (Tang,

2006). Sodhi et al. (2012) identify a schism in the field of SCRM between the different dimensions and a large proportion of the supply chain risk literature focuses on operational risk only. Often, the conceptualisation of risk is limited to losses as a result of poor co-ordination of normal supply-demand activities. In some cases, the concept of risk and uncertainty have been incorporated into existing concepts of supply chain management, such as mitigation strategies and issues concerning bullwhip effects (Towill, 2005, Hung and Ryu, 2008), supplier performance and selection (e.g. Zsidisin and Ellram, 2003), inventory management and increased supply chain co-ordination (Christopher and Lee, 2004, Towill, 2005, Beasley et al., 2006).

Growth in the SCRM field has seen an expansion of the literature that is dedicated to the phenomena of disruption risk (Sodhi et al., 2012), reflecting the increase in well publicised disruption events (discussed earlier). In fact there are many that believe that SCRM should only be concerned with disruptive events (Sodhi et al., 2012, Colicchia and Strozzi, 2012). Disruptive events are usually conceptualised using a quantitative measurement of risk; that of probability of occurrence x impact or loss (Sheffi and Rice, 2005). Current practice within companies has shown a prevalence towards dealing with known risks which have high probability of occurrence as practitioners tend not to consider unexpected (and therefore lower probability) events (Kleindorfer and Saad, 2005, Chopra and Sodhi, 2004). While there is growth in research into disruption risk, there is also an acknowledged gap of empirical research in these low probability, event based risks (Sodhi et al., 2012).

There is also a tendency within both the literature and in practice to consider the consequences and outcomes of risk rather than its cause (Zsidisin et al., 2005). Peck (2006a) and Trkman and McCormack (2009) are particularly critical of these approaches, citing that these are only able to counter known, specific threat based risks and often ignore sources of uncertainty. To address this, a number of authors have defined risk in terms of the sources of uncertainty, rather than dealing in specific outcomes (Christopher and Peck, 2004, Juttner, 2005, Manuj and Mentzer, 2008a). Risk sources are defined as 'variables which cannot be predicted with any certainty and from which disruptions can emerge' (p. 122, Juttner, 2005). Common

categories of risk sources are shown in table 2.1. While there are some differences between the categorization of sources, what is common is differentiation of risk which arises from both internal demand and supply activities and the external political, social and economic environment. This extension of the supply chain vision to incorporate the external environment is key as these frameworks allow for the better understanding of the nature of externally generated and potentially uncontrollable risks (Wu et al., 2006).

Authors	Risk Sources
Christopher and Peck (2004), Juttner (2005)	Process, Control Mechanisms, Demand, Supply, Environment,
Manuj and Mentzer (2008a)	Supply, operational, demand, security, macro, policy, competitive, resource
Ritchie and Brindley (2007)	External environment, industry specific, supply chain configuration, partner specific, node specific
Rao and Goldsby (2009)	Environmental, Industry, Organizational, Problem specific risk, Decision maker risk

Table 2.1 : Categories of uncertainty/risk sources

Ritchie and Brindley (2007) categorise sources as being either endogenous (internal to the supply chain) or exogenous (external to the supply chain). Endogenous risks here are both supply chain and industry specific and highly contingent on the supply chain structure, performance and governance. Rao and Goldsby (2009) make the point that risk can largely manifest itself as endogenous to organisations as they potentially have some capability to manage negative elements of this risk. This is their definition of problem specific risk – risks which arise from how organisations strategically manage risks. However, this raises a question over the capability of organisations to firstly identify risk, particularly where there are significant uncertainties, and whether they are in fact able to control any impacts. Less controllable risks, and therefore less avoidable, are those which arise from

wider macro-economic and political factors; categorized as exogenous by Ritchie and Brindley (2007).

This categorisation is built on by Trkman and McCormack (2009) who also use this concept of exogenous and endogenous risk/uncertainty. Here, they also define endogenous risk as being contingent on the supply chain itself, although they conceptualise uncertainty in this instance as either from a market or technological turbulence perspective. Exogenous risks here are further split into those which are discrete, one off events, or continuous i.e. ongoing turbulence (Trkman and McCormack, 2009). The idea of turbulence is an important construct. Trkman and McCormack define turbulent conditions as 'characterised by frequent and unpredictable market/and or technological changes within an industry which accentuate risk and create an inability to forecast accurately' (pg. 250, Trkman and McCormack, 2009). This introduces a more complex conceptualisation of supply-demand/operational risk; that supply chain risk management should consider how to manage exposure to uncertainty from both a demand and technological perspective. Christopher and Holweg (2011) also emphasise the need for supply chains to recognise risks from operating within a more turbulent environment. They postulate that there has been a steady increase in the level of volatility in the operating environment since 2008 and that we have now entered an 'era of turbulence' (Christopher and Holweg, 2011). This again points to an increase in uncertainty in 'normal' supply chain operations, rather than risk sources being solely from discrete disruptive events. However, Christopher and Holweg (2011) also point out potential opportunities associated with this increase in uncertainty.

2.3.3 Supply chain risk management

As with definitions of risk, definitions of SCRM are varied; table 2.2 shows the most prominent definitions used across the literature. There is some convergence, however, that SCRM should be part of a broader framework that incorporates both operational and disruption based risks (Christopher and Peck, 2004, Trkman and McCormack, 2009) that is concerned with identification, assessment and mitigation of risks (Sodhi et al., 2012) .

Authors	SCRM definitions
Christopher et al. (2003)	The identification of potential sources of risk and implementation of appropriate strategies through a co-ordinated approach among supply chain members, to reduce supply chain vulnerability
Norrman and Jansson (2004)	.. to collaborate with partners in a supply chain, apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources
Juttner (2005)	Identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole
Tang (2006)	The management of supply chain risk through co-ordination or collaboration among supply chain partners so as to ensure profitability and continuity
Manuj and Mentzer (2008b)	..distribution of performance outcomes of interest expressed in terms of loss, probability, speed of event, speed of losses, the time taken for detection of events and frequency
Neige et al. (2009)	.. identification, assessment, analysis and treatment of vulnerability and risk in supply chains

Table 2.2: Definitions of SCRM

The process of risk identification, assessment and mitigation is the most common underpinning of SCRM (Chopra and Sodhi, 2004, Sodhi et al., 2012). Much of the literature therefore conforms to this framework, with the majority focused on the identification and assessment of risk and how well these processes are conceived and implemented within supply chains (Blos et al., 2009, e.g. Kern et al., 2012, Lavastre et al., 2012). There is a sub-set of literature that deals solely with one specific category of risk such as product quality and safety (e.g. Tse et al., 2011, Marucheck et al., 2011), information risks (e.g. Mohd Nishat et al., 2007) or financial risk (e.g. Blome and Schoenherr, 2011). There is a significant number of papers and research which looks to use quantitative models and mathematical reasoning to either identify risk, assess its likely impact on supply chains and/or optimise

contracting decisions based on lowest risk (e.g. Wu et al., 2006, Shi et al., 2011, Lockamy and McCormack, 2012). Conceptualisations of risk here vary in terms of the type of risk dealt with (e.g. as to whether it is operational risk, disruption risk or both). However the common factor among much of this literature is that risk is quantifiable, measurable and therefore, by inference, is inherently knowable.

This is however not the case, given the unknowable aspect of risk. Peck (2005) also identifies the systemic nature of supply chains, this being failures and risks associated with the emergent properties of the system when taken as a whole; the combination of exogenous and endogenous factors. Peck also highlights how this systemic risk can lead to 'creeping crises', using the examples of the Foot and Mouth and fuel strike crises in the UK which both demonstrated how a small variance within the chain quickly ripples through to all other connected areas (Peck, 2005). Cheng and Booi (2008) build on Peck's research and identify three levels of risk impact:-

- Level 1 Entire network: risks which exist at a network level which threaten the viability of the entire network
- Level 2 Sub-network : risks which are contained at a branch of the network which carries out self-contained activities
- Level 3 Individual node : risks which affect one specific organisation

The interconnected nature of the supply network, however, could see risks at levels 3 and 2 escalate to the entire network if not contained. There is therefore a need for organisations to have visibility of, not just their own internal risks, but those risks and uncertainties that lie at the outer reaches of their supply chain and wider network. Harland et al. (2003) developed a tool to aid organisations to assess risk across their network. This tool recognised the need to identify and map the structure of their network, in order to help identify sources of risk and then build collaborative frameworks to develop and implement a cross-organisational strategy. However, their research identified the complexities in measuring risk at a network level, and the limitations for organisations to develop strategic options at this level. Since then there has been only a few studies to further the capability of risk identification, using

modelling techniques to overcome the problems of complexity and interconnections of risks (see Lockamy and McCormack, 2012).

However, there still remains a gap in research to help develop frameworks for organisations to identify risks (Rao and Goldsby, 2009), particularly at a supply chain and supply network level (Khan and Burnes, 2007). There are also gaps in empirical research to identify the effectiveness of supply chain risk management processes (Khan and Burnes, 2007). As thinking in the field has developed, this understanding of a more complex construction of sources of risk and uncertainty has led to the development of the concepts of supply chain vulnerability and resilience. That is, rather than focusing on the absolute prediction of disruptive events or risk outcomes and specific mitigation strategies, to focus instead on either the exposure of the supply chain to risk or uncertainty and its inherent resilience to mitigate against any adverse outcomes.

2.3.4 Supply chain vulnerability

The terms supply chain vulnerability and resilience are therefore directly associated with supply chain risk management and could in effect be considered subsets of the SCRM process. Managing supply chain vulnerability and resilience is in effect managing risk within the supply chain. However, from an academic perspective, these constructs remain largely under researched (Juttner, 2005, Ponomarov and Holcomb, 2009, Juttner and Maklan, 2011). The question is how does vulnerability differ from risk?

Table 2.3 shows important definitions of SCV. Christopher and Peck (2004) straightforwardly use the dictionary based definition of vulnerability as being 'likely to be lost or damaged'. One of the first conceptualisations of vulnerability was by Svensson (2002), through empirical research in the automotive industry. His definition of vulnerability is 'a condition that affects a firm's goal accomplishment dependent upon the occurrence of negative consequences of disturbance' (pg.112, 2002). This is virtually indistinguishable from that of supply chain risk, based on the occurrence and negative consequence of any disturbances. However, he also

conceptualises vulnerability in terms of dependencies. These are defined as ‘ a link, a tie, or a bond between one company in relation to another’ (pg. 730 Svensson, 2004) and describes three levels of dependencies :-

- time – e.g. product lifecycles, timeliness of product flows
- functional – business activities and flows of goods
- relational – relationships between supply chain actors

Here, the higher the level of dependency between organisations equates to a higher level of vulnerability. This level of vulnerability is also dependent on the level of indirect dependencies, both horizontal and vertical across the network and whether or not firms have visibility of these dependencies (Svensson, 2004). His concepts were subsequently developed by Juttner (2005) who also conceptualises vulnerability as the interdependency and interaction between organisations within a supply chain or network. Juttner (2005), however, defines vulnerability as ‘an exposure to serious disturbance arising from supply chain risks and affecting the supply chain’s ability to effectively serve the end customer market’ (p. 124, Juttner 2005). Christopher and Peck (2004) also agree that it is the *exposure* to various risks sources, both internally and externally to the supply chain that specifically characterise vulnerability. The higher the exposure to these sources, then the higher the vulnerability of the supply chain under study (Juttner and Maklan, 2011). Vulnerability therefore differs from risk in that it is not just the likelihood of the risk occurring but the level of exposure which dictates the potential outcome.

Authors	Definition of SCV
Svensson (2002)	.. a condition that affects a firm’s goal accomplishment dependent upon the occurrence of negative consequences of disturbance
Christopher and Peck (2004)	An exposure to serious disturbance arising from risks within the supply chain as well as risks external to the supply chain
Rao and Goldsby (2009)	‘ exposure to an event and the uncertainty of possible outcomes’

Juttner (2005)/Juttner and Maklan (2011)	an exposure to serious disturbance arising from supply chain risks and affecting the supply chain's ability to effectively serve the end customer market
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Table 2.3: Definitions of Supply Chain Vulnerability

Peck (2005), in contrast to much research in this area, uses a qualitative, inductive approach to conceptualise vulnerability within the defence/military sector. Her research expanded the concept of vulnerability to the supply network (vertical and horizontal structures), building on the concept of risk sources. Her findings reveal a more complex, systemic view of vulnerability with an inter-play of risk sources, dependencies and drivers at multiple layers of the supply network:-

Level 1 : value stream/ product, process and information flow

Level 2 : asset and infrastructure dependencies

Level 3 : organisations and inter-organisation networks

Level 4 : the external environment.

(from Peck, 2005)

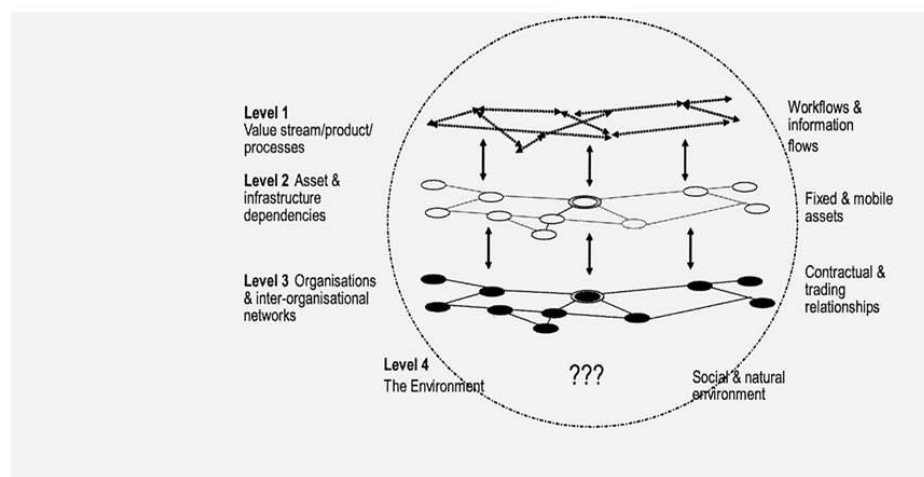


Figure 2.4 : Interdependencies of a supply system (pg. 218, Peck, 2005)

The relationship between these levels is shown in figure 2.4. Uncertainties, and therefore risk can be sourced at each of these levels, with a complex interplay of effects transmitted through the network. This is a more systemic, network conceptualisation of risk and vulnerability and implies that the impact of risk sources is dependent on the exposure and therefore vulnerability of the particular supply network under study.

Wagner and Bode (2006) concur with this view, in that supply chain vulnerability is a function of certain characteristics of the supply network. However, they identified that there is a lack of understanding around the mechanisms and conditions that drive vulnerability. From the existing literature, they were able to identify four drivers of vulnerability:-

- customer dependence – reliance on single or few customers for volume
- supplier dependence – reliance on single or few suppliers for volume
- supplier concentration – small supply base or at the extreme single sourcing
- global sourcing – global supply lines

This indicates therefore that vulnerability is a function of supply chain characteristics. These, though, Wagner and Bode admit, do not fully explain all of the factors at work.

This view is confirmed by Ritchie and Brindley (2007). Although they deal more with the concept of SCRM, they see the exposure to risk as a function of exogenous factors (e.g. the external environment) and endogenous factors such as supply chain configuration and managerial decision making. Levels of vulnerability are therefore contingent on the network structure and operational factors, the industry within which the network operates along with external environmental, social and political factors. The concepts of inherent 'structural' vulnerability, as to

how supply networks react in light of external stressors, would seem to be under-researched.

2.3.5 Supply Chain Resilience

Resilience, as a term, is often used interchangeably with vulnerability and risk within the literature. However, as with vulnerability, this concept is fairly unexplored in its own right (Ponis and Koronis, 2012). The concept of supply chain resilience is in response to the acceptance that not all risk can be avoided or controlled (Peck, 2006b). Resilience, in the context of supply chain risk, has been characterised as a mitigation strategy, either through building in redundancy or flexibility (see Sheffi and Rice, 2005).

However, this definition has evolved, as table 2.4 shows. Christopher and Peck (2004) define SCR as ‘the ability of the system to return to its original state or to a new, more desirable state after being disturbed’. It is therefore not just the opposite of vulnerability; it also encompasses ideas regarding the capability of the system to respond to uncontrollable, predictable risks. The idea of ‘flexibility’ as a strategy for resilience is common thread throughout the resilience literature (Sodhi et al., 2012). Christopher and Holweg (2011) refer to the need for ‘structural flexibility’ to be built into the supply chain. Structural flexibility is defined as the ability of a supply chain or network to adapt to fundamental changes in the business environment. This suggests a more strategic approach to resilience, through the adoption of flexible processes and structures rather than the more classical risk management approach to put in place mitigation plans in light of disruptions.

Authors	Definition of resilience
Christopher and	The ability of the system to return to its original state or

Peck (2004)	to a new, more desirable state after being disturbed
(Ponomarov and Holcomb, 2009)	Adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of consecutiveness and control over structure and function
Juttner and Maklan (2011)	..means to respond and recover at the same or better state of operations and this includes system renewal
(Ponis and Koronis, 2012)	The ability to proactively plan and design the supply chain network for anticipating unexpected disruptive (negative) events, respond adaptively to disruptions while maintaining control over structure and function and transcending to a post-event robust state of operations, if possible, more favourable than the one prior to the event, thus gaining competitive advantage

Table 2.4: Definitions of resilience

It can be seen that the concepts of supply chain risk, vulnerability and resilience are highly interconnected. Christopher and Peck (2004), Peck (2006b) and Juttner and Maklan (2011) have looked to reconcile the relationships between the different concepts; that organisations and supply chains need to consider the drivers and consequences of both. Juttner and Maklan (2011) emphasise the systemic interrelationships between the concepts (figure 2.5). Here SCRM actions help to reduce the probability of exposure, hence the vulnerability, while any actions taken to reduce the impact of any risk increases the latent resilience.

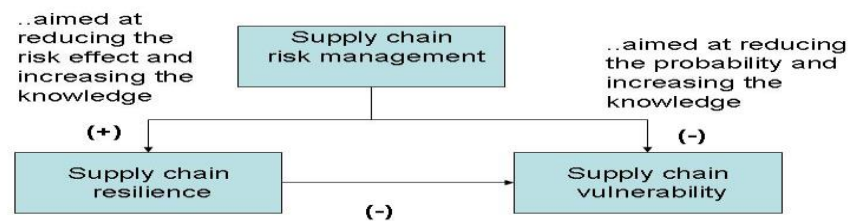


Figure 2.5 : Relationship between supply chain Risk management, SCR and SCV.(pg.249, Juttner and Maklan 2011).

Juttner and Maklan (2011) specifically link resilience to four related capabilities of supply chains, namely :-

- flexibility – ability to adapt to or absorb disruption
- velocity – pace or adaptation or pace of response
- visibility – transparency/availability of information on supply chain operations and events
- collaboration – willingness of parties to share risk-related information

Resilience and vulnerability have long been the focus of other academic disciplines. Ponomarov and Holcomb (2009) borrow definitions of resilience from other disciplines – ecological, psychological, organizational and economic - to develop a more encompassing, multi-disciplinary definition of resilience (see table 2.4). Vulnerability and resilience, in the field of ecology, are much more developed phenomena. As there are parallels between supply chain systems and ecological ones (Ponomarov and Holcomb, 2009, Ponis and Koronis, 2012), using concepts from this field could therefore support and create a deeper understanding of vulnerability and resilience for supply networks.

Ecological systems are complex systems – that is they are self-organizing and have high degrees of interdependence with interactions between structure and process over time (Gunderson, 2000, Allen and Holling, 2010). In reality, supply chains and networks are also complex and highly interconnected so can be defined in the same vein as complex adaptive systems (Colicchia and Strozzi, 2012). In the field of ecology, there are two mainstream definitions of resilience; that of engineering vs ecological resilience (Gunderson, 2000). For engineering resilience, the system has one single equilibrium state and its resilience is characterised as the time and distance it takes to return to this steady state post a disruption(Gunderson, 2000). Ecological resilience on the other hand acknowledges that there are multiple ‘steady states’ and resilience is the magnitude of disturbance that can be absorbed before the system has to change its structure. This then suggests that resilient structures can have multiple forms.

Within complex systems, ecologists define four stages of adaptation, in effect how systems evolve over time (Allen and Holling, 2010). These four lifecycle stages are :-

- exploitative – rapid growth
- conservation – accumulation of material and energy, mature phase
- creative destruction – release of accumulated ecological capital
- re-organization – low levels of stability as system shifts states

Resilience within each of these levels is dependent on three main elements (Fraser et al., 2005)

- the level of wealth or accumulation of capital
- novelty and innovation and the resultant level of diversity
- level of connectivity

High levels of wealth accumulation and connectivity with low instances of novelty or innovation equate to a higher level of vulnerability. Within the exploitative phase, resilience is high as there are significant levels of innovation and diversity, but the system becomes increasingly more fragile as it moves through the conservation phase. In this state, the system is stable but brittle in that it is unable to cope with even small levels of disturbances (Gunderson, 2000). This is due to the high levels of capital and interconnectivity. Small scale changes can travel quickly through over-connected systems, creating catastrophic results (Allen and Holling, 2010). This echoes the type of creeping crisis as defined by Peck (2005). Within these systems, any accumulated capital is locked in and becomes unavailable to support adaptive capacity. It is novelty and innovation that create adaptive capacity, creating the environment for experimentation of different structures and processes. It is through this process of experimentation that existing structures are destroyed, releasing capital and allowing a re-organisation of the system. If economies of scale are at work within a system, then the larger scale organisations potentially stifle smaller scale enterprises, potentially dampening innovation (Allen and Holling, 2010, Taleb, 2008). This runs contrary to the commonly held belief that a lack of volatility equates to a stable system; in effect volatility is in itself not an indicator of risk. The more volatile a system is, the more resilient it is, as it potentially has well developed adaptive mechanisms (Taleb, 2008).

Concepts of 'adaptive capacity' and the conceptualisation of the supply chain as an adaptive complex system have therefore started to filter through into supply chain vulnerability and risk research (Colicchia and Strozzi, 2012). Adaptive capacity is a function of resilience and is defined by Carpenter et al (2001) (from Ponis and Koronis, 2012) as:-

- the amount of change a system can cope with without having to change form or function
- the degree to which a system can organize itself without disorganization

- degree to which a system develops capacity to learn to adapt to disturbances

This capacity – i.e. the speed of response and how well a supply chain can recover – can therefore be seen as a combination of the structural and operational capabilities of the supply chain and how well actors within the system learn and develop strategies. This suggests that vulnerability is therefore related to the level of exposure, the residual resilience contingent to the environment within which supply chains operate and how they are structured and co-ordinated but also how quickly they can learn, adapt and innovate (Ritchie and Brindley, 2007, Ponomarov and Holcomb, 2009, Juttner and Maklan, 2011).

Conceptualising vulnerability and resilience at a whole system level – in this case the food system – gives rise to different perspectives. Firstly, ecological definitions of resilience indicate that the food system has more inherent vulnerability, through its high level of connectivity and concentration in economies of scale (Fraser et al., 2005). Secondly, it suggests a tension between adaptive capacity - the capability of the system to return to its status quo post-disruptive events - versus pressures for transformation to different sets of structures and operations. Systemic vulnerability could therefore be related to how well the system is able to cope with change. In their rather long definition of SCR, Ponis and Koronis (2012) highlight that competitive advantage can be gained by resilient supply chains; their ability to adapt the system post-disruption leading potentially to a higher level of performance. Disruption which prompts change can therefore be seen as an opportunity and a process of creative destruction ultimately could result in a better arrangement of capital and material flows. However, the question is, if the level of disruption triggers significant system change, would this be judged as undesirable? This creates complexity for the conceptualisation of vulnerability – here system threats which could trigger change could ultimately result in positive outcomes. The question at a system level, is how well this transition between different states is managed – i.e. a controlled transition vs a sudden shock based transition.

2.3.6 System transition and its relation to vulnerability

The field of system transition is a separate area of research in its own right. Definitions and concepts in this field help to characterise the systemic interaction of external threats and internal structures and behaviours which could combine to trigger transition. Food supply systems, as with other supply networks, can be defined in terms of socio-technical regimes. These are described as ‘semi-coherent set of rules carried by different social groups’ (Geels, 2002) and a ‘pattern of artefacts, institutions, rules and norms assembled and maintained to perform economic and social activities’ (Smith et al, 2005). System change, i.e. transition from one regime to a new one, is based on a function of the agency of regime members, the resources needed for the change to be enacted, and the co-ordination of responses and actions (Smith et al., 2005) In this model, landscape pressures (including global factors such as climate change, population growth) are in effect disruptions that can trigger system-based transitions (figure 2.6).

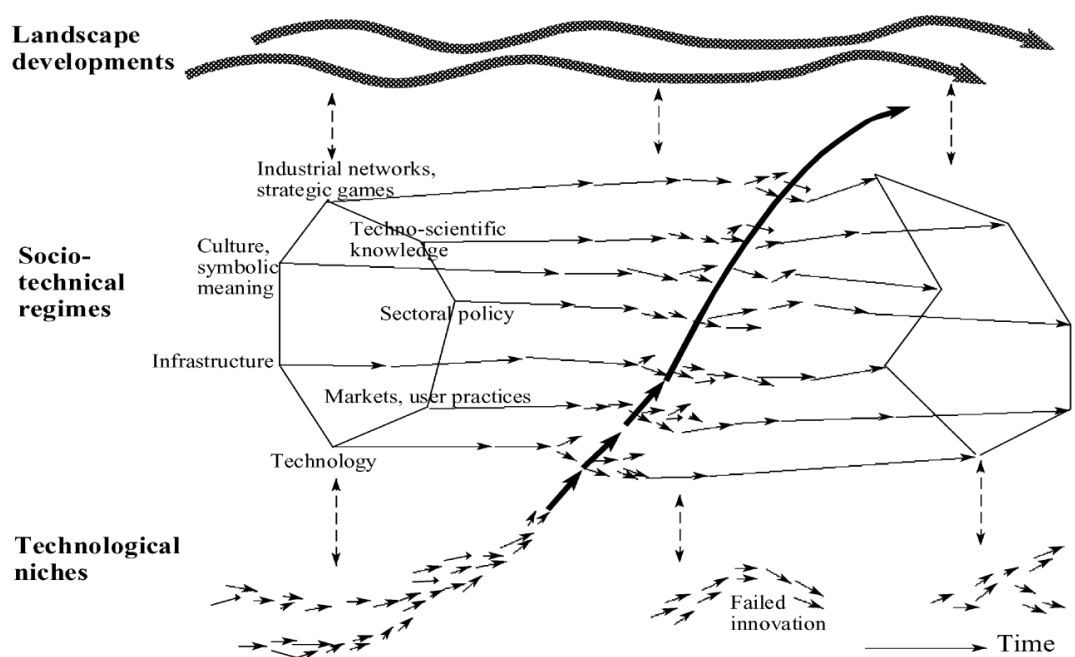


Figure 2.6: Model of technological transition (pg. 1263, Geels, 2002)

Smith et al (2005) identify two processes which can enact regime change:-

1. Shifting selection pressures on the regime [landscape pressures]
2. The co-ordination of resources available inside and outside the regime to adapt to these pressures

(pg. 1494, Smith et al, 2004)

Selection pressures therefore present threats and risks, while the co-ordination efforts are a function of the system and therefore represent its resilience. Transitions can often be crisis-led or initiated by 'disruptive-innovation' where social change is often an unintended by-product (Christensen et al., 2006). There are also strong forces of inertia, driven by investment in status quo power structures and institutions which prevent adoption of system-changing or 'catalytic' innovation (Christensen et al., 2006). Smith et al. (2004) argue that it is not just the existence of selection pressures that is important, but it is also how these pressures are articulated; whether there is coherence or dissonance in understanding and whether they are expressed in a way which enables a response by the current regime. Whether the members of the current regime accept the need for change, and the scale and shape of change is therefore a key determiner as to whether any managed transition is enacted.

This gives rise to a number of important points in conceptualising vulnerability at a system level. Firstly, vulnerability here is a function of exposure to threats which could trigger system change, while resilience becomes the ability to manage this transition successfully. Secondly, the visibility of these threats will be coloured by the perception of actors within the current regime; a common understanding of risk and the need to act is needed at this system level in order for actors to respond. Thirdly, the inherent structures and behaviours of a system will act to try to retain status quo in the face of threats creating in itself a level of vulnerability.

2.4 Risk and Vulnerability in food supply chains

While academically, post 2006, there has been increased interest in supply chain vulnerability and related fields, there has been surprisingly little academic focus specifically on risk and vulnerability in food supply chains. Previous studies in understanding risk in food supply chains have tended to be single issue focused, majoring on the environmental aspects (e.g. Vasileiou and Morris, 2006, Manning, 2008) or food safety aspects (e.g. Roth et al., 2008).

van der Vorst and Beulens (2002) use case studies in chilled salad, fresh vegetable and cheese chains to explore sources of uncertainties. They identify specific characteristics unique to the food sector which increase uncertainty; that of perishable food stuffs, variability and seasonality in demand (driven in part by weather conditions) along with high variability in supply of produce due to harvest, yield and weather unpredictability.

Vlajic et al. (2012) examine a meat supply chain in order to develop a framework to assess robustness. They identified a comprehensive set of factors, both externally and internally which were potential sources of vulnerability for the focal firm (a meat processing and packaging plant). Here, for the firm, risk was framed in terms of potential impacts on operating costs and ultimately profit. While there were a number of internal controllable sources of vulnerability (e.g. quality control procedures on the production line), the research pointed to inherent vulnerabilities specific to meat supply chains and the environment they operate in – namely market price fluctuations, variability in the availability and quality of raw materials plus biological factors such as animal disease.

One study of note which examined the network as whole was a report, commissioned by the UK government, into the health of contingency planning across the system. This was in response to concerns over the impact of the foot and mouth crisis. Peck (2006b) examined the contingency capability of multiple retailers,

processing and manufacturing firms across the food supply network. The report highlighted how retailers tended to pass risk down the chain, by relying on their suppliers to deal with any disruption. Despite this, there were signs that the need for contingency planning and risk management has gained traction within the network. However, the report concluded that there is a tendency for actors to focus on internal risk factors, in their immediate control, and to ignore factors which exist in the wider network and environment. Since this there has been very little academic research into risk, vulnerability or resilience within UK food supply chains (as of 2012).

2.5 Academic research post 2012

The field of SCRM and vulnerability has moved on since 2012. There has been a widespread acceptance of the need to move away from risk measurement and threat based tools and approaches, recognising the inherent difficulties of predicting specific threats and outcomes in complex environments with high levels of uncertainty (Pettit et al., 2013, Fiksel et al., 2015, Scholten et al., 2014). There is also a groundswell of acceptance that these risks often cannot be avoided or mitigated against. Consequently, there has been a significant rise in research focusing on the concepts of resilience and robustness. For example, 49 peer reviewed papers have been published post December 2012 which specifically address the concepts of supply chain resilience or robustness. Direct research into the construct of SC vulnerability, however has fallen; a search revealed just 4 papers of which 2 had direct relevance to this research - Vlajic et al. (2013) and Chowdhury and Quaddus (2015). Here, as with other research into resilience, vulnerability has become subordinate to the construct of resilience.

Authors	Conceptual focus	Conceptual framing	Level of analysis	Methods/ nature of study	Main findings
(Pettit et al., 2013)	Resilience	Resilience as a function of both vulnerabilities and capabilities	Supply chain/focal firm	Survey	<ul style="list-style-type: none"> - development of a SCRES measurement tool - linkages between vulnerability factors and capability factors - provisional evidence for

					linkage between increased resilience and improved supply chain performance
(Fiksel et al., 2015)	Resilience	Resilience as a function of both vulnerabilities and capabilities	Supply chain/Focal firm	Discussion/ Managerial implications	As above including -Vulnerabilities are hard to avoid -the need for organisations to balance and match capabilities to vulnerabilities
(Vilko et al., 2014)	Uncertainties	As environment dependent or decision maker dependent	Supply chain	Literature review and conceptual model building	-conceptual separation of risk and uncertainty -typology of uncertainties
(Scholten et al., 2014)	Resilience	Resilience as proactive and reactive	Supply chain	Case study	-integrated framework of antecedents for resilience and disaster management processes
(Scholten and Schilder, 2015)	Resilience	Resilience as proactive and reactive	Supply chain	Case study	-collaboration as an antecedent of resilience -mutual dependence between parties can increase resilience
(Hohenstein et al., 2015)	Resilience	Resilience as proactive and reactive	Supply chain	Systematic literature review	Four phases of SCRES -readiness, response, recover and growth -Common proactive and reactive strategies -3 measures – customer service, market share and financial performance
(Durach et al., 2015)	Robustness	Robustness as proactive approach to enable the supply chain to resist or avoid change	Supply chain	Systematic literature review	-2 dimensions of robustness: Resistance and avoidance -Robustness as a intra and inter-organizational construct -8 antecedents of robustness
(Chopra and Sodhi, 2014)	Resilience	Resilience as the ability to withstand disruptive risk	Supply network	Supply network modelling	-Strategies to balance supply efficiency with resilience -Segmentation -Re-configuration -Advocate over-estimation of risk -Longer term cost benefits of resilience vs short term impact on efficiency
(Wieland and Wallenburg, 2013)	Resilience	Resilience as a higher order construct consisting of agility (reactive) and robustness (proactive)	Supply chain	Survey	-2 relational competences : Communication, co-operation and integration -Communication and co-operation as both antecedents to resilience -Integration does not necessarily lead to an

					increase in resilience
(Brandon-Jones et al., 2014)	Resilience and robustness	Resilience – system which returns to normal after an accepted period of time Robustness – able to maintain function in light of internal or external disturbances	Supply chain	Survey	-Resource based view of resilience and robustness -Both as performance outcomes -Linkages between resources, capability and outcomes -Robustness is a separate construct from that of resilience -Visibility is an antecedent of both
(Kim et al., 2015)	Network resilience	Network resilience as ability of network to withstand disruptions at node or arc (connection) level	Supply network	Modelling	-Resilience is a structural property of a supply network -Function of nodes and connections -Redundancy doesn't necessarily lead to overall resilience and could lead to sub-optimal resilience if overall network structure is not considered
(Vlajic et al., 2013)	Robustness and vulnerability	Robustness is the desired property of the supply chain that delivers reliable performance Vulnerability is a function of specific disturbances, their frequency and length of time	Supply chain	Model/assessment tool and case study	-Development of vulnerability measurement tool -Impact of disturbances are related to specific characteristics of the supply chain
(Johnson et al., 2013)	Resilience	Resilience as adaptive capacity, ability to absorb shocks and to adjust to new connections	Supply chain	Case study	-3 element of social capital - Structural - Cognitive - Relational -All could impact positively on capabilities to improve resilience
(Leat and Revoredo-Giha, 2013)	Resilience	Resilience as a function of capability and vulnerability plus the ability of a system to return to its original state	Supply chain	Case study	-The need to balance capabilities relative to specific, sector vulnerabilities -Collaboration linked to reduction in vulnerability
(Chowdhury and	Resilience and	Resilience as capability of	Supply chain	Case studies	-4 key vulnerabilities of Bangladeshi RMG

Quaddus, 2015)	vulnerability	supply chain to respond to disruptions and recover from them. Function of capability and vulnerability			industry -Core capabilities for mitigation
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Table 9.1: Summary of key articles in the field of SCRES (2012-2015)

Resilience, therefore, has become the dominant concept. Table 9.1 summarises the key papers. There still remains ambiguity in the field and Hohenstein et al. (2015) state that SCRES is still lacking in a consistent conceptual understanding. However, there is convergence emerging from recent literature as resilience being:-

- A combination of proactive and reactive strategies
- Ability of the system to withstand disturbance and return to its normal state after a period of time

While Fiksel et al. (2015) define resilience as 'the capacity of an enterprise to survive, adapt and grow in the face of turbulent change' (pg.82), the concept of adaptation and the ability of a system to deliver improved performance (as per Ponomarov and Holcomb, 2009) seems to have been lost in many cases. There has been, therefore, a surge in interest in the concept of robustness and the ability of a supply chain to withstand disturbance without interruption or change. Even here though, there is some disagreement as to the differences between robustness and resilience. Durach et al. (2015) make a distinction between the two concepts; robustness being proactive strategies to ensure the system can return to its previous state post disruption, while resilience is defined by them as being both proactive and reactive. Here resilience is a higher order construct consisting of agility and robustness (Wieland and Wallenburg, 2013). However, Brandon-Jones et al. (2014) disagree and see robustness as a separate construct as the ability of the system to withstand disruption without any interruptions to performance.

Much of the research post 2012 therefore looks to clarify these two constructs and to determine the dimension or antecedents of resilience or robustness e.g. Durach et al. (2015), Hohenstein et al. (2015). There has been significant research into the linkage between human capital and relational aspects,

including collaboration (Johnson et al., 2013, Wieland and Wallenburg, 2013, Scholten and Schilder, 2015). Johnson et al. (2013) in particular draw attention to the cognitive processes of actors as a contributor to resilience. Here it is the importance of having shared common goals and codes which allows alignment of actions supporting resilience.

Brandon-Jones et al. (2014) present a framework which uses a resource based view of the firm (in that resources are linked to capabilities and to outcomes) to develop a conceptual model of resilience and robustness, Here they directly link resilience and robustness (as they differentiate between the two) to performance outcomes. This linkage is reinforced by Vlajic et al. (2013), Chopra and Sodhi (2014).

Most significantly, for this thesis, is the disconnection of vulnerability from resilience. While the move away from threat based approaches and the measurement of risk supports the arguments presented in this chapter, there is a danger that the disconnection of resilience from vulnerability, and hence risk, results in misaligned strategies. While there is increasing evidence that general capabilities such as visibility (Brandon-Jones et al., 2014), and collaboration (Scholten and Schilder, 2015) can improve resilience, divorcing capabilities from specific vulnerabilities could lead to a false sense of security. In this regard, the researcher agrees with the research of Pettit et al (2013) whose findings identified direct linkages between vulnerability factors and capabilities. Here they advocate a 'balance of resilience' which matches the costs of developing capabilities with the increasing exposure to risk, vulnerability. Excessive levels of capabilities could lead to an erosion of profits, but not recognising key vulnerabilities leads to an increased exposure to risk (Pettit et al., 2013). Further evidence to support the need to reconnect vulnerability and risk to resilience is given by Chopra and Sodhi (2014). They cite the tendency for actors to underestimate the probability and impact of disruptions as making it easier to ignore risks and not put in place mitigation strategies. They advocate therefore for actors to over-estimate likelihoods, therefore triggering mitigation actions, which they argue would lead to reduced costs in the longer run.

There still remains a significant gap in research into the concepts of vulnerability and resilience at a network level. Only one major research paper, post 2012, was focused at the network level. Here, Kim et al. (2015) model how network structure impacts resilience (as a function of the number of nodes and their interconnections). They define resilience at a network level as being ‘an attribute of the network to withstand disruptions that may be triggered at the node or arc [connection] level’. This, however, is a narrow definition of resilience that focuses only on structural aspects.

While it is important that academics look to clearly define constructs, and their antecedents and outcomes, at a theoretical level, it is also important to remember that supply chain management, ultimately, is operationally driven. How actors respond to and think about vulnerabilities and the actual practices in operation therefore must be considered as an important part of furthering knowledge in this field. Narrowing of research studies into isolated attributes of vulnerability and resilience may further knowledge on the direct linkages but at the risk of excluding other potential factors. This links therefore to the advice of Peck (2005) that ‘valuative’ frameworks with multiple perspectives are also a vital part of the research landscape. This thesis has looked to meet this need in part.

2.6 Research gaps

In essence the supply chain literature is founded on the basis of how organisations look to manage market, technological and operational uncertainties. Often supply chains are conceived as dyadic relationships with little conception of supply systems as wider networks. These supply chains are characterised in terms of flows of product or services and information between organisations. In reality, modern supply chain are more interconnected than ever and therefore, globally, are more exposed to crisis led events and more complex combinations of uncertainties, many of which elude quantification. In particular ‘black swan’ events are in the main unpredictable, and possibly unknowable a priori (Taleb, 2008). The wider supply

network is often not considered and exogenous factors which drive uncertainties are often seen as outside the scope of supply chain management. While the supply chain risk literature has sought to expand supply chain management to consider risk management, much of this remains at an abstract level. The majority of research is focused on 'measurable' risk, with the aim to quantify and predict probabilities of outcomes. In addition, this research often deals with the effects of discrete risk sources, there is insufficient understanding as to how multiple sources of risk and uncertainty combine, particularly how exogenous drivers act on endogenous factors within the supply network itself. There are gaps in research on the systemic nature of risk and vulnerability and the potential for small disturbances to cascade through the supply network.

There is very little research into how the structure and dynamic behaviour of a supply system contributes to its relative vulnerability and how capable different supply system states are of withstanding effects from uncertain events before their structure is changed or disrupted. There is therefore a need to develop a more holistic understanding of the interaction of risk factors, both exogenous and endogenous to the supply network and how these contribute to vulnerability or resilience. Using concepts of ecological definitions of resilience and vulnerability could help to support this. Studying these concepts, in effect the reverse of predicting precise risk sources/events, could give a more comprehensive understanding of the extent of the impact on supply chains when faced with the inevitable unknown disruptions that will present in the future. These concepts are, in reality, still in formation, and there is a need to develop normative models which help to synthesise the characteristics and dynamics of supply chains which impact on vulnerability or improve resilience.

There is no doubt the UK food system faces multiple challenges in the future including uncertainties in terms of climate change, competing land use, energy availability and price, availability of imports, bio-security and the need to consider wider social and ecological concerns (e.g. health, bio-diversity). While there is

research which focuses on the impact of each of these risks, most of this is focused on single issues (e.g. climate change) rather than examining the interplay between the different risks. In addition, there is very little research which takes a supply network view, therefore ignoring the interconnected nature of the system. In this respect there is little understanding of the interaction of the combination of effects on the food system as a whole, from farming through to retail and how the perception of actors impacts on strategies and exhibited behaviours in response to risks. From a practitioner perspective, this type of research would help to highlight potential breakpoints within the system and where improved mitigation strategies are required. From a policy perspective, this type of research is needed to understand how robust the UK system is as a whole, in light of global risk and uncertainties, and where policy intervention could be effective in developing adaptive capacity and innovation to support a more resilient network.

2.7 Research Questions

This gave rise to a set of five research questions which guided the focus of the thesis. These are:-

RQ1: How do actors conceptualise risk and vulnerability within the UK food supply system?

RQ2: How do the endogenous characteristics of the UK food supply system, in terms of its structure and dynamics, contribute to the perceived level of vulnerability in light of global, exogenous uncertainties?

RQ3: How adequate are these conceptual frameworks of vulnerability, resilience and adaptive capacity in light of global phenomena?

RQ4: What are the implications for stakeholders and policy makers in their aims to reduce vulnerability and encourage a more robust UK food system?

RQ5: What are the implications for future research into concepts of vulnerability, resilience and adaptive capacity?

Drawing on advice from Smith et al (2004), Peck (2005) and March and Shapira (1987) that risk and vulnerability are both subjective and how they are perceived will determine behaviours and strategies, the first research question looks to establish how actors in the food system perceive risk and vulnerability. The second research question is then designed to address the literature gap in identifying the exogenous and endogenous factors which are perceived by actors as important to the construct of vulnerability in the UK food system. This question is focused on how these factors interlink and their potential systemic influence on vulnerability. Both these questions are designed to focus the interrogation of the Chatham House data, mining it for actors' understanding of threats that impact their organisations and supply chains along with factors they judge to be important for either vulnerability or resilience. The principle objective of these is to further the body of research in understanding the interrelationships between risk sources, the inherent properties of supply network and the environment in which they operate and how these characteristics combine to influence vulnerability. Research question three looks to understand how the thesis findings fit into current academic thinking on risk and vulnerability and how well existing conceptual frameworks explain the phenomena under examination. The comparison of findings to existing research supports the process of theory building (Gill and Johnson, 2002). Research question four examines how these findings impact on stakeholders within the food system while research question five explores the contribution of this thesis to the body of knowledge on supply chain vulnerability. These therefore discuss the relevance of the research and explicitly determine the academic contribution of the thesis to the field of supply chain vulnerability.

3.0 Chapter Three – Methodology

3.1 Introduction to Methodology Chapter

This chapter explains the methodological approach that guided the researcher through the thesis and the analytical process followed to interpret the data. The thesis is unusual in its' structure, in that the data collection was undertaken in advance of the main thesis and for a related, but in effect, different purpose. The Chatham House study involved a broader examination of the data collected to understand the policy implications for the UK food system. It did not perform an in-depth analysis of the data and therefore was unable to build theory. In this sense the data remained untapped. This was recognised by the project team at the time and it was understood that more analysis was needed in order to understand better the contexts of risk and vulnerability. This thesis therefore re-examines the data, taking a deeper, more analytical approach in order to build theory in relation to risk and vulnerability in the UK food supply network. This allowed the development of an original and distinctive contribution for the thesis. This chapter therefore looks to tell both the story of the CH project, the basis for the data, but also the approach taken throughout this thesis.

In a sense, both projects start from the same philosophical stance. As the researcher was responsible for the design of the CH methodology and for this thesis, it stands that the discussion around the research philosophy reflects both studies. This philosophy was re-examined at the start of the thesis, to check that the underpinning for the CH study was indeed valid for this thesis. The chapter therefore starts by explaining the central philosophy which underpinned the researcher's approach in both studies, it being the same, despite the slight difference in research purposes.

In turn, it explains the epistemology and methodology underpinning the Chatham House study. This is important to understand and justify as this formed the basis for the data used in the thesis study and informed the researcher's approach and thinking in designing the data analysis framework for the thesis. In a traditional PhD, this section would justify the choice of methodology and show a clear line of sight between this choice, the data collection and the validity of the findings. In this instance, this section explains in some detail the methodology and approach for the CH study as a proxy for the justification of validity for the thesis. As the researcher was responsible for the CH overall research design and the development of the data collection instruments this was felt to be appropriate. The next section explains the research structure for the CH study, the methods and data instruments used to collect the data. This section also discusses the theoretical underpinning of the scenarios, which formed a core element of the CH study. From the thesis perspective, a large portion of the data collection revolved around actors' responses to these scenarios so it also felt important to explain their usage.

The second part of the chapter deals solely with the approach taken by the researcher for this thesis. As the thesis re-examined data already previously collected as part of the Chatham House project, this section explains the analytical stance along with the procedures undertaken in order to address the specific research questions posed as part of this study.

3.2 Research Philosophy and theoretical perspective

3.2.1 Research philosophy

The philosophical underpinning of research projects has an important bearing on the research design and ultimately on the quality of the research outcomes (Easterby-Smith et al, 2002). The five elements which contribute to research philosophy and design are outlined in figure 3.1. Ontology is described as the 'study of being' (pg 10, Crotty, 2003), in other words the nature of reality. Epistemology is

the ‘theory of knowledge’ (pg 3, Crotty, 2003) in effect how knowledge is formed. Both these philosophical perspectives inform the theoretical stance taken by the research – the set of assumptions that provide the context for the research (Crotty, 2003) which in turn inform the methodology and the methods chosen – the strategy and tools for data collection and analysis.

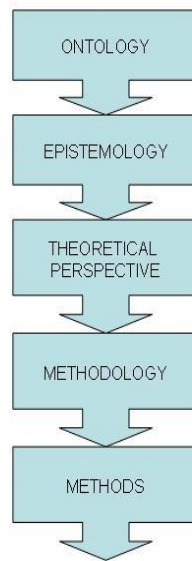


Figure 3.1: Five elements of research design. Adapted from pg 4, Crotty, 1998

Generally, there is a lack of consistency between the use of terms and associated perspectives, particularly between ontological, epistemological and theoretical perspectives. Epistemological and ontological definitions often differ and are used interchangeably. The following discussion recognises this and deals with both the ontological and related epistemological stance taken by the researcher for both the CH study and this thesis.

From an ontological perspective, realism is defined by Bhaskar (1989) as being where 'ultimate objects of scientific inquiry exist and act (for the most part) quite independently of scientists and their activity' (pg.12, 1989). This perspective recognises that objects, including in some part social phenomena, exist outside of the mind (Crotty, 2003). This perspective would therefore recognise the existence of the concepts of supply vulnerability and risk, therefore indicating that these fields can be studied. A sub-set of the ontological perspective of realism, that of critical realism, which makes a conscious compromise between the two extreme positions (Sayer, 2000). This position recognises the existence of social conditions independently of the observer but recognises that concepts are in effect constructed (Easterby-Smith et al., 2002).

Positivism, an epistemological concept, is the belief that objective methods can be used to inquire about the social world, which exists outside of the human consciousness (Easterby Smith et al., 2002). Positivist-based epistemologies and research designs are deductive in nature and 'entail the development of a conceptual and theoretical structure prior to its testing through empirical observation' (pg34, Gill and Johnson, 2002). This position can be considered consistent with the ontology of realism. 90% of management research is judged to belong within the positivist tradition (Meredith et al., 1989) and positivistic methods are the prevailing approach within the field of supply chain management (Burgess and Singh, 2006). There has been a tendency for empirical studies of supply chain risk and vulnerabilities to take this approach (Peck, 2005), although recent years have seen more case studies, albeit with mixes of qualitative and quantitative methods (Sodhi et al., 2012). Positivist studies in supply risk have tended to measure the level of variability to desired supply chain performance as a key indicator of risk. Criticism of this approach is founded on reductionist tendencies, common to positivist approaches, which fail to comprehend the complexities inherent in multi-layer supply chain systems (Peck, 2005).

The assumptions underlying positivist research designs rest on the belief that the environment within which the supply chain operates is 'static' and therefore exhibits predictable system behaviour (Peck, 2005, Pilbeam et al., 2012). However, Demchak (1996) argues that this approach can overlook a number of key organisational and wider environmental issues. Nohria (1992) takes the view that 'all organizations are in important respects social networks and need to be addressed as such' (p.4, 1992). This proposes a more social and relational-based concept of the supply network, with focus on the interrelationships both intra and inter-organisations. This chimes with the social constructionist epistemology, which holds the premise that meaningful reality is contingent on human practices (Crotty, 2003).

While the researcher recognises her own natural bias towards a positivistic position, the dynamic, socially contingent views of supply networks are judged to be more consistent with the researcher's perspective of supply chain networks. This is also consistent with the IMP definition of industrial networks, in that 'firms operate in the context of interconnected business relationship' and that 'these relationships affect the nature and the outcome of firms' actions' (pg. 357, Gadde et al., 2003). The research also takes the stance on risk and vulnerability, from a social science perspective. This is guided by the Royal Society publication on risk (1992), in that risk is largely a culturally determined phenomena. This stance is therefore more consistent with a constructionist epistemology. This is largely based on the perception of stakeholders within the supply system, focusing on how these risks and vulnerabilities are conceived. While the risks posed to the supply chain could ultimately result in real consequences, the behaviours and strategies employed by supply chains to counter future risks and vulnerabilities are based on perceptions of how these risks could play out in the future, their likelihood and potential impacts.

Any deductive-based design was also judged problematic. As the theory and concepts of supply chain vulnerability are in their infancy, it is difficult to build a priori theories (Gill and Johnson, 2002). In addition, the future element of the research and the level of uncertainty inherent in the conceptualisation of forces exogenous to the system under study make objective measurement, in the positivistic sense, difficult. All these factors suggest that, despite some natural bias,

a positivistic approach, from an epistemological perspective, would not have been appropriate.

3.2.2 Theoretical perspective

At face value, the epistemological approach of social constructionism was seen as a more consistent philosophy with both the CH study and the thesis. This stance recognises that while research attempts to define the nature of reality, there is always an inherent cultural lens applied to the way in which we view the world. While some definitions of social constructionism are based on the absence of pre-existing reality (Easterby-Smith et al, 2002), others judge this stance to be completely compatible with the ontology of realism; in that the ideas or concepts are real, and not solely confined to the mind (Crotty, 2003). This difference reflects the broad spectrum of definitions used to describe social constructionism (see figure 3.2); this ambiguity and lack of clarity creates a level of confusion over the exact epistemological positioning of constructivism. Constructionism is often portrayed as solely idiographic, viewed as creating a subjective explanation of meaning (Gill and Johnson, 2002; Easterby-Smith et al, 2002). However, the researcher rejects this definition. While it is in essence a more 'interpretive approach' than positivism, Crotty (2002), by contrast, argues that social constructionism implies that meaning is generated through the interaction between object and subject, rather than meaning being subjected on the object under study (Crotty, 2002). In addition, Crotty (2002) subscribes to the original concept of interpretism (or *Verstehen*) as meant by Weber (1962), in that constructionism looks not just for subjective meanings (understanding) but also to ascribe some appropriate causal explanation. This definition can be said therefore to have some synergy with the relativist epistemological dimension as defined by Easterby-Smith et al (2002). It can be said therefore that the epistemological and theoretical approach of the CH study and the thesis sit within the social constructionism spectrum, but with synergies with the relativist position (as shown in figure 3.2).

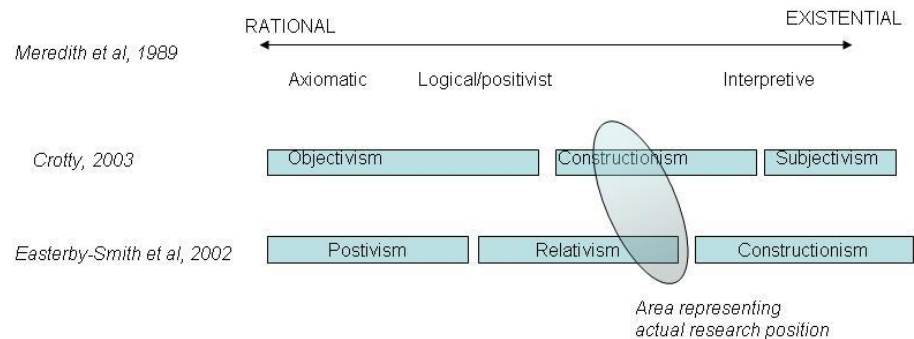


Figure 3.2: Research position (compiled by author from sources shown)

3.3 Epistemology and Methodology (Chatham House study)

3.3.1 Epistemology

Criticism of constructionist, interpretivist methods has focused on a tendency to be unstructured, perceived to be lacking in rigour. However, it is argued that this type of research can still be subject to rigour and structure in the collection and analysis of data (Strauss, 1987, Easterby-Smith et al., 2002) without compromising its interpretive nature. Inductive-based theory is often said to be ‘grounded’ in data and experience. This gave rise to the development of grounded theory, a comparative method to conceptualise and build theories directly from the collection and analysis of data, contingent to the area under study (Glaser and Strauss, 1967)

which also gave structure and rigour to the research and analysis process. The definition of grounded theory is 'the actual production of meanings and concepts used by social actors in real settings' (pg. 457, Gephart, 2004). In this way the theory emerges from the data itself, based on how well it describes or fits into conceptual categories as proposed by the researcher (Suddaby, 2006). Grounded theory has come to be associated with a strict set of procedures but at its heart lie two key principles. The first is constant comparison, where data is collected and analysed at the same time. The second is theoretical sampling, where decisions about the next set of data to be collected is determined by the emergent theory from the analysis (Glaser and Strauss, 1967, Suddaby, 2006). The comparative nature of the research, and the intertwining of theory generation and testing across different cases (in a sense both inductive and deductive) is therefore designed to facilitate the creation of causal models (Gill and Johnson, 2002).

A research design is defined as a 'framework for the collection of data' (pg. 32, Bryman and Bell, 2003) while research methods are the techniques and tools used to collect data (Bryman and Bell, 2003). The researcher, for the Chatham House study, made the decision not to use classic grounded theory as the primary method. Originally, this decision was taken primarily owing to constricted timescales and lack of resources; this meant that data analysis could not be undertaken at the same time as the data collection. This consequently made a systemic process of theoretical sampling difficult. While looking to avoid 'methodological slurring', Suddaby (2006) emphasises that grounded theory is in essence pragmatic, recognising the messy reality of research and the need for researchers' intuition and 'feel' to guide the process (Suddaby, 2006). The researcher, guided by this, took a pragmatic approach and while the process did not follow a classic, established procedure of grounded theory (as proposed by Strauss and Corbin, 1998), a grounded approach was used to analyse and interpret the data (Easterby-Smith et al., 2002). In this way, while the analysis and data collection were not simultaneous, the products of the research were shaped from the data rather than from a priori deduced frameworks (Charmaz, 1983).

This was recognised as a risk, both to the CH study but also to this thesis. This was due to the danger that the research could be accused of ‘analytical interruptus’ (Gill and Johnson, 2002), where findings are not lifted to a higher conceptual level. This is the criticism levelled at ‘thick’ phenomenological descriptions often when the process of theoretical sampling to choose further cases is not followed (Gill and Johnson, 2002). However, Weber (1970), argued that the process of description or ‘*verstehen*’, can provide an interpretation of events as ‘causally adequate’ by creating an interpretive understanding of ‘social action’ where past experience can give guide to future actions. Crotty also argues that this creates not just understanding but also a method of explaining (Crotty, 2002) In this way a hypothetical explanation of the phenomenon can be created, which gives an understanding of some level of causality, therefore avoiding analytical interruptus. Weber (1970) therefore advocates the use of the ‘ideal type’ as a guide for researchers to develop conceptual or mental constructs to illuminate what is ‘possible and adequate’. However, the researcher also recognises the limitations to the research in terms of theory building. While the findings will live at a higher conceptual level, the lack of testing in further conditions will limit their generalisability. This, however, is a common occurrence with inductively generated research as Eisenhardt (1989) pointed out – in that it can be testable and empirically valid but will lack the attributes of ‘grand theory’, therefore remaining at a modest, idiosyncratic level. (Eisenhardt, 1989) The researcher has taken guidance from this advice.

3.3.2 Research Quality Criteria

The question of research quality criteria is an important one, particularly for constructionist, grounded approaches to avoid criticisms of validity and lack of rigour (Kaufman and Denk, 2011). Traditionally, for positivist studies, the criteria used for assessment is based on four categories – that of internal validity, reliability, objectivity and external validity (Bryman and Bell, 2003, Kaufman and Denk, 2011). However, many authors see these categories as problematic for more qualitative, constructionist research as they suggest the existence of one objective reality and echo the emphasis of positivist research on demonstrating clear cause and effect

(Bryman and Bell, 2003, Easterby-Smith et al., 2002, Kaufman and Denk, 2011). Some authors have adapted the definitions of the criteria to fit better the goals of constructionist research (see Easter-by-Smith, 2002 or Kirk and Miller, 1986), while some have developed new frameworks. One such framework is that developed by Lincoln and Guba (1985) who proposed using credibility, dependability, confirmability and transferability as more appropriate indicators of quality for this type of research. The researcher has taken guidance from both approaches, using a merged framework as the basis for the assessment of research quality (table 3.1).

Criteria	Definition	Source
Internal validity/ Credibility	-Whether the study gains access to the experiences of those in the research setting -The quality of theoretical reasoning, based on how well data supports findings -A clear line of sight between data and theoretical findings	Easterby-Smith et al. (2002) Yin (1994);Bryman and Bell (2003)
External validity/Transferability and Generalisability	-Whether the constructs developed apply in other settings	Easterby-Smith et al. (2002) Kaufman and Denk (2011)
Reliability/ Dependability	-The level of transparency in data collection methods -The repeatability of the study	Easterby –Smith et al. (2002) Auerbach and Silverstein (2003)
Objectivity/ Confirmability	-Whether the results are trustworthy and reflect the experiences of those involved in the study - The level to which the subjective values of the researcher have been imposed on data interpretation	Bryman and Bell (2003) Kaufman and Denk (2011)

Table 3.1. Research Quality Criteria

3.3.3 Research methodology for CH study

The original CH study was therefore built around a case study approach. Case studies, when predominately using qualitative methods, are considered to be more aligned to inductive-based, theory building research (Eisenhardt, 1989, Yin, 1994,

Bryman and Bell, 2003). Case studies are concerned with an in-depth examination of the complexities of the area under study (Stake, 1995). The revelatory form of case study is distinguished by the focus on identifying the unique features of the case, based on an idiographic approach (Bryman and Bell, 2003). Case based research is therefore normally targeted at either an individual, organisational or supply chain level. However there are examples within a more comparative design framework where the unit of analysis lies at an industry level (Peck, 2005). Inter-organisation networks are described as complex and overlapping webs (Nohria, 1992). These webs are often invisible when viewed from the stand-point of a single organisation and that to understand them, there is a need to analyse the system or network as a whole (Nohria, 1992). To gain a better understanding of the food networks' interdependencies and complexities, the most appropriate unit of analysis for the CH project was judged to be at an overall industry level.

Comparative designs use identical methods to compare and contrast two or more cases (Bryman and Bell, 2003). The strength of this particular approach is the ability to compare views and practices across more than one case (Bryman and Bell, 2003). This form of design is also consistent with inductive form of theory building (Easterby-Smith et al, 2002).

3.3.4 Case study selection

The UK food system is a large area of study and to limit this, it was decided to focus on the retail element of the system i.e. supply chains with routes to market through retail organisation as opposed to food service. The retail sector equates to 57% of the total supply of food (in revenue terms, DEFRA, 2014) and therefore constitutes the larger mechanism by which food is bought and consumed. It is also here, in the direct purchasing of food stuffs that availability and affordability of food i.e. food security, is concentrated. The two cases chosen for the CH project were the UK dairy and wheat retail supply systems. The two industries are complimentary and have some interconnectivity – through the supply of wheat based feed for cattle.

However, the dairy and wheat industries have inherent differences (table 3.2), significant to aid comparison between the sectors and to provide some level of generalisability to the results (although within the limits of the research design).

Dairy	Wheat
Livestock based	Arable based
Trade imbalance	UK virtually self-sufficient
No payment support until recent CAP reform	Historical payment support since WWII
Integrated supply chains	Transactional supply chains
Supply contacts – fixed prices	Market trading
Family ownership	Rise of contract farming
Traditionally small-scale with some intensification	High levels of intensification

Table 3.2: Differences between dairy and wheat supply systems (compiled by author)

Previous studies of vulnerability have tended to examine cases that were either horizontal (e.g. industry sector) or vertical (specific supplier-customer relationships) in nature. In common with Peck (2005), limiting the research to just vertical or horizontal perspectives could potentially exclude vital insights, considering the premise of the research to examine the wider, systemic context of risk and vulnerability. The CH design therefore incorporated data collection from multiple organisations within the UK wheat and dairy supply networks. In this sense, the unit of analysis was the retail supply/industrial network through which wheat or dairy products are delivered. However, it is recognised that the network is made up of supply echelons. There will be a need throughout the research to combine different levels of analysis, principally because the levels of risk and vulnerability may be perceived or experienced differently by different groups of actors (Bryman and Bell, 2003). However, in order to limit the scope of the study (to consider wider support

networks would have made the study too unwieldy) the network was limited to key groups of actors defined below

- Retailers
- Food Manufacturers
- Primary and secondary processors
- Producers
- Input/farm support organisations
- Actors peripheral to the network but have an interest or impact on it such as academics, scientists, government officials and NGOs

From the relativist perspective as described by (Easterby-Smith et al., 2002), the issue of external validity is more concerned with the 'issues of whether the research procedures can provide an accurate representation of reality' (pg. 53 Easterby-Smith et al., 2002) and whether sufficient perspectives have been included. This was the premise used in the selection and number of perspectives chosen. The question of research access is always a key determinant of the research process (Easterby-Smith et al., 2002) and therefore the participant selection was predominately determined by those agreeable to take part. The project, being sponsored by Chatham House and UK governments, did create greater leverage for access than through Cardiff University alone; this therefore facilitated the number and quality of participants. By using this data, the PhD thesis was able to capitalise on the access granted through the larger project.

Participants were selected in advance to represent a broad spectrum of opinion across the whole supply system - private, public and non-governmental (NGO) sector perspectives; small to large organisations; external and internal to the supply system itself. Target participants were senior representatives of the organisation, preferably from a strategic or supply chain orientation. To collate a sufficiently broad representation of the supply system, a wide variety of organisations were asked to participate. This included a number of competing

organisations which generated some concerns over the handling of both competitive and confidentiality issues.

The actual profile of participants for each of the data collection instruments is shown in table 3.3. As can be seen, the actual spread of participants was not as diverse as originally planned, with some significant gaps in representation from the dairy farming sector. However 13 actors from farming organisations, including 4 who have direct involvement in dairy farming were participants. Overall, 82 actors were involved in the research (the totals shown in the table come to 101 but 19 actors attended multiple events or were part of the original interviews)

	Area of representation	General Interviews	Supply interviews	All workshops	TOTAL
Direct supply system	Dairy farmers		2	1	3
	Wheat farmers		1	5	6
	Farming industry bodies	4	3	6	13
	Agricultural inputs organisations	3		2	5
	Dairy processors		3	4	7
	Wheat milling	1		2	3
	Wheat – baking			1	1
	Wheat processing industry bodies		1	3	4
	Grain trading			1	1
	Brand manufacturers			7	7
	Food manufacturing industry bodies			1	1
	Retailers	1	1	3	5
	Retail industry bodies	2		3	5
	Food service	1		0	1
Support industries	Logistics and transport organisation	1		0	1
	Waste/packaging services	1		3	4
	Bio-fuels industry	1		1	2
Government	Devolved/regional government			3	3
	UK government	1		2	3
	EU government	1		2	3
Other	NGO - environmental/animal welfare	2		3	5
	Academics - food/agrcultural/environmental	3		4	7
	Scientists	1		3	4
	Financial/insurance sector	2		2	4
	Agricultural colleges			3	3
Totals		25	11	65	101

Table 3.3 List of project participants

3.4 Chatham House project design and methods

3.4.1 CH study design

Qualitative methods were chosen as the core data collection instruments. This family of instruments are strongly aligned with inductive-based approaches (Bryman and Bell, 2003), enabling the richness of data required in order to contribute to the development of theory (Easterby-Smith et al., 2002). Strengths of these approaches also include flexibility and ability to explore wider and more complex phenomena. Qualitative approaches are often criticised as ‘unstructured’, with low levels of reliability, i.e. the ability to replicate the data or draw the same conclusions (Bryman and Bell, 2003), although from a constructionist perspective, the level of transparency in data collection methods and analysis to facilitate external scrutiny is more pertinent in the discussion of reliability (Easterby-Smith et al., 2002). To counter concerns over replicability, semi-structured forms of data collection (e.g. interviews/workshops) were employed.

The research was designed in four phases (table 3.4) and a schematic of the design is shown in figure 3.3.

Phase	Description	Aims
1	Exploratory Phase	To gain initial insight into the concept of supply vulnerability within the chosen supply systems
2	Scenario development	To identify key global factors and develop narratives of their possible future effects on global food supply
3	Data collection	To collate perspectives and reactions from the chosen supply systems
4	Data analysis	To understand future policy implications for the UK food system To identify the potential implications for supply chain management

Table 3.4: Research Phases for CH project

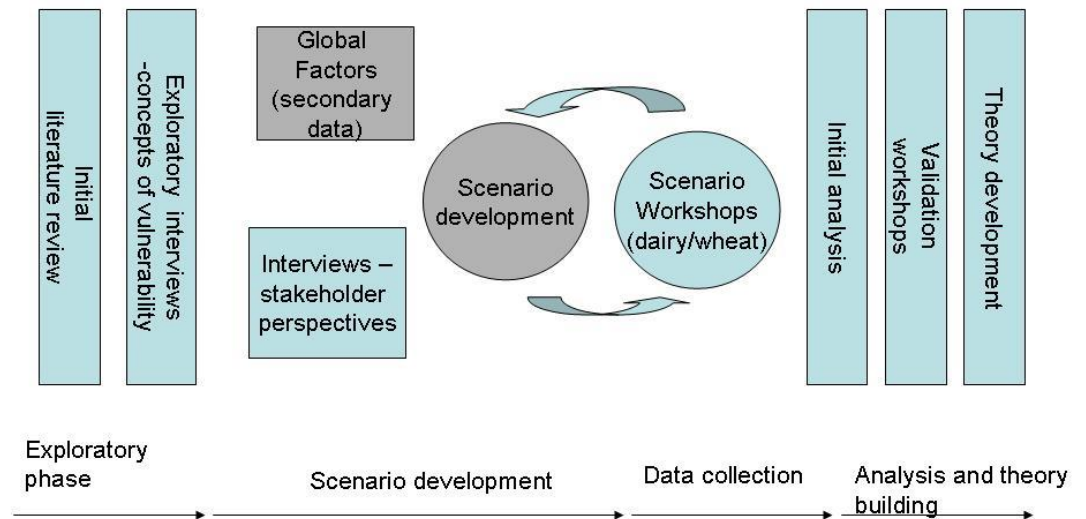


Figure 3.3: Schematic of Chatham House study research design

3.4.2 Phase 1: Exploratory phase

This phase was designed to scope the area under study. It entailed a literature review which encompassed an overview of the academic literature on risk and vulnerability and previous research on food systems and food security. It also involved a number of exploratory interviews with actors across the food system. These were unstructured conversations aimed to help frame the issues facing the sector. These were not included as part of the thesis data, as there was already judged enough data to support findings and in part these interviews repeated much of the subsequent data collected in phase 2, scenario development.

3.4.3 Phase 2: Scenario Development

The central purpose of the Chatham House study was to investigate future key global trends, their interdependence and potential influence on the UK food supply system. The inherent problem with dealing with the future is that, by its nature, it is uncertain and therefore to a large extent unknowable. However, there are a number of methodologies which support the amassing of knowledge and judgements for future-based research including Delphi methods and scenarios.

Delphi studies deal with 'informed judgements', using a structured process to combine the knowledge, ideas and subjective views of a panel of experts in order to support better decision making (Adler and Ziglio, 1996). It was developed in the 1950s and 60s by the RAND corporation, used primarily as a forecasting method to assess the direction of possible future trends (Adler and Ziglio, 1996). It is a useful approach when faced with a complex problem, with high levels of uncertainty on the present and future condition under study and where analytical techniques would not lend themselves (Linstone and Turoff, 1975, Adler and Ziglio, 1996). It is also judged an appropriate method to support exploratory theory building related to future trends (Meredith et al., 1989, Akkermans et al., 2003, Melnyk et al., 2009). It has also been used within the SCM field to explore trends such as the future use of ERP (Akkermans et al., 2003), future SCM trends (Ogden et al., 2005, Giunipero et al., 2012) and barriers to sustainable SCM implementation (Melnyk et al., 2009).

However, one of the main drawbacks associated with the methodology is its tendency to treat each component as an independent variable (Adler and Ziglio, 1996). In contrast to the collation of expert information on the likely trajectory of individual trends and predictive forecasts of the future, the Chatham House project looked to understand the possible *range and combinations* of global trends and uncertainties. It especially focused on challenging any underlying assumptions within the food network as to how future trends could play out (thus taking advice from Taleb (2007) in that actors have an inherent propensity to think the future will look

like the present). For this reason, a Delphi study was ruled out based on this specific concern; that it could narrow focus to a few, more certain trends and therefore limit the exploration of uncertainties and trends judged less likely by supply network actors.

In contrast, scenarios, labelled 'prospective planning scenarios' (King, 1975) look to detail the possible consequences of current strategies and behaviours while developing alternative strategies and plans to cope with a range of potential different future circumstances. These types of scenarios differ from future forecasts; they are not intended to be predictive but to 'illuminate the major forces driving the system, their interrelationships and the critical uncertainties' (pg. 146, Wack, 1985).

Scenarios were initially developed during World War II as a tool for military planning. During the 1960s, Herman Kahn started to use scenarios in business prognostication (Schwartz, 1998). However, most famously, scenarios were adopted by Royal Dutch Shell group in the 1970s, developed by Pierre Wack, as part of their strategy planning process. The Shell style of scenarios were developed to deal with the wider external environment to the organisation (Wack, 1985) to help decision makers better understand the forces that drive the business and the potential uncertainties that could create 'surprises' and therefore changes in the operating environment. Wack developed a number of scenarios which challenged the commonly held premise then that the oil price would remain stable over the following decade (Schwarz, 1998). Shell were able to use the scenarios to develop a number of coping strategies which pre-empted the potential for oil price variability and so enabled them to be better prepared for the oil price shock in 1973-74.

Shell continued to develop the use of scenarios throughout the 70s and 80s, used primarily as a key tool for medium-term analysis, embedded within their strategic planning process (Wack, 1985). Their aim is not to create an accurate forecast of the future but to help inform better decision-making based on a range of possible future outcomes (Schwarz, 1998). Part of the process is to tap into current management concerns about the future, while identifying where key uncertainties lie in the wider context that have the potential to change the current trajectory of

trends and expectations. Scenarios in this context are presented as narratives (Wack, 1985, Schwartz, 1998), reflecting the current perceptions of 'world views' held by managers but then using stories to explore how different futures may develop (Schwarz, 1998). It is for these reasons that scenarios were selected as an appropriate approach for the CH study, over and above Delphi methods.

As the methodology evolved out of business practice, as yet there is little academic treatment of its effectiveness. It has had only limited use so far within the SCM field - rare examples of use of these types of scenarios as the underpinning methodology to examine future conditions pertinent to SCM are Mazzarino (2012) and Heiko and Inga-Lena (2013). It is the complex nature of the future plus the inherent unreliability of predictive forecasts that scenarios look to counter and are therefore seen primarily as business tools to help manage uncertainty (King, 1975). However, in this regard the process of developing scenarios, through the exploration of management perceptions and meanings, has synergy with the social constructivism tradition (Crotty, 2003). In particular, the traditional theoretical perspective of phenomenology asks the researcher to look beyond pre-conceived notions of the world and to 'call into question our whole culture, our manner of seeing the world and being in the world in the way we learned it growing up' (Wolff, 1984 in Crotty, 2003). This form of critical enquiry is closely aligned with the philosophy underpinning the Shell scenario development, that of challenging senior management perceptions and world-views. This methodology therefore provided a way of organising and gathering thoughts and perspectives on how global trends would interact in the future, plus creating the necessary stimulus for actors to strategically think through the potential implications for future UK supply systems.

The scenario development phase consisted of three main strands of work :-

1. General interviews: semi-structured interviews with experts/stakeholders associated with the wider food supply network
2. the examination of secondary sources to identify key global factors and trends

3. the development of four scenario narratives (from data from strands 1 and 2)

Strands 2 and 3 were a significant part of the wider Chatham House project, and the majority of work in each was undertaken by other researchers within the research team. However in strand 1, the general interviews were the source of primary data for the scenario development. These interviews were conducted principally by the author with actors across the food network. They were designed to understand how actors viewed the global food crisis and their thoughts for the future direction of the food system. The interview template is shown in Appendix A and a summary of the finalised scenarios is shown in figure 3.4.

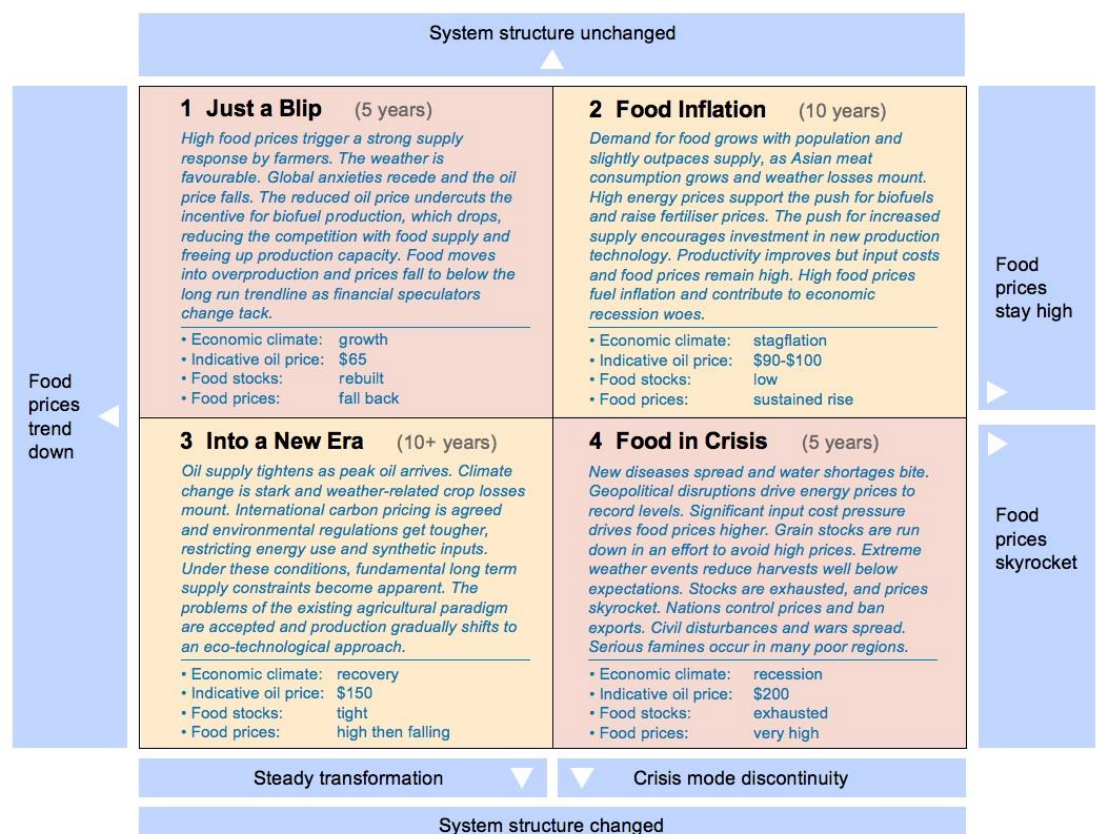


Figure 3.4: Overview of the four scenarios

3.4.4 Phase 3: Main data collection phase

The data collection phase was split into two sections :-

- A: Supply chain sector interviews with actors directly involved in dairy or wheat supply chains
- B: Workshops with dairy/wheat supply networks actors to explore behaviours and actions in response to the scenarios

The semi-structured interviews were designed and conducted solely by the author. The author also designed the scenario workshops but was aided in data collection by other researchers (due to the number of participants).

A:Supply chain sector interviews

To understand specifically how supply chain actors saw risks and vulnerability in the food system, semi-structured interviews were used (the schedule is shown in Appendix B). The eleven interviews were designed to elicit the different groups of actors' (principally farmers, processors, traders/wholesalers and retailer) perceptions from within the supply chain. The interviews took place during the food crisis period of 2007-2008 so answers were coloured by this context. However, many of the questions focused on actors' main focuses and concerns, any risks they faced generally, and the courses of action and strategies they were likely to employ. The interviewees were not exposed to the scenarios so the responses reflect the status quo as they perceived it.

B:Scenario workshops

A series of workshops were built around the scenarios as part of the data collection strategy. The workshops were designed to elicit perceptions and reactions

from actors as to the potential impacts of global factors on UK supply systems. Workshops, described as 'loosely steered conversations' (pg.5 105, Easterby-Smith et al, 2002), are useful in exploratory based work. Their strength lies in the ability to generate a wide variety of views, along with dynamic discussion and responses to explore and develop concepts and ideas (Saunders et al., 2003). Managers and decision makers often look for evidence to support their own world view (Wack, 1985; Easterby-Smith et al, 2002) which leads to short term, narrow strategic thinking. The use of scenarios here looked to challenge these views, as a 'concept of dynamic rather than of static planning' (pg.38, King 1975). Criticisms of workshops have focused on their potentially unstructured nature and the need for strong and effective facilitation (Easterby-Smith et al, 2002). In addition, social or peer pressures are a concern when dealing with a collective group.

There were two sets of workshops (repeated for wheat and dairy sectors). The first sets of workshops (known as the initial workshops) were used to test the development of the scenarios and gave initial feedback as to how actors responded to the different narratives. A structured set of questions were used to guide participants in their response (shown in Appendix C). Feedback from these workshops was then used to adjust the scenarios. The second sets of workshops were more intensive in nature, being spread over two days (four days in total, 2 for wheat, 2 for dairy). These were known as the core workshops.

To counteract problems with steering the core workshops, an outline structure was developed, based on a set of pre-determined questions and tasks. To aid with data collection and to create some standardisation to allow comparison between the groups, each group were asked to complete pre-drawn templates (Appendix D). The templates were principally designed to answer the original set of research questions for the Chatham House project. Workshop participants were asked to consider, as part of the task, any potential breakpoints, policy or strategy failures and general concerns.

The questions were designed to draw out responses to each of the four scenarios in turn and were framed as follows:-

Q1 - What are the likely implications of the global scenarios on the UK supply system?

- draw a timeline of potential events and changes over the 10 year time horizon
- identify any trends which will be significant
- identify how key economic, social, technical, environmental and political factors circumstances may be affected over the timescales

Q2 - identify the likely reactions, responses and behaviours by sector/supply chain echelon to each of the scenarios

- strategies, market focus, objectives and priorities
- how products, process, assets and relationships may change

To help to counteract concerns over confidentiality, each participant was asked to sign a confidentiality agreement, the workshop being run under 'Chatham House' rules. However it was recognised that participants would still be circumspect when revealing specific company-relevant data so questions and tasks were kept either at an industry or sector level. To help counteract concerns over peer pressure and to facilitate the collection of richer data, participants were divided into a number of groups. For question 1, groups were allocated randomly, for question 2, groups were arranged by sector (e.g. farming sector, processing sector etc.). Time constraints meant that each group could only consider 2 of the 4 scenarios, although where possible at least 2 groups were asked to consider the same scenarios to allow comparison.

Outputs from each of the group were recorded in two formats; the completed templates as recorded by the groups themselves and notes taken of their general discussions. Plenary discussions were also recorded in note form.

3.4.5 Phase 4: Analysis

This phase saw the analysis of the data. This analysis was conducted at a broader level, designed only to elicit policy concerns. The findings indicated that the UK food system would need to combine four potentially conflicting goals – those of resilience, sustainability, competitiveness and the ability to meet consumer expectations (see figure 3.5). This led to policy recommendations including the need to establish a cross-sector consortium to develop a vision for UK food supply, how to meet its skills and resource needs and how to develop joined up cross-government policies to meet the diverse needs of food supply. However, this was the point at which the project was judged complete with the final report delivered to stakeholders. No in-depth analysis of the data was undertaken and therefore there was no scope, within this project to develop theory with regards to risk and vulnerability in the food system.

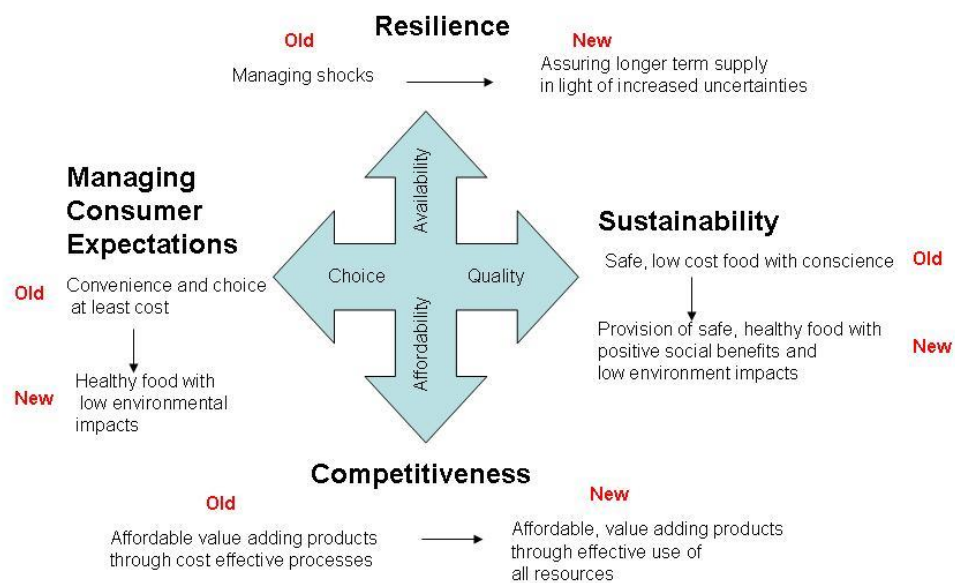


Figure 3.5: Key findings from the Chatham House project

3.5 Approach for thesis

This thesis therefore provided the opportunity to undertake the conceptual work that was not possible as part of the Chatham House study. The data was extremely rich in its nature and had only been narrowly examined in the CH study, focusing on the policy implications of the changes in global dynamics. In a sense the CH study did not take a fully academic approach in that there was no linkage of findings to academic literature or development of theory. There was therefore the opportunity for a more in-depth, focused examination of the data. Secondly, the data collected had, in many cases, specific relevance to the field of supply chain vulnerability. The supply chain network interviews in particular asked direct questions as to actors' views on key vulnerabilities for their organisations and sectors. The other sources of primary data, especially from the scenario workshops, by their nature implicitly revealed how actors perceived threats. However, this data was not explicitly examined in the CH study and thus had been left untapped. Thirdly, the majority of the primary data had been collected by the author and therefore it was felt that there would be sufficient 'ring-fencing' of the data in terms of original contribution and separation from the CH project.

3.5.1 Primary data usage

The three main sources of primary data for the thesis were taken from the following sources:-

- general interviews
- supply chain network specific interviews
- outputs from the series of scenario workshops

It is difficult to separate out how the data sets were used in the analysis – ultimately all of the data contributed to the conceptual frameworks developed as part of this thesis. However, broadly speaking, table 3.5 shows how specific data sets were used. The general interviews were used specifically to set the context of the time (the period 2007-2008). The supply chain sector interviews’ original purpose was to elicit views from actors on the key threats facing their own particular organisation and sectors; therefore the data here was in the same vein for the thesis. However, the data was also used to understand how different aspects of risk affected different echelons of the supply network. The sets of workshops gave the richest data set and form the basis of the core analysis for the thesis.

Data collection	Original purpose (Chatham House Project)	Thesis purpose
General interviews (Food system dynamics 2007-2008)	-To understand how actors perceived the dynamics of the food crisis in 2007 -To identify core global factors which could create changes in future dynamics -To develop the four scenarios	-To contextualise the dynamics of 2007/2008 period
Supply chain sector interviews (wheat and dairy actors)	-To understand actors’ perceptions of key drivers of risk and vulnerability impacting their organisation	-To understand actors’ perceptions of key drivers of risk and vulnerability impacting their organisation -How wheat and dairy actors conceptualise risk -How risk categories apply to the different echelons of the wheat and dairy networks
Initial scenario workshops (1 x wheat actors, 1 x dairy actors)	-To test scenarios for plausibility -To gauge initial reactions from actors	-Thematic analysis to identify risk categories -To identify the core factors which impact on vulnerability of the wheat and dairy supply networks -To build a conceptual framework which shows how these factors

Core scenario workshops (1 x wheat actors, 1 x dairy actors)	-To identify the potential impact of scenarios on UK food system -To understand the likely actions, behaviours and strategies actors across the food system	interlink
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Table 3.5: Data usage in CH project and thesis

3.5.2 Analytical approach

In keeping with the research philosophy and structure, a grounded approach was used to guide the analysis. This describes the process of the systematic analysis of the data, without externally imposed structures, to tease out themes, concepts and patterns (Easterby-Smith et al, 2002). The analysis was conducted using a framework proposed by Yin (2010) and is shown in figure 3.6. The analysis stage undertook a five step process as follows :-

- 1 – compilation of data
- 2 – disassembling of data
- 3 – reassembling of data
- 4 – interpreting the data
- 5 - conclusions

This process was chosen as it exhibited the necessary rigour to demonstrate an empirical link to the theoretical reasoning (Crotty, 2002) and to support the development of a level of theory abstraction (Suddaby, 2006). It also allowed a degree of transparency for other researchers to follow. From a constructionist perspective, validity comes from the transparency of the interpretation of data and the ability of other researchers to follow the process undertaken (Auerbach and Silverstein, 2003, Bryman and Bell, 2003). Table 3.7 (shown at the end of the section) indicates how the data was used in each chapter, the guiding research question, the phase of the research framework and the level of analysis utilised.

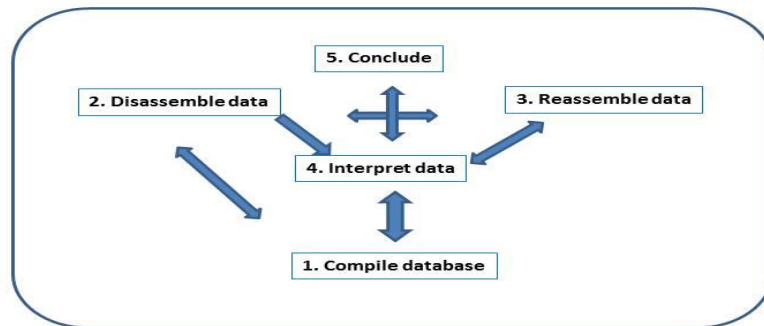


Figure 3.6 : Diagram of analytical approach- adapted from pg. 186, Yin (2010)

1. *Compilation of data*

This phase is the act of organising the primary data in preparation for coding. The software package nVivo was used to compile the data sources. The data sources comprised of interview transcripts by actor (from the general and supply specific interviews) and the written outputs from the scenario workshops. These outputs took the form of notes from discussions in plenary session, notes from discussions in the various groupings and the completed templates (as shown in appendix D). This resulted in 77 different separate documents or sources, with a total of 58,765 words that required analysis before coding. This indicates the size of the data and the coding task faced by the researcher. Each source was classified (using nVivo source classifications) as either being generated from the general interviews, the supply

chain specific interviews or from the scenario workshops. Where possible, sources from the scenario workshop were also classified as to the specific scenarios they related to (e.g. *Into a New Era*). The sources were also coded to two specific nodes – either wheat or dairy – and then nodes related to specific supply chain echelons (referred as supply actors) and or groups of actors more peripheral to the food system (referred to as peripheral actors) as shown in table 3.6. Classifying the sources in this way enabled analysis by scenario, by types of actor and/or by the wheat and dairy sectors.

Type	Classification
Agri-input and farm support organisation	Supply
Dairy Producer	Supply
Dairy processor	Supply
Wheat producer	Supply
Wheat processor	Supply
Wheat trader	Supply
Manufacturer (usually brand)	Supply
Retailer	Supply
Consumer group	Peripheral
Academic/scientist	Peripheral
Government	Peripheral
NGO	Peripheral

3.6 Classification of groups of actors

2. *Disassembling of the data*

This is the process of breaking the data down into codes to develop overarching themes. Here the process used the documented system of open coding,

common to grounded analysis (Strauss and Corbin, 1998, Easterby-Smith et al., 2002). The aim of open coding is to create concepts that fit the data by scrutinising the source materials (Strauss, 1987). Here open coding was used to generate two levels of code:-

Level 1 : initial codes from first examination of the data

Level 2 : category development from a re-examination of level 1 codes

Guidance given by Strauss (1987) was followed here to generate level one codes. He advises four elements to the approach :-

1. Ask the data a set of questions, specifically what study are these data pertinent to
2. Analyze the data in minute detail
3. Use theoretical memos to allow the researcher to move to an analytical realm
4. Do not assume the analytical relevance of any face value facts unless they have earned their place in the codes

(Adapted from pg 45,(Strauss, 1987)

The first pass coding took a considerable amount of time, due to the amount of data involved. In the first pass of coding, 268 individual codes were identified. A second pass at coding, looking to combine core themes, gave rise to 170 level 1 codes with 37 theoretical memos (giving an indication of potential level 2 codes). These level 1 codes are shown in Appendix E.

Emerging from the data were three sets of core themes:-

- Trends within the food system as observed by actors
- Specific threats and risks affecting the food system
- The factors which impacted on the ability of the food system to respond to threats

While the first set of codes were useful in setting the scene (they were partly used to inform the context in Chapter Four), the further two sets of codes specifically revealed how actors perceived risks and the factors that could impact the vulnerability of the food system in the future. By re-examining the level one codes and the theoretical memos generated as part of the coding process, these two sets of themes were developed as level 2 codes. These level two codes emerged as both concepts of risk and/or vulnerability. A set of codes could be directly linked to risk and these are explored in Chapter Five. A set of 35 further level two codes emerged with potential significance for risk and vulnerability. These are shown in Appendix F.

3. *Re-assembling the data*

This stage is concerned with the development of core categories and the emerging patterns and linkages between these categories. Core categories are those which are central to the investigation, appear frequently in the data, can be easily related to other categories and have implications for a more general theory (Strauss, 1987). The aim here was to develop level 2 codes into core category codes to aid the development of theoretical concepts. Yin advises the researcher to 'play with the data' (2010) to understand the emerging patterns and how these relate to the overall concepts and research questions. The researcher took this advice in two ways. Firstly, a series of matrix analyses, generated from nVivo were undertaken. These included a comparison of:-

- Level 1/2 codes vs data collection instrument (e.g. how the codes relate to the specific data collection events)
- Level 1/2 codes vs each of the scenarios
- Level 1/2 codes vs type of actor (using the source classifications shown above)
- Level 1/2 codes vs wheat or dairy sector actors

Secondly, as key codes emerged, these were transferred onto post-it notes and a large map was constructed (using brown paper) to start to understand how these codes interrelated with each other. A picture of the map is shown in appendix H. The process used here was axial coding. Axial coding is a well-defined method to develop level three codes/core categories (Easterby-Smith et al., 2002) . It involves the examination of each emerging core category in relation to each other to determine its centrality to the overall research themes ((Strauss, 1987). Here then level 2 codes were refined and developed into core categories. Once the core categories had been identified, a process of selective coding was used. This process involved the re-examination of the original data to check and balance the interpretation of the concept – as advised by (Easterby-Smith et al., 2002) and (Strauss, 1987) and re-coding data, to create more of an evidential trail, to the core categories. In this manner the core categories were refined and developed (these are shown in Appendix G). This revealed a complex web of categories which needed further organisation to facilitate the next phase, that of interpretation. Categories were therefore grouped in sets, based on whether they related to types of risk, either exogenous or endogenous factors, which impacted on the vulnerability of the food system as discussed in Chapter Seven.

4. Interpretation

This phase is concerned with the development of theory from the core categories, in essence ascribing meaning to the findings (Yin, 2010). This in turn then allows the researcher to rise above the detailed analysis and identify stories and themes at a higher level of abstraction (Easterby-Smith et al., 2002). Here the linkages between categories were explored further, developing a conceptual framework of the factors which could influence vulnerability (this is shown and explained in Chapter Seven).

Eisenhardt (1989) advocated the building of theory from cases through the synthesising of previous work and reviewing their strengths, weaknesses and applicability. This can also be achieved through the comparison of case data to previous theories and models in the literature (Gill and Johnson, 2002). The author followed this advice and this process involved a comparison of the theories and conceptual frameworks developed to those reviewed as part of the literature review. These findings are presented in Chapter Eight.

For inductive, case study based research, the quality of the research is based on how well the data supports the theoretical arguments that are presented (Bryman and Bell, 2003, Yin, 1994). It is recognised here that the interpretation presented in this thesis is only one way among others (Auerbach and Silverstein, 2003). In addition, dependability (or reliability) here comes from the support of this interpretation so that other researchers can follow it. However interpretation requires the researcher to move from a representation of the actors' logic to one which imposes their own external logic – in effect an ontological oscillation in imposing an objectivist stance (Gill and Johnson, 2002). This relates to the research quality criteria of confirmability (see table 3.1). This, objective stance, however, is an inevitability of the nature of research, the role of a detached observer is, in effect, illusory (Chubin and Restivo, 1983). This can be countered by both a level of reflexivity on the part of the researcher but also in identifying the practical ramifications of the research and the opportunities to test findings in the real world (Gill and Johnson, 2002). A large part of the analysis therefore was based on a reflexive piece. This was in two parts. Due to the timescales involved in the thesis with data collected in the period 2007-2008, an assessment was taken as to how the landscape in the food system has changed since then and whether the findings from this thesis still had relevance. The reflection also involved thinking through the potential ramifications of the findings for stakeholders and how they could have an impact in 2015. The discussion presented in Chapter Nine is the output of this process.

5. Conclude

Here, Yin (2010) advises the researcher to reflect on the broader implications of the study, particularly in challenging existing ways of thinking and research. The concluding chapter to this thesis therefore presents the overall contribution of this thesis, its limitations and the implications for future research.

3.6 Conclusions

This chapter has set out the methodological stance of the thesis, borne out of the original CH project. It explains the methods used for data collection for the CH project and how this data was examined afresh for this thesis. It explains the grounded analytic approach taken by the thesis. Table 3.7 summarises how the data sources were used, and in which chapter. It also shows the level of analysis associated with each chapter.

Chapter	Data Sources	Used How?	RQ	Research Framework	Level of analysis
4	-General interviews	-To contextualise the dynamics of 2007/2008 period	-	1.Compilation	Quotes from transcripts
5	-Initial scenario workshops -Main scenario workshops	-By scenario, key responses by actors related to conceptions of risk and vulnerability	-	1.Compilation	Quotes from transcripts
6	-Supply chain interviews -All scenario workshops	-How wheat and dairy actors conceptualise risk -Thematic analysis to identify risk categories -How risk categories apply to the different echelons of the wheat and dairy networks	RQ 1	2.Disassembly 3.Reassembly	Level 1 and 2 codes Core categories for risk
7	All data combined	-To identify the core factors which impact on vulnerability of the wheat and dairy supply networks -To build a conceptual framework which shows how these factors interlink	RQ 2	2.Disassembly 3.Reassembly 4.Interpretation	Level 1 and 2 codes Core categories for vulnerability Theoretical concepts

8	All data combined	-To compare theoretical concepts to existing literature	RQ 3	4.Interpretation	Core categories Theoretical concepts
9	All data combined	-To bring dynamics of the food system up to date -To reflect on impact and relevance of research	RQ 4/5	4.Interpretation	Theory building
10		-To outline contribution of the research	RQ 5	5.Conclude	

Table 3.7 : Chapters and data usage/research framework

Chapter Four: The dynamics of the UK Food System (2007-2008)

4.1 Introduction

The data for the thesis was collected during the period 2007-2008. This chapter aims to set the context for that period, in terms of the global dynamic and the UK context, for the food system and specifically the wheat and dairy networks. In addition, a set of 20 interviews were conducted as part of the CH project, designed to support the construction of the four scenarios. For this thesis, however, they helped to understand what actors thought were the key dynamics in the global and UK food supply systems at that time. The actors here were a mix of those directly involved in the supply network and those more periphery to the food system. Their mix of comments therefore gave a good overview of the concerns regarding the food system at that time.

The first half of this chapter presents a short summary of the global context in 2008, focusing on longer term concerns that came to the fore at the time of the crisis. NB. For a more in-depth examination of the global food demand and supply factors see Ambler-Edwards et al. (2009). The chapter then gives a short overview of the UK retail, dairy and wheat sectors. The second section of this chapter presents the key findings from the 20 interviews, focusing on core themes and trends that emerged in relation to the global context.

4.2 Global food crisis in 2008

4.2.1 Global context

The food price crisis was in full flow at the time of the data collection for the CH project. Prices started to rise from early 2006 but by August 2007, the FAO Food Price index was 47% higher in comparison and 60% higher in August 2008 (FAO, 2008b). This was driven by rises in the prices of key global commodities. Between

August 2007 and August 2008 the price of US hard wheat rose by 120% and the price of whole milk powder by 69%.

Short term factors were partially responsible for the 2007/2008 price rises, including historically low levels of global cereal stocks, low harvest yields due to poor weather conditions, coupled with high oil prices, coincided with record increases in global demand (Ambler-Edwards et al., 2009). However, the wide ranging impacts of the sharp price rises drew attention to structural, longer run changes affecting global food demand and supply. Debates started to coalesce around a number of key uncertainties and risks such as population growth, land competition, resources constraints and climate change.

Global demand for food is growing, driven by population growth. In 2008, the potential effects of this became more widely understood. The global population is forecast to reach 9 billion by 2050, and in 2008, the World Bank had predicted that food production will need to double in the corresponding period (World Bank, 2008). Concern then was growing over the capability of global agriculture to keep pace. Annual global per capita grain production was in decline, falling from its peak of 342 kilograms in 1984 to 302 kilograms in 2006, and the previous seven years had seen total world grain production fall short of global demand (Brown, 2008).

A number of uncertainties surrounding the capability of agriculture to respond become more clearly articulated. Reports at the time suggested that only 22.7% of the earth's available arable land, 10.1 billion hectares, was suitable for rain-fed agriculture (FAO & IIASA, 2007). The bulk of this is already being utilized and much of the remaining land is of low quality with significant problems of soil degradation. Water was and is a more serious concern. Fresh water constitutes only 2.5% of the total water available (Clarke and King, 2004). Overall usage stands today at 54% of this supply (of which 70% is used directly for agriculture); if per capita consumption rises across the globe at the rate seen within developed countries, this could increase to 90% by 2025 (UN Population Fund, 2001). Global economic growth, along with food production, has been highly dependent on the supply of fossil fuels, especially oil. While demand has soared over the last three decades, supply has

struggled to keep pace (Evans, 2009) and the high oil prices in 2007/2008 sparked concern over future supplies and the possibility of an oil-supply crunch (IEA, 2008, Stevens, 2008). On top of this, the Stern report (Stern, 2006) had been published in 2006, warning that climate change could be 'the greatest and widest-ranging market failure ever seen' (pg.i, Stern, 2006) . Rising temperatures and levels of CO₂ are expected to see global agricultural output decline by 16% (Von Braun, 2008). At the time, many thought prices would fall back from their peak but opinions were being voiced that these factors signalled a structural change which would keep prices higher in the long term (FAO, 2008a).

4.2.2 UK and policy context

Higher prices fed through to the UK and food price inflation peaked at 12.8% in August, 2008 (ONS, 2008). This sparked a re-interest in the production of food in the UK and food security in general (see The Daily Telegraph, 2008). This was translated through to government who published a number of food security reports (DEFRA, 2006, DEFRA, 2008b). In 2008, the Cabinet Office undertook an extensive review of food and related policies in the 'Food Matters' report (Cabinet Office, 2008). The report re-emphasized the importance of food and food production and highlighted a number of challenges for the UK food system. This marked a change in the position of government in recognising the need to pro-actively manage food production.

Major reforms to CAP payments were also underway. In 2005, payments had been decoupled from production volume and instead, were based on land area farmed. In 2008 a health-check was underway and other changes were being proposed including agreements to reduce cereal set-aside, abolish dairy quotas and reduce price interventions (Atkin and Fane, 2008). This signified major change for both the dairy and wheat sectors.

4.3 Supply chain context

4.3.1 Retail sector

Total consumer expenditure on food and drink in the UK was £174bn (DEFRA, 2010b). The UK agri-food sector contributed 7.1% of GVA in 2008, with the size of the retail sector valued at £22bn (DEFRA, 2010b). The UK retail sector is highly concentrated and in 2007, the four major retailers controlled around 75% of sales (TNS, 2007). While total food sales are split evenly with the food service sector (DEFRA, 2010b), retailers exert a skewed influence over the farming and processing bases, with around 75% of all products processed in the UK destined for the retail supply chain (DEFRA, 2009a). The problems associated with the power imbalance have been well documented (see White, 2000, Hingley, 2005, Fearn et al., 2005). As of 2008, retailers continued to exert cost pressures down the supply chain, with only around 36% of retail price going to UK producers (DEFRA, 2009a).

4.3.2 Dairy sector

The UK dairy industry contributed £1,384M of GVA to the UK economy in 2008 (DEFRA, 2010b). This equated to the production of 13.3bn litres of milk (DEFRA, 2008a). Liquid milk makes up 47% of the market, with cheese, yogurts, desserts and milk powders the rest (DEFRA, 2008a). The overall structure of the sector is shown in figure 4.1.

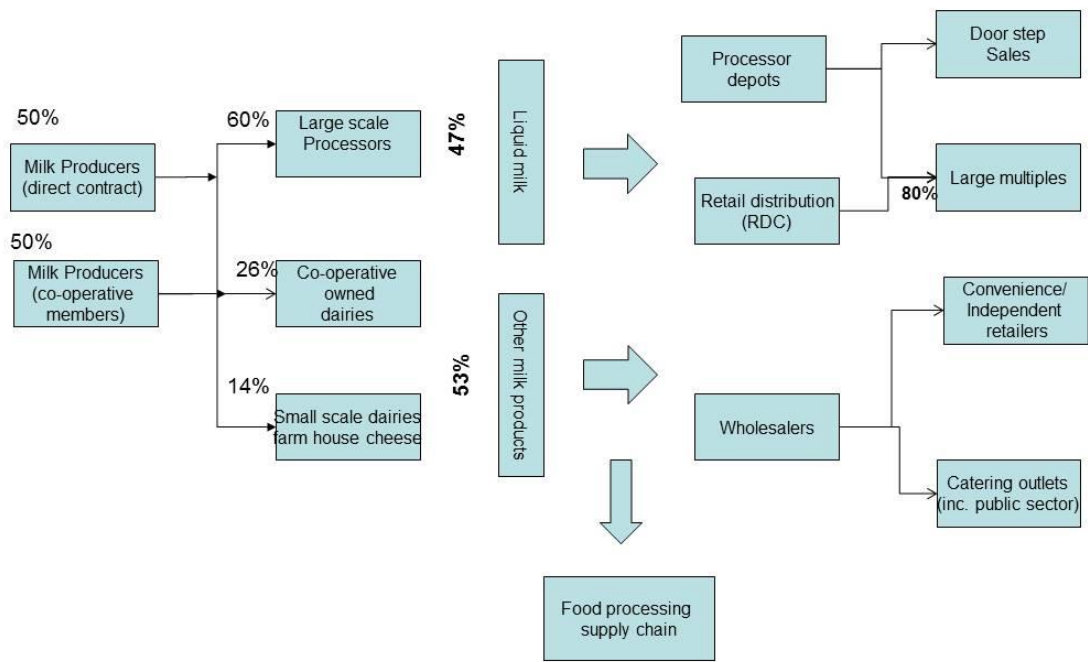


Figure 4.1 : UK dairy supply network (compiled by author from DEFRA, 2008d, DEFRA, 2010b)

The industry has seen significant trends in concentration. Concerns were ongoing over the exodus of dairy producers from the industry, 21% had left since 2005 (AHDB, 2015). However, milk production overall continued to increase due to higher yields, adding to concerns over the intensification of the industry (Burley, 2008).

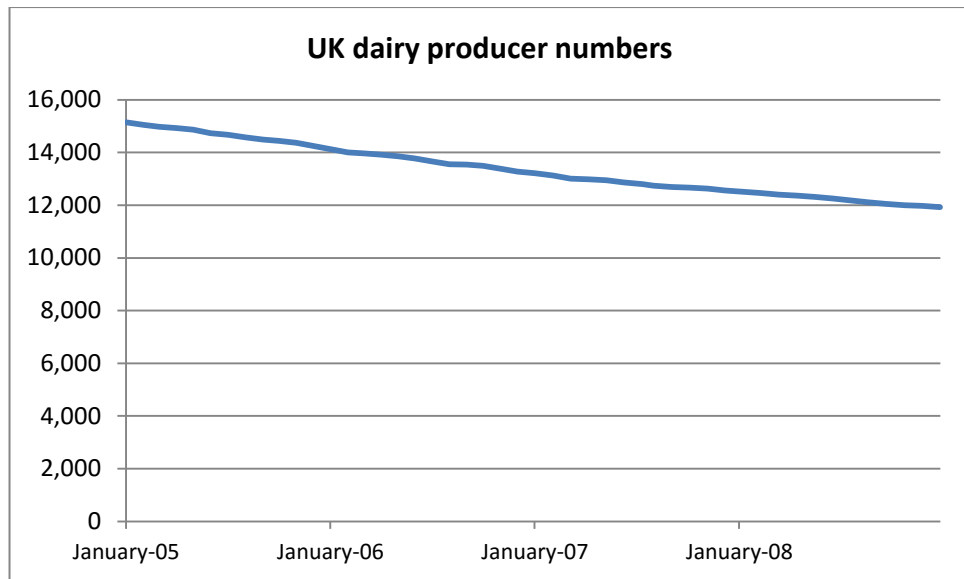


Figure 4.2 UK dairy producer numbers (AHDB, 2015)

The UK dairy industry had experienced high levels of change and instability in the preceding decade. In 1994, the Milk Marketing Board was the sole purchaser and supplier of milk. However, after de-regulation, the supply of milk fragmented between either milk producer co-operatives or through direct supply contracts to processors (Franks, 2001). In 2008, producers were split evenly between supply contracts for milk co-operatives and processors (DEFRA, 2008d). However, the processing sector was highly concentrated with only four companies responsible, at that time, for 60% of milk production (Dairy Crest, Wiseman, Arla and Glanbia).

Relationships within the milk supply chain had a history of being fractious and a government report highlighted an ingrained culture of adversarialism and blame (EFRA, 2009). The main clashes have been over perceived unfair farm-gates prices. However, in 2008, farm-gate prices were benefiting from global price rises and the average farm-gate price stood at 25.9ppl, 25% higher than in 2007 (DEFRA, 2008a).

This concern had prompted some retailers to create more integrated supply chains for liquid milk with producers on single-retailer supply contracts (Stevenson, 2004). However, there was still a concern that prices were not enough to cover costs of production (The Grocer, 2008).

4.3.3 Wheat sector

Wheat processing is the largest food manufacturing sector in the UK. The production of bread, biscuits and cakes contributed £3.8bn to UK's GVA in 2008 (DEFRA, 2010b). 2008 saw a rise in planted wheat area, up by 14% from 2007 (DEFRA, 2008a). This corresponded to significant rises in global wheat prices, as wheat prices rose in the UK by almost 100% to 2006 prices (DEFRA, 2008a) – figure 4.3.

There were 26,000 holdings registered as cereal farms in 2008 (DEFRA, 2008a). Between 1984 and 2007, the area planted with wheat in the UK fell by 6.3% (DEFRA, 2008a). However, ongoing improvements in yields have ensured that UK remains a net exporter (FAOSTAT, 2008), and 14% of wheat was exported in 2008(DEFRA, 2008a).

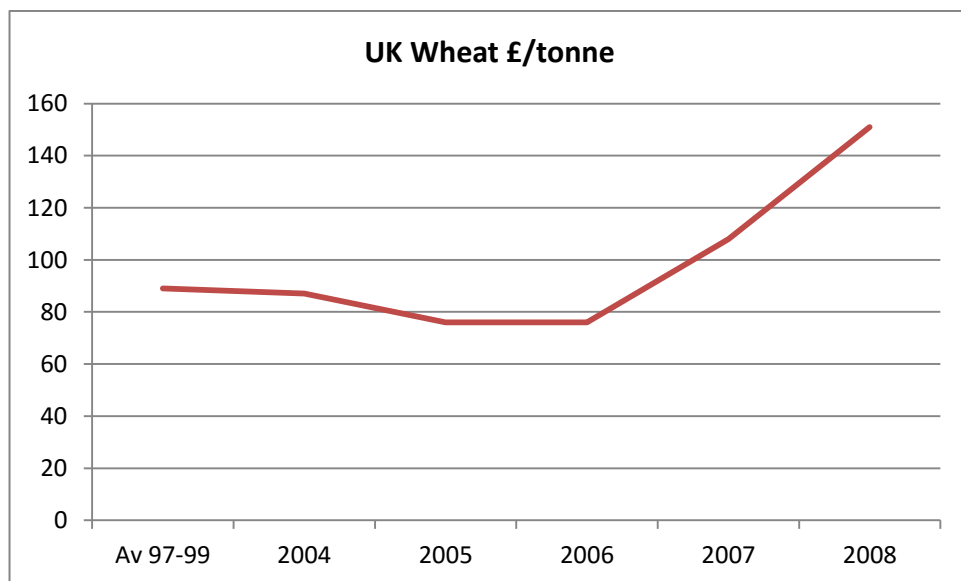


Figure 4.3 UK wheat price/tonne trends (compiled by author from DEFRA, 2008c)

In 2007, government set out a policy for the development of a bio-fuels industry in the UK, to support sustainable future energy needs (EAC, 2007). This triggered a flurry of optimism in the farming base that a new market would emerge,

creating higher demand for wheat supply, and therefore higher prices. However, concern was also raised over how sustainable bio-fuels actually were and whether this market would exacerbate competition for land(EAC, 2007)

The structure of the industry is shown in figure 4.4. In 2008, 51% of wheat was used for the production of animal feed, 41% was milled for flour, of which 58% was used for bread making purposes (DEFRA, 2008a). As can be seen, this supply network is more disconnected than that of the dairy network. Grain traders act as the core purchasers of wheat, rather than direct purchases by mills or feed processing plants. Wheat is a globally traded commodity, trading therefore underpins the behaviours and mechanics at the upstream end of the network. Further downstream, there are complex flows between primary processing (e.g. flour) and secondary processing (e.g. bread-making).

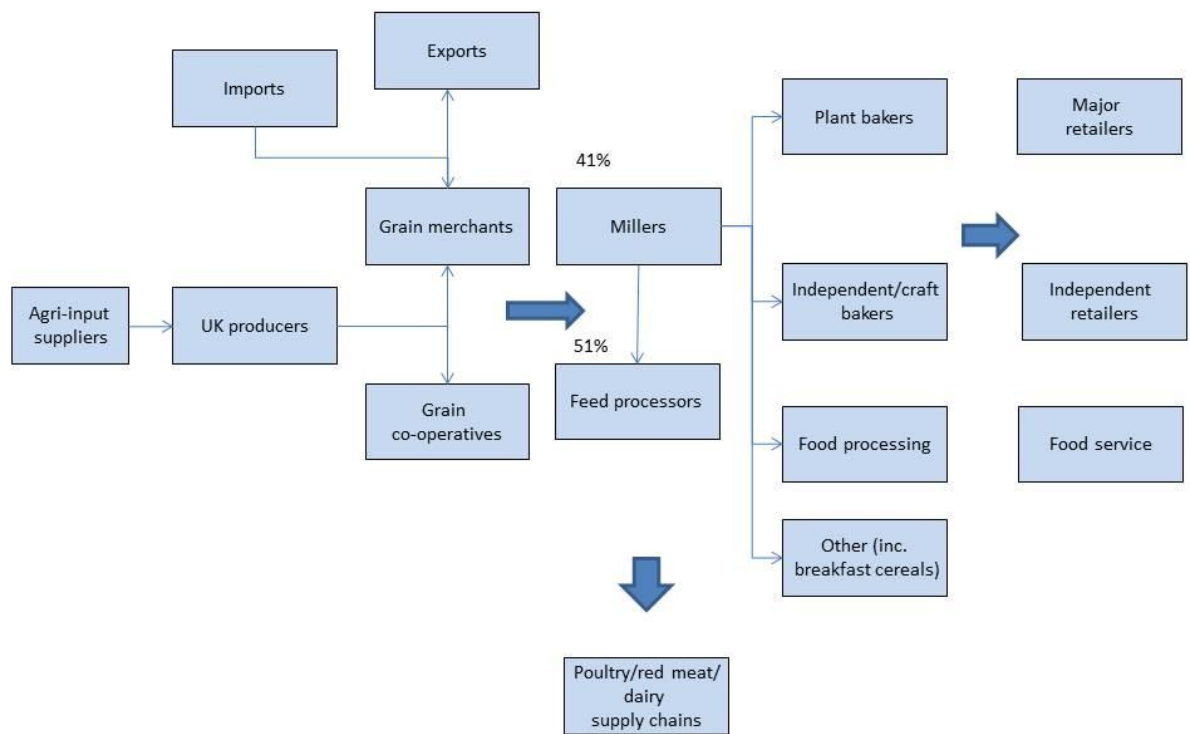


Figure 4.4; UK wheat supply network (compiled by author from DEFRA, 2008a, NABIM, 2008)

In 2008, the UK had 59 mills, run by 31 companies of which, the two largest companies accounted for approximately 50% of production in the UK. The baking sector is also highly concentrated with three organisations accounting for almost 30% of the market. Here these organisations enjoy brand dominance in the market (The Federation of Bakers, 2008) where 70% of bread produced is sold into the major retail outlets (DEFRA, 2010b).

4.4 General Interview and Actors' responses

4.4.1 Response to global situation

As was expected, actors were predominately concerned with the events of 2007 and the circumstances affecting the spike in food prices. The interviews revealed actors did generally understand how global events were contributing to the inflationary effects seen in 2007/2008. While there was some difference in opinion as to whether longer term factors were at play in the 2007/2008 crisis, a number of these factors were seen by actors as significant trends for future global food supply. These were:-

- the availability of land
- competition for land between food, feed and fuel
- climate change and increasing weather variability
- the availability of water
- the availability of energy

Many actors predicted a greater proportion of land given over to agricultural production as a result of the higher price rises. This then brought conflicts over the usage of land, soil quality and the problem of degradation and the competition between feed, fuel and food sources.

Energy, and the arguments as to whether globally peak oil production had been reached were voiced, but actors were more concerned about inflationary effects causing a rise in energy prices and therefore input prices. Actors recognised that it may be water that could be the bigger constraint, both globally and in the UK.

'We haven't started to think of water as a scarce resource but water could be a key problem – sooner or later population could expand above water resources.' Member of UK Levy board

50 % of participants expressed concerns that global factors could spell a longer term structural change to supply and demand dynamics; a new normality as it were.

'It is this same globalised environment that is now moving us towards a new paradigm, and at a much faster rate than expected. We are leaving the age of plentiful resources and moving towards one in which there is much greater awareness of the scarcity of resources' Retail industry representative

Others were cautious as to whether the 2008 price rises really did indeed spell the tipping point, but did express concern that over the longer term, the food system was facing significant change. All but one believed that global food prices, although falling back from their peak in 2008, would remain high, which in itself signals a significant shift in the market. Concern was also raised about the possibility of longer term price volatility impacting the UK market.

'There is likely to be a protracted period of inflation in food prices. There is a consensus in the food industry that price rises are expected over the next 3 years and likely to be an upward trend in prices over the longer run' Food system analyst

'Volatility has become the norm; we have torn up planning assumptions that seemed safe only two years ago.' Agri-food input supplier

4.4.2 Globalisation

One theme of note in actors' responses was increasing globalisation. In common with other industries, the food system in the UK has been subject to the trend of globalisation. In 2008, 41% of all food consumed in the UK was imported, underlining the increasing dependence on the global market.(DEFRA, 2010b)

'Over recent decades, globalisation has resulted in a much broader and more complex competitive arena. Business is done at a higher tempo and places greater demands on organisations' (and individuals') responsiveness and adaptability.' Retail industry representative

The rise in multi-nationals and the reduction in trade barriers have led to an expansion of companies supplying to global markets. Multi-nationals, supplying regional areas (e.g. the EU), dominate the industry while national smaller companies have suffered.

'The effects of globalisation have meant that products and materials are shifted around the world –location and nationally don't really matter anymore.' Public health and nutrition expert

Increased inter-linkages to the global market sparked a dichotomy of perspectives, the global market was both seen as an opportunity for UK expansion but also as a threat – threats from imports were mentioned in particular by supply chain actors. Greater exposure to global markets as a result of the dismantling of CAP subsidies linked to production also created concern for some supply chain specific actors, potentially generating more price volatility.

'UK is exposed to the global price and is vulnerable to global issues' Retail industry expert

*'From an era of UK/EU CAP-inspired protection, we are now in a global market where there are no interventions, no mechanisms for controlling prices'.
Feed/Grain agent*

One specific area of concern, was that of the dependency on imported feedstuffs for livestock. In 2008, 60% of all soya fed to livestock in the UK was imported (Ambler-Edwards et al., 2009) and sources in South America, at the time, were increasingly switching to GM crops, restricting sources (as the GM types are not authorised by the EU).

'the EU feed industry is only 22% self-sufficient, relying on soya from Argentina and Brazil to make up shortfalls in the supply of protein to Europe's livestock. Temporary bans on imports from those sources as a result of asynchronous authorisation [for GM] could create real problems for EU livestock production.' Cereal industry association representative

4.4.3 Environmental sustainability and government intervention

Many actors expressed concern over the impact of agricultural on the environment. This was expressed predominately as the impact of carbon emissions and there was recognition among many that more needed to be done. However, a few actors, very strongly, expressed their belief that the food system is fundamentally unsustainable in its current form. Here, increasing intensification and industrialisation were seen as major drivers of an unsustainable system. This view was not reflected by more mainstream supply actors.

'The pressure of higher meat demand will create the need for more homogeneous meat; the pressure will be to increase industrialised meat production which has environmental consequences.' Public health expert

'There is a big push for industrialisation in production techniques (e.g. in Africa). This is driving an increased use of fertiliser and an increase in the use of seed varieties that are suited to the market rather than suited to local conditions (leading to smaller number of seed varieties in use). This narrowing of bio-diversity can also be seen with livestock e.g. breeds of cow world-wide are very narrow' Environmental activist

'For example concentrated animal feed has resulted in a separation of animals from the land. There is a lot of feed going into a small land space; this is equating to a lot more methane, nitrous oxide, ammonia and water pollution' Research institute representative

4.4.4 Role of government

Linked to concerns over environmental sustainability, some advocated a more pro-active strategy from UK government. Actors highlighted the conflict between private, commercial concerns and the need for greater action on sustainability and health issues. Intervention by government to help mitigate power imbalances in the food supply chain was also suggested to support better sharing of profits.

'The private sector 'does' sustainability with the consumer in mind. When something resonates with the consumer then that's fine (e.g. carbon) but when it doesn't there is a big gap. The private sector is doing some good but there are major gaps. For example, in the trading relationships, promoting justice and fairness for primary producers and for labour.' Research institute representative

'The government don't have enough control within the industry and they are in effect pushing food onto the consumers which is unsustainable both from an environmental and health perspective' NGO representative

Many mainstream actors were very sceptical of increased government intervention. In fact, many argued against it, believing a more free-market approach, with less regulation, would support a more competitive industry.

'There is too much politics in agriculture.....I'm very sceptical about interference in the economic cycle. CAP reform [i.e. less intervention] has not meant that we have run out of food etc.' Cereals industry representative

Many actors saw the EU and UK position on GM as untenable, and a potential contributor to further pressures on food supplies. There were calls for government to act to support more approvals of the application of GM technology.

'In the UK some have spent the last 10 years trying to alter the public mindset that has been allowed to develop around GM; from now on, with no such action having been taken, we should expect clear and appreciable shortages in the supply of commodity crops, in particular animal feed to the UK market.' Agricultural supplies expert

4.4.5 Key trends in the market

The rise of a more demanding consumer, with higher expectations was a strong theme running through the interviews. UK consumers now expect a wide range of choice, with food products that fulfil multiple criteria from product quality, the method of production (e.g. organics) through to fair trade – this has been coined 'values-based purchasing'.

'Growth in consumer expectations..... consumers want their food supplier to deliver everything: differentiated products (GM, non-GM, organic. Local etc), right quality, right price, meeting environmental standards, good ethical practices, taking care of consumer health.' Retail industry representative

'In the largely conflict-free developed world, the supply of plentiful, safe food has been taken for granted and our focus has shifted instead to values - issues affecting environment, health, animal welfare' Retailer

Concerns over the link between food consumption and health were also prominent here. Actors pointed to the growing trend of obesity as a core issue for the UK. For some actors this linked to further evidence of unsustainable behaviours in the food system, especially the conflict between the need to keep food prices low versus commercial interests.

'Obesity is the number one public health issue. How to tackle dietary change is going to be the key question'. NGO representative

'There needs to be recognition that cheap, highly promoted, highly industrialised food is a problem. It is in the government's interest that food is cheap and this has been the policy for 100's of years. Industrialised food production enables this policy but this effectively externalises the cost' Public Health expert

4.4.6 Trends in the supply network

CAP reform, the switch to single payments and the removal of price intervention mechanisms was recognised as being one of the biggest changes to producers and the food market. This has driven many producers to become more market orientated and was seen as a driver for lower volumes to have been produced post reform (2004), particularly in the dairy sector (due to lower overall prices for milk).

'The move away from direct subsidies [has been the biggest change]. Cereal market has not adapted yet but will need to quickly. Wheat producer

For the wheat sector, the emergence of bio-fuels also created some uncertainty in the market. On one hand, bio-fuels were seen as providing a new market outlet for wheat and therefore having a positive effect on prices; in that it had the potential to absorb any over-production at a farming level (rather than having to export wheat at lower prices).

'[Bio-fuels]The grain market has not had any new market for a long time. Bio-fuels could create a 'demand shock' Wheat producer

A significant trend over the last few years has been the consolidation of processing firms and the trend toward larger farms. These are responses to the need to increase efficiencies and maintain profit margins within the sectors. Many general and supply chain actors saw the inevitability of the continuation of these trends in response to price and margin pressures

'Manufacturing will become the business of even fewer and bigger (global) companies. More mergers will divide the market between the big players and a relatively few, small, niche-led businesses. There won't be much in between'. Grain market trader

Associated with this was considerable debate about whether 'local' constituted a more economically and, potentially, environmentally effective structure versus the trend towards globalisation. Some actors believed that local sourcing had traction, particularly with a growing consumer interest in the provenance of food.

'Simple supply economics also suggest an increased retail focus on locally produced foods that combine (positive) local identity with fewer "food miles"' Dairy industry association representative

This counter-trend to globalisation saw actors picture a potential blending of the small and large. The larger scale organisations here were expected to get bigger, centred around the assumptions that economies of scale (i.e. global, larger

concentrated structures) bring greater efficiencies. This would leave space for niche, smaller scale systems at a local level.

'The UK's food system will become divided, in effect, into two areas - local and global. The concept of national food supply will become irrelevant. 'Agri-input industry expert

'There could be increasing tension between the centralised/volume based concept of production and a strengthening consumer preference for food with a clear local or regional provenance' Retail industry representative

The UK retailers exert significant power across the system. However, some actors saw the potential for this power imbalance to switch around in light of any potential global scarcity or increasing global prices.

'The question is, with supply/demand becoming tight and moving from a buyers market to a sellers market, how will these positions be re-evaluated? E.g. the retailers have been able to 'beat up' the producers in an over-supply market..... but any change towards tighter supply could mean that this becomes more difficult'. Energy market expert

'The true foundation of negotiating strength is scarcity. As commodities become scarcer, even the biggest buyers will need to compete intensely to secure supplier'. Retail industry representative

4.5 Conclusions

This chapter has set the context for the period 2007-2008 when the data collection for the CH project took place. It has highlighted the key dynamics of that period, those relating to the global situation and an overarching view of the dairy

and wheat supply networks. It has also given an overview of the key concerns and trends that occupied the mind of actors during this period. This chapter has shown that this was a pivotal moment in the UK food system, as actors became more aware of the convergence of factors which could present significant vulnerability for the network. Chapters Five, Six and Seven explore this in more depth, while Chapter Nine provides an update of the responses by policymakers and supply actors since this period.

5.0 Chapter Five: Responses to the Chatham House Scenarios

5.1 Introduction

The aim of this chapter is to present the outcomes from the scenario workshops, in order to start the exploration of the key themes related to risk and vulnerability. The scenario workshops were a central part of the CH study and so produced a significant amount of data. These workshops encouraged actors to think more widely about the food system as a whole and to explore how threats could play out in the future. The scenarios provided an opportunity to test their reactions and thoughts when exposed to different combinations of external threats and shocks and therefore were helpful in revealing where actors saw areas of vulnerability. The scale and types of threat differed across the scenarios – from Just a Blip to Food in Crisis – therefore providing a unique way of exposing actors to different stimuli in order to test their responses.

The workshops were also designed to give rise to thinking about possible courses of actions that would be taken by each echelon of the supply chain, also giving rise to insights into how actors' perceived the severity of threats, and revealing the range of potential behaviours across the supply system. The differing responses to the separate scenarios allowed different perspectives to be voiced; this was also true with responses to one particular scenario where views could differ between different groups, even when responding to the same set of circumstances. The questions posed in the workshops were designed to understand the behaviours and impacts on actors in the wider food system, including government and consumers. This allowed a more holistic, systemic understanding of the dynamics and core interdependencies. The differing perceptions are therefore presented here in this chapter, forming an important part of the thesis in the understanding of the complexities surrounding actors' perceptions of risks.

In order to preserve the complexity and ambiguity of the base data, this chapter presents the actual responses to each of the scenarios in turn. This formed

part of the data compilation phase (as explained in the methodology chapter) and quotes are presented here as they were given verbatim from the workshops, without analysis or coding applied. Validity in this case is concerned with the 'quality of theoretical reasoning' (Bryman and Bell, 2003). It was felt important to present this data before proceeding to a higher level of analysis, to show a clear line of sight between the data, the analysis and the subsequent conceptual findings.

As actors were grouped together at the workshops, data was captured at a group rather than at an individual level. In addition, due to restrictions and sensitivities expressed by actors over competition laws, it was agreed that no direct quotes by individuals were recorded. In this section therefore any quotes given are those offered by groups of actors. However, each quote is attributed to the supply chain echelon that each group belonged to.

5.2 Scenario 1: Just a Blip

High food prices prove to be a temporary blip and soon return to the long-term trend-line. There is a possibility, however, that if food prices fall back sharply, financial speculation in commodities will operate in reverse and lead to exaggerated food price volatility. *High food prices trigger a major investment in increased production. Over a two- to three-year period, marginal land and spare capacity are brought back into production, double-cropping is more widely adopted and food production surges.*

In spite of climate change fears, the weather proves remarkably favourable. There are almost no major crop losses affecting feed or food and sustained rainfall in Australia breaks the long-running drought, bringing harvests back to normal levels.

Geopolitical stability in oil-producing regions is seen as improving following the 2008 US election, and oil supply concerns ease. As a result of receding global fears and a jump in energy efficiency investment, the oil price returns to levels around \$65 per barrel or below. Food input costs decline.

The reduced oil price undercuts the economic competitiveness of crop-based bio-fuels, and ethical pressure from NGOs builds. Bio-fuel production falls, freeing up food production capacity.

The combination of a strong supply response and favourable conditions moves food into overproduction and prices fall. Financial speculation, which had been a significant factor in driving up prices, then shifts sharply causing the food price to plunge further, ending up well below the previous long-run trend-line.

Farmers reel from the dramatic collapse of food prices. This paves the way for volatility around the trend-line in the years that follow.

Figure 5.1 : Just a Blip narrative (Ambler-Edwards et al., 2009)

5.2.1 Responses to Just A Blip

This scenario was met with some scepticism and thought to be an unlikely outcome by many of the supply chain actors. This underlined the beliefs expressed in the interviews that the food price rises in 2008 spelled the end to a period of food deflation and that food prices were likely to remain high. Instead, many actors placed their own interpretation on the scenario, envisaging a period of increased price volatility, rather than a return to pre-2008 prices, creating a series of blips as prices rise sharply and fall again.

‘There would be increased awareness and concern about the implications of future possible blips ‘ Wheat supply actors

There were a few voices that dissented with the scenario of increased price volatility and believed that the food price hikes at the time, would indeed decrease back to pre-2008 levels. This indicates the level of heterogeneity of the overall group.

However, in the main, supply actors judged this scenario, one of volatility, as an uncomfortable and dangerous position, where the prospect of continued price volatility would create many difficulties in sustaining profitability. The uncertainty would affect producers in particular, making it very difficult for longer term planning and investment.

‘A blip scenario is bad news because farmers like stability – it’s hard to make long term decisions’ Dairy supply actors

A blip therefore presented one of the worst situations for food supply actors. One where there was no stability, higher prices could not be counted on to forge better margins, limiting the level of capital available and the willingness to invest.

'A blip would lead to continued low profitability and lack of investment in new technology and limited long term efficiency gains. Less investment leads to poorer techniques and storage of grain' Wheat supply actors

From a consumer perspective this scenario offers some relief, in that prices fall back to their pre-2008 levels, although, according to actors' perception of the scenario, there would be continued price spikes. Even in periods where prices were high, it was felt that the retailers would look to protect the consumer and not pass on price increases. This would cause issues for some in the supply chain who would have to absorb any input price increases, thus impacting their profitability.

'There could be problems in passing cost increases down the supply chain. Retailers are reluctant to increase prices. Big manufacturers may be able to pass on prices to retailers but not the smaller manufacturers.' Dairy processors

This scenario was thought particularly challenging for dairy farmers, with even more pressure on profit margins and no room for capital investment. It was expected that there would be a continuation of the contraction of the industry.

'Farmers will get out of a volatile industry. They may not invest or invest and then get caught out [with drops in prices]. There will be a loss of critical mass with a steady decline'. Dairy supply actors

The wheat sector would not be immune, potentially having difficulty in maintaining profits. Production could see a retreat to the most fertile areas of the UK (predominately the east of the country) with little extra planting.

Some actors saw increased price volatility as a driver for more collaboration across chains with processors entering into longer term contracts with suppliers in order to stabilise and agree fixed term prices. However there was strong dissent

from some wheat actors who thought high price spikes would mean more opportunistic profit taking by farmers and therefore a reluctance to enter into longer term, fixed price contracts.

'Blips act against long term supply chain agreements because farmers go for short term gains' Wheat supply actors

However, despite more pressure on margins, some actors felt that processors and manufacturers would not look to change their current strategies or trajectories.

'..there will be little impact on manufacturing ,it will be business as usual' Agri-input and producer interest actors

Interestingly, actors saw this as a positive re-enforcement for current government policy and the preference for limited or minimal intervention. This scenario therefore reinforced faith in markets and therefore their ability to keep food prices low through both UK and global competition, with no need for interference or increased intervention from government in the form of direct farming subsidies (e.g. CAP).

'... restriction of public expenditure in agri-food because of the belief that the market can cope.' Dairy supply actors

'Government will let the market sort it out (there is a variable response across the market) and hope for the best. The assumption is that food imports will keep inflation in check' Wheat supply actors

However, actors felt that continued confidence in lower food prices created an opening for the government to be opportunistic in light of these prices and use fiscal measures to address wider policy concerns such as sustainability and specifically health concerns.

'Government will see an opportunity to take liberties with taxation on foodstuffs. There could be taxation on fats and sugars to reduce health bill'. Dairy supply actors

5.2.3 Just a Blip Summary

The rejection of the original narrative of Just a Blip by a great many actors (in that many did not believe that prices would fall back to pre-2008 levels) indicates that, at the time, many believed that the dynamics of the global food system had changed the landscape for UK food supply. While not seen as likely, it was perceived by supply actors as a positive scenario for government in that it vindicates the underlying position of faith in markets (as adopted by Labour at that time, but also by subsequent Governments to date) and their preferred policy positions of lower interventions in food production and supply. It also ensures that food bills are kept at an affordable level, thus circumventing potential social and welfare issues. Price volatility however was the number one concern for actors, and the inherent pressures this could put on profit margins. As this scenario reflected a situation not that different to the one before the food crisis in 2008, one of reducing prices and low investment in agri-food, actors were familiar with the risk and threats that this presented. In this sense, the risks identified here were known and well understood. It could be argued therefore that these risks could be extrapolated as their daily concerns affecting their own organisation and situations.

5.3 Scenario 2: Food Inflation

Food prices stay high for a protracted period. They contribute significantly to inflation, but the economy adapts and the existing food system copes. *Demand for food continues to grow in step with increases in world population. Higher meat consumption in Asia and further bad weather and climate-related crop losses ensure that demand persistently outpaces production growth, albeit by a narrow margin.*

Oil prices stabilize at around \$90–100 per barrel, high enough to maintain the push for bio-fuels, and high gas prices and capacity constraints keep fertilizer costs high. The imperative to increase food production leads to widespread deployment of new technologies; these include a range of bio-technologies, and methods for improving the efficiency of water consumption and nitrogen application. Continuing efforts are made to reduce food waste in the system. Improvements in practices push up production but come at a price, with input costs rising overall. Production struggles to keep pace with demand and global grain stocks are not rebuilt.

Following the investments in new food production technology, the widely feared fundamental limit to global food production is avoided or at least delayed. The structure of the global food production system remains largely unchanged, but the new intensification adds to environmental pressures.

In Europe, even as the supply of non-GM crops shrinks worldwide, consumers continue to resist imports of GM food and feed. EU policy requires reduced use of fertilizers and pesticides for environmental reasons, further adding to feed price pressure by constraining local output.

Persistently high food prices contribute to the woes of a recession that hits developed countries along with high energy prices. High food prices add to pressure for wage increases in emerging markets, where expenditure on food represents a relatively large percentage of average income; this translates into higher export prices and contributes to inflation in developed markets.

The world is ultimately judged to be experiencing a 15-year 'long-wave' upswing in commodity prices. The sustained high food prices, combined with the difficult economic conditions, cause a rise in the proportion of personal income spent on food, ending the previous long-run downward trend.

Figure 5.2 Food Inflation narrative (Ambler-Edwards et al., 2009)

5.3.1 Responses to Food Inflation

In this scenario, actors expressed significant concern over the impact on the consumer and their ongoing ability to afford food stuffs. From the supply chain actors' perspective, their concerns were based on the squeeze on consumer spending power. While Food Inflation offered an opportunity for higher profits, it was recognised that this came with a social impact on the consumer, particularly those in lower income groups. The idea of a more polarized society, split between those who could afford higher value food and those who can't, becomes more marked in this scenario as social inequalities become more exacerbated.

'socio-economic divide will widen and there will be a need to manage the problems which arise from a more fractured and polarized society. The poor suffer most – and as poverty is correlated with obesity so health is likely to

suffer too' (comments made during the plenary session at the Dairy workshop)

Price here for many consumers becomes the overriding purchasing criteria and this was thought to be at the expense of health and environmental values and concerns. Some favoured more intervention from government – in policies such as free school meals, food vouchers etc.

'.. need for greater social provision, free school meals etc' Dairy supply chain actors

There was also recognition that the widening of the divide between rich and poor had potential consequences for increased social dis-order including food riots. Actors saw a potential pinch point where continued price pressures, along with spates of panic buying, could tip this scenario into a crisis. The rise of black market trading also causes some concern particularly over food standards and associated food safety.

'[national government] .. will need to focus on economic stability and social justice (avoid social unrest)' Wheat supply chain actors

A positive consequence of the need to keep costs down was the overwhelming recognition that levels of waste should be tackled across the whole of the supply chain and in the home; in effect to view waste as a resource. This scenario provides the financial incentive for better waste practices and more integration of waste businesses with producers, processors and even retailers. More availability of capital for investment could pave the way for more investment in anaerobic digesters and co-operation between producers and recycling/waste processing companies.

'farmers will look for cheaper alternatives for fertiliser. The waste industry has the opportunity to provide these'.

'There could be more strategic relationships between waste companies and larger agri-businesses or even retailers' Dairy processors/producers

In fact for producers, this scenario was seen as a potentially advantageous position with higher food prices generating higher profits. This would incentivise farmers to produce more in the UK and actors from the dairy industry thought that this would create possibilities to increase milk output. If the pre-longed period of inflation coincided with the abolition of milk quotas in 2015, then this was seen as a major opportunity to increase milk production and export more milk products both to the EU and globally. For the dairy industry, this was predominately viewed as a positive scenario, with the better, more efficient farmers able to capitalise and improve their gross margins. It could also have the effect in delaying the exit of some of the lower quartile farmers, perhaps perpetuating inefficient farms.

Pressures remain however on inputs and again, the challenge for farmers will be to protect their gross margins. If input costs were excessively high in this scenario, actors saw this as a key factor for producers to create savings and efficiencies. The dairy industry was split on how this would manifest itself. Either this would result in a switch back to more grass based systems (extensive) or it could trigger a further intensification of dairy farming with more use of genetics to optimise inputs and an increased focus on conversion rates of inputs to outputs in terms of milk yield per cow.

'...increased seasonality of milk production [though switch to grass based systems] with less reliance on feed to achieve optimum yield' Dairy supply actors

'more investment at farm level leading to more intensification. This will mean more herds are milked three times per day' Dairy supply actors

The continuation of the trend for intensification, driven by higher input prices, was also echoed by actors in the wheat sector. Actors also saw this as an opening for an acceptance of GM technology, based on fears over rising prices, to help optimise inputs and increase wheat yields.

'rising input costs will see more marginal land in production, higher intensification including the use of GM' Wheat supply actors

In this scenario, it was felt that the cost of EU/UK agri-environmental schemes could increase. Due to pressures to keep costs low, mainly driven by retailers, then any further internalising of carbon or other environmental costs would be difficult to bear.

Actors from the wheat sector had specific concerns over price volatility in this scenario and how this would impact gross margins; it was felt that rising input prices would be subject to higher levels of volatility. These concerns were often framed by a need to develop more risk management and financial products to help producers and grain traders manage price volatility (hedging etc.). Processers and millers here were expected to use more fixed price contracts to help smooth out volatility but at the potential expense of higher margins.

'there will be a need to better understand risk in order to lock in margins. The range of products offered by companies to manage risk will become more of a priority' Wheat sector actors (grain traders/processors)

Higher selling prices and profit margins were seen as a driver for increased investment in the farm section, in terms of infra-structure, equipment, transport and particularly in technology. This was felt to be the catalyst for an expansion in UK food production, reversing the trend of the last couple of decades. Interestingly, while there was felt to be more money available to invest in R&D and new technologies, actors referred mainly to the use of existing technologies and practices (although with further leading edge development). In this scenario, there was no sense of the need for new technologies. However, concerns were raised as to the current level of investment in UK based R&D (private and government) and the need for even more money to be invested in this area. From wheat supply actors, there was a call for research to be more directed towards increased productivity/efficiency and away from environmental sustainability impacts.

'There needs to be a strategic direction of R&D away from the environmental to productivity. There is no present funding for wheat breeding. This is a must. Either through private companies or INNES/NIAB venture' Wheat producers

Here, the current trend for either the commoditisation of products – cheap produce in high volumes – or differentiated, branded products with higher margins continues and becomes more marked. In effect, the drive for more branded differentiation could increase as a vehicle to justify any higher prices to consumers. This was seen as a necessary strategy for processors, as while this is a potentially positive scenario for producers, it is the processors or manufacturers that seem particularly vulnerable. In these sectors, actors felt that they would feel the pressure from increased input costs but would be the least able to pass on costs further up the chain. To counteract this, actors saw this strategy of differentiation as key to gain more value added revenue and therefore margin. In conjunction, actors saw the need for increased marketing and advertising in order to convince the consumer of product value. This poses some difficulty for fresh milk which is in effect a commodity product.

[farmers would need to be].. lowest cost producer or would have to differentiate. They would need brand investment to justify increase in price (for differentiated strategies). Dairy processors

However, higher costs of production and higher end prices were felt to exacerbate the threat from cheaper imports (for dairy). The trend for consolidation in the dairy industry was expected to continue in this scenario, with processors forced to move to large-scale, centralised and efficient sites (i.e. disinvest older legacy sites); thus concentrating the dairy processing sector further. Threats from lower cost imports could even lead to the migration of processing facilities to cheaper, non-UK locations (Eastern Europe was mentioned specifically). Any migration of UK processing would signal a threat to the dairy production base as the associated supply base in the UK would become redundant.

'more migration of investment in dairy production and processing – to Eastern Europe. More dairy products sourced externally to UK/EU' Dairy supply actors

Actors did pose an alternative to this, where processors initiated more cooperation with producers. This could result in the use of more exclusive and stringent supply contracts between farmers and processors and the development of

more dedicated integrated supply chains. It could also trigger different ownership models, such as vertical integration in the dairy sector. Actors also pointed to a potential shift in power to processors and producers and away from retailers if supplies became tighter.

'There would be more direct relationships with farmers e.g. Tesco herds' Dairy processors

'Could be a struggle to secure relationships with farmers and processors, with powerbase potentially shifting to the farm-end of supply chain' Retail actors

As a response, retailers could also look to lock in prices with more contractual agreements with processors and manufacturers. Retailers would look to the supply chain to absorb the increased costs to save passing them onto the consumer; this in turn would put more pressure on the supply chain to focus on cost savings and efficiencies.

Actors in the wheat sector also identified collaboration as a key strategy in this scenario to help counter supply uncertainty and price volatility. However it is interesting to note that it was horizontal collaboration with processors, rather than vertical. Millers and producers spoke about increasing the co-ordination and collaboration within their own supply echelons to assure supply and to keep costs lower. This is perhaps because wheat supply chains are more fragmented and integrated chains are not the norm. It was recognised however that current competition laws would create a barrier to this.

'More cross-industry collaboration is needed, particularly to prevent any escalation in crisis. Current competition laws are a barrier to horizontal collaboration. There would need to be a lifting of current competition law restrictions, recognising this as for the public good.' Wheat sector actors

'Strategic relationships will need to become stronger, driven by both the uncertainty of supply and the need to reduce costs' Wheat supply actors

Strategies to re-formulate products in the dairy sector were also seen as key – i.e. using less concentration of milk in cheese or other processed products to reduce costs. This could also trigger an increased use of non-dairy alternatives if proven to be cheaper. Some actors also foresaw an increase in local foods in this scenario as a strategy to ensure supply and to create the necessary differentiation for dairy products.

'Lower concentration of milk in processed products – reformulation, e.g. cheese has 9.5 times milk input rather than 10 times) Dairy processors

It was very much thought that, in this scenario, the price incentives would see an end to the need for CAP .i.e. no set-aside payments, no single farm payments. This theme of less government intervention in the farming sector was fairly consistent theme among actors in this scenario.

'Higher prices would provide the opportunity for politicians to pull back from CAP payments' Wheat supply actors

5.3.2 Food inflation summary

In this scenario, businesses and farms continue to become bigger and more concentrated, there is more collaboration up and across the system with a sense of more integration and dependency. Producing more with less through streamlining of processes and the use of technology becomes the key theme. Many considered the new higher price points as *'a rational place to be'* and *'an acceptance of a new normality'*. This gives the sense that many of the supply chain actors felt comfortable with this scenario. In effect, it was viewed by them as an extrapolation of the current position (in 2008) and was a natural consequence of the pressures on global food supply and therefore prices. In this scenario, the status quo continues with the same systems, practices and organisational structures, albeit at higher price points. Higher

prices were viewed as positive, and if higher input costs could be balanced, this provides an opportunity for the industry to improve margins and increase investment. The majority of risks lay therefore at the door of the consumer and the government, as food could become less affordable. In this sense, as with Just a Blip, the risks here were known already by actors – the balance between pressures on cost and prices – and it re-enforced their belief in the strategies already employed across the food system as being those with the highest rate of success.

5.4. Scenario 3: Into a New Era

Input prices initially stay high as per capita production falls steadily. In response, the system of food production is required to shift dramatically so that increased yields are delivered efficiently through 'regenerative' rather than purely 'extractive' uses of resources. *Global oil production stays flat and begins to tighten. The view spreads that 'peak oil' has arrived. The oil price rises above \$150 per barrel but is held in check by reductions in energy consumption and the widespread deployment of energy efficiency technologies. Oil prices sustained at a high level support a continuing emphasis on bio-fuel production.*

The effects of climate change become starkly obvious, with weather-related losses reaching higher levels every year. Developed countries agree on carbon pricing, and developing countries sign up over time. Many countries introduce water pricing in response to serious drought conditions. Tougher environmental limits on pesticides and fertilizers are introduced, and nitrogen pricing is debated.

Food production per person is in decline, food shortages are more frequent and prices are climbing. Under these conditions, it becomes clear that food production is hitting fundamental long-term constraints. The media refer to this as 'peak food.' Social values and preferences shift decisively towards what are broadly viewed as 'sustainable' methods, and wherever there are affluent consumers, the demand for local, seasonal, increasingly vegetarian, fairly traded and organic food continues to rise.

At the same time, high food prices permit investment in new agricultural technologies aimed at increasing production while addressing environmental issues - soil degradation, water contamination, pest resistance, biodiversity loss and greenhouse gas emissions. Over a period of 10 years and beyond, a new eco-technological production approach emerges that includes: crop rotation, cover cropping, agro-forestry, 'green' fertilizers derived from agricultural and food waste, new varieties (that have resilient, pest-resistant, nitrogen-fixing qualities), more efficient use of inputs through advanced information technology, and reduced water use.

The new approach has a smaller environmental footprint, fewer synthetic inputs, better health outcomes, and higher yields. It starts in pockets, co-existing with the old approach, and gradually takes hold as more farmers adopt the new methods. The old approach gives way and the international food industry and trading rules gradually restructure around the new production paradigm, lifting the environmental and production constraints of the old system. Per capita food production rises as the new approach spreads and food prices finally begin to fall.

Figure 5.3 Into A New Era Scenario Narrative (Ambler-Edwards et al., 2009)

5.4.1 Responses to Into a New Era

Food system actors found this scenario particularly challenging. They found it difficult to buy into the circumstances and triggers which would see a wholesale change in the systems, structure and behaviours described in this scenario. The only plausible trigger, from the supply actors' perspective, was a significant shift in consumer behaviour; towards more environmentally conscious consumption and a radical change in priorities. This was felt to require a radical step-change in understanding by consumers of the environmental impact of food production. They felt change would not be initiated by government or from within the supply chain but could only be driven by consumer behaviour.

'Forces for change in the New Era would need to come from the consumer rather than from within the supply chain' Dairy processors

Actors' struggled with the concept of a wholesale move away from current production technologies and processes. They often interpreted the new eco-technological production methods as organic systems, which they saw as limiting food production volumes. The consumers' behavioural switch would have to include the consumption of less meat and livestock products – these in turn become luxury items – along with an overall reduction in the level of food consumed in order for this scenario to be viable.

'Organic [systems] won't bear out in the long term due to environmental concerns. It is more expensive to produce and there are limitations on what you can produce and how much..... There would need to be a 75% reduction in livestock production but actually can't see how we would get there' Dairy supply actors

'Dairy and meat product become luxury items with more moves to vegetarian diets' Dairy processors

It was very difficult for supply system actors to envisage what would bring such a change in consumer purchasing patterns, although any adverse change in climate and associated climate change concerns was seen as the most likely trigger. Actors recognised that there would be a significant power shift to the consumer in this scenario, away from the supply chain, which would alter the dynamics in the whole food system.

Any movement from the consumer base in this direction could have the effect of opening more opportunities for government to put through more environmentally led regulation, thus enforcing more sustainable behaviours from the supply chain. The media was identified as a powerful mechanism to help support this change. If this was harnessed to broadcast a unified message on the environmental impacts of food production then this, in conjunction with government action, would also provide the platform for consumer behavioural change.

'Demand will also need to be addressed. Government will need to implement consistent and well thought out policies to reduce consumption' Dairy supply chain actors

Actors saw this scenario triggering a reversal in the trend for intensification. For dairy, this would see a move back towards traditional grass fed systems, creating more seasonality in milk supply. This would have the effect of lower yields and a reduction in milk production. For wheat supply, actors saw the environmental measures as constraints, lowering yields and therefore constricting production. There was a particular concern over the potential spread of organic farming for

wheat production; actors here strongly felt that this would signal a radical reduction in yields and therefore output.

'Yields will go down. While yields have not decreased with current environmental changes, there are questions over how yields could increase in this future state' Wheat producers

Climate change was also seen as impacting the ability of UK farming to produce. In this scenario more adverse weather conditions would act to reduce both milk and wheat yields and output.

As opposed to food inflation, higher input costs here were viewed more negatively and were seen as a disincentive for investment in agriculture. This, in combination with climate change, was seen as a driver for a contraction in UK farming and a reduction in food volumes produced. Both this contraction and the instigation of choice editing to improve the environmental impact of food would reduce the level of choice for consumers.

'There will be choice editing of the range of product available so that ultimately all consumers eat food of a certain minimum environmental standard' Dairy supply chain actors

'Less food choice, less processed food and less protein available' Wheat supply chain actors

This sees the responsibility for the environmental standards of products pass to the retailers from the consumers, where retailers become the custodians for the supply chain and enforce higher environmental standards.

Once the retailers take ownership of environmental standards (as demanded initially by the consumer), the standards are written into contracts [with suppliers] Dairy supply chain actors

A role for government is also identified here, that of developing more legislation to force more transparency of environmental standards through

mechanisms such as product labelling etc. These actions are seen by actors as a consequence of both consumer preference and the retailers' response to this demand. In this sense, government is viewed as a follower in this particular scenario rather than as a leader.

For actors, this scenario presented the possibility of supply restrictions; either through a reduction in food production volume in the UK or through reduced availability of food imports. This again led to comments on the need for supply chain actors to enter into longer term contracts; to secure supply from a processor perspective and to counter volatility from a producer perspective. Interestingly, this scenario was seen as key driver for greater integration in the wheat supply chain.

'Less reliability of crop e.g. yields, output, availability of inputs and volatile prices. Producers will look to enter into long term partnerships with processors who want to ensure supply' Wheat processors and producers

There were positives to this scenario. Actors envisaged a rise in quality standards and environmental credentials of products. This included higher levels of traceability, better understanding of carbon emissions and water usage plus improved animal welfare standards. From a supply chain perspective, these higher levels would become standard entry requirements for suppliers in order to compete for retailer contracts.

All actors would then adhere to 'chain of custody' fulfilling a responsibility to meet carbon, water and other environmental criteria'. Wheat product manufacturers/retailers

This opens the door therefore for competition based on sustainable and environmental credentials rather than just price.

'This would be a new area for competition – "The Green Competitive Edge". Major companies would develop a strategy to be early exploiters of the opportunity to respond to the New Era and take market share from laggards.'
Dairy manufacturers/retailers

This would require significant innovation and development of new products to both deliver more differentiation but also to meet the new standards and create competitive advantage. This would also signal a shift in marketing strategies to emphasise environmental benefits. Again, whether capital would be available to allow this investment in innovation and rebranding was hotly debated.

To achieve these higher environmental standards, actors looked to technology and process innovation as the principle mechanisms. It was thought there would need to be a significant leap in current technology to generate both cleaner energy but also to lower the environmental impact of farming i.e. reduction in carbon emissions, better resource utilisation.

'This would require large scale investment in technologies, particularly methane control – a quantum leap in technology' Dairy sector actors

This investment to drive innovation was seen as a major sticking point. Higher prices could provide some increase in the level of innovation but to generate the step change needed, it was felt that the investment needed to come from government due to the scale and level of change needed. Clean energy, which didn't put extra demand on land usage (i.e. not second generation bio-fuels) was seen as a particular problem that would need to be solved before higher environmental standards could be achieved. The success, or failure, to develop technologies is seen by actors as absolutely vital in this scenario. This was not seen solely as a UK challenge and it was recognised that there was need for global co-operation to help share possible innovation and technologies. Again this points to a significant role for government to help facilitate this collaboration.

Actors foresaw competition between different strands of technology and practices e.g. green fertilisers vs GM. However, the majority of actors looked to the concept of 'sustainable intensification' as the solution to the problem rather than other production systems or technologies such as organics. Sustainable intensification was articulated as the efficient use of inputs, using fewer resources such as land, water, fertiliser to produce more; e.g. higher yielding crops. There were also actors within the wheat sector who saw this as a potential window for the

acceptance of GM, when viewed in the light of its potential to develop breeds which use fewer resources (e.g. water).

'Technologies are needed to allow effective waste conversion to N, P, K (fertiliser). 1% productivity per year [for wheat] and is now tailing off – incremental change won't do it. GM is a must but it will take 7 years to come through' Wheat producers

'More intensive and environmentally friendly production methods and technology needs to be available to increase yields and reduce environmental impact' Wheat supply actors

If technologies fail and food production goes local, then economic growth will fall along with employment in the food sector. If new technologies take off, then this will mean economic growth.

Actors saw the heightened concern over environmental impacts, along with more regional production, as prompting a move away from centralised supply systems to more regional or locally based facilities, driven in part by higher transportation costs and consumer preferences. Retailers could also trigger a switch to increased local (UK) and regional sourcing. This however presented a challenge for current supply chain structures with inbuilt investment in consolidated, centralised processing facilities and distribution networks.

'... a shift to more regional processing than centrally based assets' Dairy processors

'There is an opportunity for retailers to reinvent themselves. This may mean developing local, independent, self-managing stores with locally sourced products etc.' Retail and food manufacturing actors

5.4.2 Into a New Era Summary

Into a New Era presented the greatest challenge for actors. Many struggled to buy-in to the wholesale change to the system of supply and demand towards a more environmentally sustainable one. While the risks associated with climate change were acknowledged, they rejected a revolutionary shift in consumer thinking as being plausible. This scenario challenged their thinking in terms of how food is produced; they could not accept that environmental production systems would be able to increase yields and allow for sufficient food production and therefore rejected their viability. Instead, they interpreted the imperative to reduce the environmental footprint of the system through the lens of current practices and structure – sustainable intensification. This dissonance indicates that in effect this scenario presents a significant threat to the status quo of the supply network structure.

5.5. Scenario 4: Food in Crisis

Multiple shocks disrupt food production and supply. Prices skyrocket as stocks plummet, triggering food shortages, famine and civil panic. *Two serious global disturbances hit agriculture in short order: the rapid spread of crop/ animal disease, and sharply worsening water shortages. These come on top of new geopolitical disruptions that affect energy supply. There are also continuing problems in financial markets. The oil price surges to record levels, well above \$200. The increase puts significant pressure on food input costs, and food prices are driven even higher by financial speculation. Very high gas prices discourage inorganic fertilizer use, further tightening the food and feed supply situation.*

Grain stocks are run down to new lows around the world in an effort to sidestep high prices, merely delaying the unavoidable impact of contracting supply. A succession of extreme weather events then reduces world harvests to well below the already lowered levels, and stocks are not rebuilt. Prices skyrocket as the true supply situation becomes apparent.

Sudden and extreme food price rises prompt many more governments to introduce price controls, subsidies and export bans which further worsen the overall supply situation. Farmers are penalized by not being allowed to benefit from the high prices and food is taken off the world market. Other countries, particularly China, scramble to tie up bilateral food supply deals. In many parts of the world farming is seriously disrupted, further exacerbating the overall supply position.

Serious food shortages develop which cause universal public shock and growing political panic. Severe famines, for which no food aid is available, occur in the poorest and least resilient regions. The shortages trigger serious civil disruptions and outbreaks of conflict. Directly and indirectly the food shortfalls cause millions of deaths, mostly in the developing world.

There is turmoil in the food industry, with some firms making vast windfall profits and others going to the wall. New policies enacted on an emergency basis have their own unintended consequences. A completely untested set of supply arrangements is forged in crisis mode. The struggle, even in the developed world, is to keep people fed, disregarding where necessary any ideas of consumer choice.

Figure 5.4 Food In Crisis Narrative (Ambler-Edwards et al., 2009)

5.5.1 Responses to Food in Crisis

Supply chain actors viewed a food crisis in the UK as highly plausible. This was envisaged as triggered by external shock-based events; specific concerns were founded around the threats of climate-change led extreme weather events, or outbreaks of animal or crop diseases. However, participants also raised the possibility that a sustained period of high inflation could itself create a crisis situation (as highlighted in Food Inflation); one in which the supply chain is unable to continue to absorb inflationary pressures and food prices start to go into free rise. This coupled with very high energy prices and more acute global food shortages would create a crisis situation without any external 'shock'.

'Climate change should be seen as a key driver of potential disruption. Climate has the greatest potential to create chaos and widespread uncertainty.' Dairy Supply actors

Other events which could exacerbate and further tip a situation into crisis were geo-political unilateral actions such as the imposition of export bans, reducing the amount of food available on the open market. This would drive increased global competition for resources and food. Power would increasingly reside in major food exporting countries and it was felt that the UK may find it increasingly difficult to

access some markets in this scenario. This tapped into fears over how the UK may already be losing out in the global market to the political force of countries such as China.

'expect to see tougher controls on imports/exports' Wheat producers

'UK is potentially being out- manoeuvred by China through her use of bi-lateral agreements. The WTO is likely not to have influence in the future and the UK needs to look towards bi-lateral agreements.' Wheat supply actors

Wheat supply actors were fairly confident in the face of crop disease; it was not envisaged that there would be a complete devastation of wheat crops across the board. However, even a contained outbreak would lead to drops in yields and therefore volumes produced, thus creating the potential for food shortages and the need to rely more on global markets. For the dairy sector, a widespread outbreak of disease (such as blue tongue or Foot and Mouth) would create a real problem for the industry, particularly if the disease wasn't able to be contained. Any significant herd loss would result in a mass exodus of farmers, either unable to access cash to buy replacement herds, or due to the shortage of replacements. The lead time to re-build herds can be up to 2.5 years, so any loss would be devastating for the sector. This reduction in herd size would severely reduce the availability of UK milk.

'Longer period of regeneration of dairy herd after disease. The cost of replacements will preclude many (in the event of cull/disease hitting stocks)' Dairy producers

'Investment in capital declines or is diverted to regenerating the herds' Dairy producers

'There will be a fall in wheat yield. If there are no crops then dairy would need to switch to grass based systems'. Wheat producers

In an inflationary driven crisis, farming output may also fall temporarily due to acute costs of inputs and inability of farmers to manage the necessary increased cash flow requirements. Producers, to survive, would be forced to reduce the level of

inputs, particularly fertilizer, which may then have the knock-on effect of lower yields.

'Credit would become a key priority – it could even become as extreme as cash on delivery' Wheat grain traders

Also required would be increased labour to support production. This threat tapped into the issue currently facing the farming sector, that of the availability of unskilled labour. A food crisis which triggered even tighter immigration controls would severely restrict the unskilled labour pool available to the farming sector – this indicates the level to which the sector is reliant on low cost migrant labour.

'Reduced immigration and barriers to entry (as UK struggles to feed itself) but in return there will be greater need for agricultural labour'. Dairy supply chain actors

Actors envisaged an escalation of the crisis, where driven by higher food prices and threat of food shortages, panic buying is triggered as consumers look to stock-pile food. Driven by the very high prices, consumers would be triggered into lower levels of consumption. It is likely that there would be a reduction in the consumption of livestock products, particularly meat, and a focus on more basic, less processed foods along with foods perceived as 'safe'. The ability to access food would become the overwhelming concern, with other values such as environmental, ethics and welfare becoming insignificant.

'There will be less concern for animal welfare and food safety. Food will become a utility' Dairy supply chain actors

Consumers could start to find their own solutions to the mounting food crisis, such as growing your own etc. Informal supply chains, including a rise in black market and 'fake' foods, would start to be more commonplace. This poses increased threats to food security and public health.

'There may be a move away from brands, and a loosening of quality standards' Wheat processors

Overwhelmingly, supply actors saw the main priority for retailers and manufacturers as securing supplies. Protectionism would be commonplace, with the stockpiling of ingredients (milk and wheat) or other inputs. The management of any crisis would likely fall to these sectors first and the success or failure of their businesses will be highly dependent on their ability to secure supplies and the strength of their trading partnerships.

'Mills may buy and hold grain stocks (in effect hoard grain stocks). This may exacerbate the situation' Wheat processors

'Processors need farmers and vice-versa. A crisis would bring inter-relationship to the fore with more collaboration but also more mergers/acquisitions' Dairy supply chain actors

First responses are likely to look to protect the ongoing viability of individual businesses. Cash and access to credit will be crucial to securing supplies. In case of prolonged crisis and shortages, product ranges would be severely rationalized, with a focus on basic, staple foods with less processing needs. This presents a particular challenge for processors; as plant loading falls, it becomes even more difficult to cover processing costs. Shortages in raw materials would lead to widespread product reformulation, potentially with lower quality ingredients. For those UK processors able to continue with production, this signals a major opportunity to raise prices (probably through bidding wars and selling to highest bidder) and generate significant profits; profiteering here was highlighted as a major risk. Actors also identified that power base would shift back to producers who would have more influence on the supply system and therefore more capability to negotiate on price.

'Security of supply will be the priority. May need to manage 'bidding wars' to secure milk supplies. Longer term contracts will be encouraged but could see processing capacity running at 50% due to low milk availability' Dairy processors

'Processors will switch to liquid milk and run down cheese stocks. Product ranges will reduce -reduction in complexity' Dairy Processors

Retailers would also have to look to rationalize product offerings, with a focus more on basic food stuffs. Again the strength of relationships would determine their ability to access supplies.

'There will be less brands and more commoditization of products. May see more vertical integration of supply chain to ensure supply and survival'
Retailers

This scenario brought tensions between supply actors into sharp relief. While actors recognised that a crisis situation would need greater integration and collaboration between supply actors, this still remains a significant issue for the supply network as a whole.

'There is some disconnect in the supply chain i.e. no real appreciation of the potential issues facing the food system. Supply chains need to understand these issues better to be able to respond. The major industry players (manufacturers and retailers) should drive collaboration and more integrated supply chains.' Dairy supply actors

Contraction of the global market and even some difficulty in obtaining EU imports would change the emphasis towards UK sourcing. For wheat, there is greater reliance on the global market with 42% of imports originating outside of the EU, of which 31% from Canada is imported specifically for bread-making purposes (although this only accounts for around 4% of total wheat consumption in the UK). This contraction and any restrictions in transport fuel or consumer mobility, would present some challenges. One of the key questions raised by actors was how could a system of centralised assets move to a more regionally or locally based supply model - a similar question to that posed in Into a New Era. This would demand a high level of flexibility of processing capacity, logistics and distribution. Those supply chains with this level of flexibility could command significant competitive advantage in this type of situation. There may already be some level of 'natural' advantage already built into some systems based on the location of plants and assets. (i.e. multiple processing plants regionally placed rather than centralised plants or smaller, local more direct supply chains). This also highlighted the concern that there is over-capacity in the

processing and producer sectors for both wheat and dairy, restricting current profit opportunities. Some actors therefore saw the crisis as an opportunity for the sectors to re-size to more profitable levels. The operation of multi-national logistics systems would be difficult in this scenario and some thought that multi-national companies could suffer as they may be less likely to adapt to more locally based systems.

'There is the potential for smaller operators to be more successful' Dairy processors

The crisis could create a new equilibrium and a smaller and more profitable industry' Dairy supply chain actors

'The model of multinational food manufacturing, in terms of global sourcing and location of processing, fails in a prolonged crisis' Food manufacturers

Supply chain actors expected the government to be forced to step in, particularly where there were any growing concerns over civil unrest and food shortages. However there was significant split between actors as to where and when the government should intervene, or not. There was an expectation that the government should step in to help increase UK production, especially to negotiate with the EU to allow some relaxation of environmental restrictions and some food standards. Other interventions identified were the relaxation of competition laws to allow increased collaboration, controls necessary to contain disease spread and the establishment of an emergency cash fund for farmers etc. In the face of an escalating or continued crisis, the initial response by government is to turn to the major retailers and manufacturers to help manage the supply chain. However, actors were particularly nervous about any temptation the government would have to take direct control for the supply chain or to implement rationing and/or price controls. It was felt that if responses are not well thought out or well-coordinated across the supply network as a whole, the crisis could escalate and government would end up forced to intervene with even more draconian measures.

'Government would be tempted to intervene – which would be a disaster. There is a whole scale of things that they could do – e.g. competition laws, suspend planning laws related to food production' Wheat supply actors

Both sets of actors, wheat and dairy, implied that the level of understanding by government as to how supply chains operate is poor. This was thought a significant problem if the government were tempted to take control of the supply in a crisis situation.

'The government needs to understand how supply chains actually operate in order to develop effective policies' Dairy supply actors

Wheat actors in particular were nervous about the imposition of price controls, this was felt to limit the ability of the industry to grow and potentially compete in the future.

'A price controlled market would lead to a contraction of trading and a stagnation of the industry through the removal of competition' Grain traders

Again the importance of investment in R&D was a key theme with a need for technical innovation to help increase food production in the UK. Again the themes here were strongly around the use of bio-engineering, although not just GM. This again highlighted concerns over the lack of innovation and technological development in food production, particularly in the public sector. There was also a need to find mechanisms to speed up the translation of technology to practical applications and to facilitate the adoption of this technology across farms and supply chains.

'Government need to recognise that huge investment in R&D is needed. There has to be a clear agenda, focusing on the specific problems highlighted in the scenarios. Government needs to provide the incentives for long term investment and recognise its role as both an incubator and facilitator of R&D.'
Wheat supply actors

5.5.2 Food in Crisis Summary

This scenario revealed the core threats and concerns of wheat and dairy supply actors. In one sense it created a situation in which some of the existing structural difficulties in the system were exacerbated. These included the poor relationships across supply chains, lack of integrated chains (for wheat), over-capacity and the capital tied into large scale, centralised assets. It also underlined the threats faced by the system; the vulnerability of crops and animals to disease and climate change, the reliance on imports especially for agricultural inputs, the need for free flow of cash and capital and access to technologies.

The need for more partnership approaches is evident in this scenario, both within supply chain but also for government. Actors identified that supply relationships would be severely tested in this scenario. Those who have already established stronger relationships, based on trust, would potentially stand a better chance of surviving and potentially thriving in this scenario (if supplies could be secured). This scenario also severely tests the structural assumptions currently in play.

5.3 Conclusions

The use of the scenarios prompted actors to think more systemically about the nature of the risks facing the UK food system. They revealed a risk profile which alters for each scenario – summarised in table 5.1. While these profiles differ by scenario, there are repeating themes; that of

- Risks to profit margins
- Cost pressures (from various sources)
- Lack of R+D investment
- Lack of capital and lack of investment funds in the food system
- Scarcity of supplies/inputs and resultant power shifts
- Nature of supply chain relationships

These risks are explored further in the next chapter. Overall, they were seen to exacerbate the issues that the actors were grappling with, in the context of the food system at that time. Three of the scenarios – *Just a Blip*, *Food Inflation* and even *Food in Crisis*, were in effect interpreted as extrapolations of the current issues within the food system while *Into a New Era* presented a completely new landscape. The risks articulated seem to suggest a level of myopia in mainstream food actors in terms of their perception of the environmental threat in comparison to those given by actors as part of the general interviews. The rejection of the *Into a New Era* scenario suggests that, in fact, this posed the largest risk for actors, in that they could not conceive of a wholesale change in how production and supply are organised. This suggests a level of fear in mainstream actors of such a systemic change. It highlighted the divide between those who believe the current system to be environmentally unsustainable – which came out more strongly on the general interviews – and those mainstream supply chain actors who buy into the current structure, albeit with more intensive practices.

The workshops revealed systemic issues with the current food supply system – inter-firm relationships, the flexibility of the current structure, the tied-in nature of investment and assets, power profile, the balancing act between rising costs and the need to provide affordable food. Evidence here suggests that risk is also based on a number of factors including:-

- The context
- The combination of risk
- The position of each actor in the food system

Other factors also emerge from the interview evidence and suggest that there is an interplay between these risks and the severity of their impact on the food system. This starts to build a more complex interpretation of risk and vulnerability which is explored in Chapters 6 and 7.

<p>JUST A BLIP</p> <ul style="list-style-type: none"> • Price volatility • Food price deflation • Reduced level of investment • Absorption of input costs • Pressure on profit margins • Reduction in agri-food payments • Continued contraction in dairy producers 	<p>FOOD INFLATION</p> <ul style="list-style-type: none"> • Affordability of food • Polarized society • Increased cost of agri-environmental schemes • Price volatility • Lack of R+D development • Input cost pressures • Profit margins • Threat from imports • Migration of processing facilities • Reduction in CAP payments • Lack of consumer awareness • Retailer power
<p>INTO A NEW ERA</p> <ul style="list-style-type: none"> • Climate change • Rate and extent of change within food system • De-intensification • Lack of investment • Reduction in food choice • Higher regulatory requirements • Supply continuity • Access to global markets • Lack of R+D development (clean energy + sustainable intensification techs) • Local vs global food systems • Lack of GM acceptance • Profit margins 	<p>FOOD IN CRISIS</p> <ul style="list-style-type: none"> • Disease (crop and animal) • Climate change • Access to global markets • Capital availability and cash-flow • Availability of labour • Food safety • Scarcity of supplies/supply continuity • Less differentiation/branding and value add • Profit margins • Power shift • Government intervention and price controls • Lack of R+D investment • Poor supply chain relationships • Lack of flexibility in supply chain structure

Figure 5.1 : Risk profile by scenario

Chapter Six: Conceptualisations of Risk

6.1 Introduction

The previous chapter discussed the types of risks articulated by mainstream food actors in response to the four CH scenarios. This chapter builds on these themes and explores further the concepts of risk, combining all the data from the interviews and scenario workshops. It specifically addresses the first research question:-

RQ 1: How do actors conceptualise risk and vulnerability within the UK food system

It does this by both presenting further primary evidence, from the supply chain specific interviews, and the results of analysis across all the data sets (all interviews and workshops). As discussed in the methodology chapter, the research was guided by a grounded, inductive approach and therefore no prior framework was imposed on the analysis. The analysis here was formed through the development of level 2 codes (in the dis-assembly phase as discussed in chapter 3). While the data revealed a complex interrelationship between risk and vulnerability, risk emerged as separate phenomena on its own, but at a lower level of conception. This chapter therefore primarily deals with these concepts.

The supply chain specific interviews are presented here as these asked direct questions as to what actors in the wheat and dairy supply chains thought were the largest threats and vulnerabilities. These interviews were outside the context of the scenarios and therefore reflected the concerns that each actor had about threats affecting their own organisation and the industry sector within which they operated. The data here helped to both confirm and add evidence to the key themes emerging from the scenarios, it also emphasised any differences in how actors perceived risks relevant to their own situation or position within the supply chain.

Due to the richness of the data, the key themes presented here are those related to risks and threats, while other themes, which were judged to be common factors or influencers on the severity of the impact and outcome of risk (i.e. vulnerability) are presented in the next chapter on vulnerability.

In line with the theory building approach, the analysis progressed to understanding risk at a more conceptual level. This chapter presents this analysis.

The structure of the chapter is in four sections :-

- Section one : Findings from the supply chain specific interviews, pertinent to risks and threats
- Section two: A summary of key threats as conceptualised by each sector and groups of actors
- Section three: The categories of risks that emerged from the combined data set
- Section four : How the risks interlink

6.2 Supply Chain Actors' perceptions of risk

This section presents the data from the supply network specific interviews, highlighting areas which either confirmed or differed from the data gathered at the scenario workshops. In some cases, there was some change of emphasis from the scenario workshops, in that actors spoke more specifically about threats and risks facing their own organisations rather than their sectors as a whole. The key themes which arise and are dealt with in this section are:-

- Core dependencies for organisations
- Competitiveness of the UK food sector
- Value adding products and higher margins
- Regulation and sustainability
- Power and supply relationships

6.2.1 Core dependencies

A range of core dependencies, which were perceived as potential threats, emerged as key themes for both dairy and wheat producers. Their reliance on fertiliser, oil and, in the case of dairy, animal feed meant that they are vulnerable to either inflationary pressures or any restrictions on supply. Even more significant, is the dependency on weather conditions; this was highlighted as a key contributor of cost (or of efficiency). The weather, and its relative variability, is judged as significant

for both wheat and dairy production, underlying the natural aspect of food product and its reliance on environmental factors.

'Weather is the single biggest influence on profitability – it's crucial that we grow our own food to feed the herd'. Dairy farmer

A further dependency highlighted was that of labour; both in terms of available workforce but also in terms of skills and capabilities. While the need for manual labour on farms has decreased, many farms and processors rely on sources of low cost labour, usually relying on immigrants from Eastern Europe. While the lack of labour and skills was highlighted as a threat in response to 'Food in Crisis', the interviews reflected the widespread concern about the current situation. Actors also expressed concern over the skills and capability of farmers and farm managers; they felt that both farms and processors needed more business-based competencies and skills (including IT skills) in order to compete. The risk here is therefore the lack of availability of this skilled resource.

'The biggest constraint is skilled labour. While casual labour for menial tasks is not so much of a problem to get hold of, farm managers need to be more skilled – have to be good business people as well being able to manage the herd. These people come at a price and it is challenging to get the right people (their skills are transferable so highly competitive)' Farmers representative

The interdependencies between the location of farming and the associated processing facilities (dairies/mills) also emerged as a stronger theme here. Historically, processing facilities were established close to the source of their raw materials. If processing facilities were to migrate outside of the UK, due to globalisation trends or for cost competitive reasons, then actors believed this threatened the associated UK supply base (i.e. it would also tend to migrate).

'UK may become very competitive in wheat but if the price of other ingredients is high or not as available here in the UK, then the food may not be processed or prepared here. i.e. take biscuits for example - if sugar/fats are

cheaper elsewhere, then may make the decision to make them where they can be cheaply sourced along with wheat e.g. Ukraine.’ Wheat trade association representative

A common dependency which affected producers and processors alike was the ability of organisations to be able to raise capital to fund investment and access cash to sustain growth. There were concerns over the future availability of funding in the food system, particularly in light of the banking crisis [which was just unfolding at the time of the interviews].

‘Processing assets need investment [in order to remain competitive] and at the moment there is no money for this’. UK retailer

The ability of firms to maintain cash flow was a serious concern, particularly for the farm base. Producers rely on maintaining cash flow to fund the purchase of inputs. There is therefore a reliance on their customers to ensure that payments are made on time.

A number of actors spoke about the importance of the UK’s transport infrastructure. This emerged as an issue for processors and retailers as they have to think more broadly about their ability to supply their facilities, customers and markets.

‘But with existing infrastructure built in part around the UK’s historic role as a wheat exporter, the UK’s capacity to handle higher levels of grain imports is in doubt. In terms of dockside infrastructure, we are already hitting the boundaries of what we can handle.’ Grain trader

6.2.2 Competitiveness of the UK food sectors

Competitiveness of the UK food network emerged as a very strong theme. Many of the risks and threats articulated by actors were related to their ability to compete. A key threat was that of cheaper imports, either from within the EU or from global sources and whether the different food sectors would be able to

compete i.e. the relative competitiveness of each of the food sectors. At the time, the relative competitiveness of dairy was more of a concern than for wheat.

'As this market [dairy] is going to become more international, decided [as a company strategy] that the UK would not be competitive in this market for the next 10 years. There are more competitive places to make commodity cheese – Ireland for example, as government supports farming more and the weather allows cheaper farming systems.' Dairy processor

This reflects serious concern over the balance of UK production versus imports in the future, both for wheat and for dairy. Further contraction in the number of dairy producers was seen as inevitable, due to over-supply and threats from cheaper imports. However, there were musings as to what would happen if this trend continued over the long term.

'Fall in producers (6.5% per annum) will continue for next 3-4 years. Farmers could lose confidence in industry and continue to leave industry – this could create a loss of critical mass. For example if we lost 4 billion litres of milk, this would be very difficult to recover from.' Dairy producer

The issue of production costs relative to the global market was also highlighted by wheat actors.

'UK is relatively high input/high output cost producer – but not the worst globally. The question is whether this is sustainable. UK may become very competitive in wheat but if the price of other ingredients is high or not as available here in the UK, then the food may not be processed or prepared here, take biscuits for example' Wheat processor

Supply actors saw the level of efficiencies within each sector, and across the supply chain, as a measure of their competitiveness. From the producers' perspective, this equated to an increase in intensification and higher yields – both for wheat and for dairy. Here, the access to technology and the availability of technology were perceived as barriers to development of more efficient production systems.

'Can't take advantage of latest technology as there are no incentives in the UK. The EU allows more farmer access to technology'. Dairy producer

'Lack of investment in R&D into production techniques. R&D seems to be focused on protecting environment/wildlife'. Wheat producer

Over-capacity in the UK processing sectors was seen as a threat to higher prices, driving down prices and therefore affecting profitability and the competitiveness of the sectors. It is interesting to note that this excess capacity or 'redundancy' was perceived as a vulnerability, in that it added cost rather helped to absorb risk.

'there is too much production capacity in the UK. Most dairies are designed to operate at full capacity – there is therefore an incentive to fill facilities. The fight to retain milk volume has kept prices down' Dairy processor

'A small amount of over capacity has a big impact on margins so achieving that balance is key'. Wheat processor

6.2.3 Value-adding products and higher margins

From a processing and retail perspective, there was a sense that the counter to low milk prices in the dairy sector was to innovate more and create higher added-value, branded products. This would help to differentiate UK dairy products and generate higher margins than for commodity products. A historical lack of innovation with the dairy industry was seen as a threat to the future ability of the industry to compete and gain market share from imported products.

'Yoghurt demand has grown overall but yoghurt manufacturing in the UK has declined. UK industry missed out as it did not focus on value add products'. Dairy producer representative

This is real issue for liquid milk which is viewed in the market as a commodity product, often where the retail price is lower than the cost of production.

‘Consumer’s perception of milk is as a poor man’s drink (if you compare it to mineral water) – e.g. Asda has just dropped the price of milk again’ Dairy processor

The issue seemed less important to wheat producers as there are no opportunities for them to process their own products. They also have access to the wider UK and global wheat markets and therefore the capability to bargain for higher prices. As for processors, the pressure to innovate is not as acute in this sector – due to higher margins – but there was still recognition that differentiation and product innovation are mechanisms to generate higher profits.

‘Increasing gap between commodity products and bespoke products. Previously flour for biscuits was seen as a commodity so the market was very competitive. This is why this business is very suited to internet auctions, based on lowest price. A lot of the market is still like this but there has been some move towards specialist flours’. Wheat processor

6.2.4 Regulation and sustainability

While environmental issues were seen as a significant threat by actors in the general interviews (as shown in Chapter Four), supply chain actors saw political intervention to implement tighter environmental regulation as an even larger threat (than that of the need to be sustainable).

‘Farming is now not just about farming for food , it is also about farming for the environment (i.e. land specifically left fallow for environment). It may be that pressures on land globally mean that the ‘environmental’ land goes back to growing food’ Wheat producer

Supply chain actors had serious concerns over the trajectory of food and farming regulations potentially acting as constraints to both the wheat and dairy sectors; both in terms of the volume produced but also the associated cost burden. Wheat actors expressed alarm at regulations to restrict the application of certain fertilisers [since 2008, regulation to restrict the family of fertilisers known as neonicotinoids has been passed].

'Range of crop protection products available. EU regulations are reducing this. There are problems with resistance to some insecticides and herbicides, this is a big issue for the industry. As regulations come in, they narrow the chemical range, this increases the costs dramatically. There is newer chemistry available, but much of this is closely licensed by the manufacturer so this means higher prices. This will be a significant cost driver'. Wheat producer

It is not just agricultural or food based regulations but other EU environment laws including waste regulations, packaging regulations along with labour laws such as the working time directive and drivers' hours. These were felt to add to the cost burden in the UK system, impacting competitiveness in comparison to the global market and causing more inflationary pressures on food prices for consumers. There was increasing concern over the capability, particularly at farm level, to comply.

'We do [farmers] want to protect farms and the environment, e.g. bird numbers etc. So elements do need to be regulated. But there are too many regulations, for example the water framework directive. The current hot potato is diffuse pollution – this is impossible to comply with.' Dairy producer

There was also a sense that, while farmers innately understand the need to protect the land, the need for greater compliance would place more cost burden on the producer. This reflected a worry as to the future direction of CAP and environmental scheme payments.

'If farmers are to continue to be the protectors of land, then surely has to be public purse money available to comply with this' Wheat producer

Interestingly, from a retail perspective, while the pressure to be more sustainable was driven in part by regulation, pressures from consumer and environmental groups were also a core driver (i.e. reputational pressures). This created a conflict between the need to promote sustainable products against the

widespread consumer expectation for choice and low cost food. The retailers therefore face the potential threat of loss of market share by taking the consumer too far out of their comfort zone; in effect taking too much risk in doing something which either is too far ahead of either consumers or competitors.

'On sustainability, we are trying to take the consumer along with us. [for example]Delisting of North Sea cod was OK, but if we tried to de-list swordfish at the moment, it would be a step too far – they would then go elsewhere to buy it. So it is about trying to bring the consumer along with you and an element of anticipating their next requirements.' UK retailer

6.2.5 Power and supply relationships

Retail power in the UK was judged to be important by actors and the interviews gave a greater insight into the impact and perceived threats to the supply system. Retailers' expectation for lower prices along with assured levels of quality and delivery is perceived to have the effect of restricting profit sharing through the chain. Each actor's relative power position, with respect to the retailers, affects their profit margins. Farmers in particular, due to the disparate, often uncoordinated nature of the farm base, were felt to be most vulnerable in the face of this leverage of power along the chain.

'The effect of the UK retailers should not be under estimated... and we will continue to see an uneven sharing out of prices across supply chain with retailers taking their share' Dairy processor

Dairy producers are more susceptible to power imbalances in the chain, more so than wheat producers. While wheat producers have the opportunity to hoard or sell into diverse markets in order to achieve higher prices, dairy producers have to have a consistent, daily and relatively local source for their milk (as it is perishable). This makes it difficult for dairy producers to swap between processors. They are then tied into specific processor contracts (those who operate in their geographical area).

They are dependent on the contracts and pricing offered by these processors, and often have no ability to negotiate price. This situation seems to play into a sense of powerlessness that emerged through the interviews.

'Farmers have no control over milk once it has left the farm – so farmers are always bottom of the heap' Dairy producer

Low levels of farm-gate milk prices was (and still are) a significant threat to milk producers. Producers here engendered a hope that processors would recognise their reliance on their producer base and so would negotiate higher milk prices, with retailers, to ensure that farmers remain profitable. Dairy producers felt that the concept of 'fair trade' should apply equally to UK producers as well as to those from overseas.

For dairy producers, the main preoccupation was therefore with processor contracts. While producers are locked in, often for up to a year, processors can vary the price at short notice.

'Prices can be varied on a whim while the farmer is locked into for a minimum of 12 months. If the farmer is looking to plan ahead then the contract does not give any more certainty on price. For example, incentives for level profile are put in place but it takes 12/18 months for changes to be made by farmers to have any effect; changes to contract are made with no consideration of this. Often seen by farmers as 'surrender contracts' Dairy producer

Consumer and producer pressure to give farmers a better deal has some effect and some retailers have moved to integrated, direct supply models for fresh milk (from specific producer pools). Single sourcing on fresh milk has given retailers more security of supply, control over how price increases are passed back down the supply chain and cost savings.

'There are clear cost savings by moving to single source – originally we had three suppliers with different cost bases, so very difficult to do cost

comparisons or explore cost savings. Having a single source has made the cost base more transparent' Retailer

In the wheat sector, supply chains are more disconnected – arable farms tend not to have direct relationships with retailers or be tied into one processor. Relationships along the supply chain were on a more informal, personal basis, this was viewed as a strength by actors (with very little usage of the type of contracts seen in the dairy sector). The informality of relationships within the wheat supply chain was seen to be under threat by some, forced by price volatility and the potential for increased global demand for wheat.

'Agreements are at best founded on good relationships – loyalty can be found in parts of the market, but not in other areas. There does seem to be an increase in relationships founded on paper and not on personal relationships – a key trend in a falling market. Where there is more volatility in price, relationship and longer term loyalty seems more appealing. Wheat processor

However, it was recognised that the disconnected nature of wheat supply chains also posed a threat, as producers were generally not focused on end-consumer demand. More integration across chains was seen as important to reduce inefficiencies (and therefore counter higher costs) and to ensure wheat produced is matched to end-market usage.

'shorter supply chains would help. There are huge inefficiencies with rejected loads – 50/100 tonnes rejected every time [due to wheat not meeting market specifications] which are very costly to deal with' Wheat producer

6.3 Emergence of risks categories

This section presents the thematic analysis which combined findings from all of the primary data. Emerging from the data were 170, level 1 codes (as discussed in Chapter Three). Here, those codes that had direct connection to the conceptualisation of risk were extracted. These emerged as either

-The main focus and concerns of actors

-Specific threats to their organisation (and/ or supply chain)

-Strategies of actions undertaken to mitigate these threats

Tables 6.1, 6.2 and 6.3 set out these common concerns, threats and strategies expressed by the main groups of actors in the study. This analysis led to the development of level 2 codes. It was at this level of analysis that categories of risk emerged along with their linkages to the level 1 codes (threats) are shown in the tables.

Actor grouping	Types of Level 1 codes	Level One codes	Level Two Codes - RISK
Dairy producer	<i>Focus and concerns</i>	Margins Milk price vs cost of production Lack of power Dependency on processor for a regular supply outlet Security of income Tied into contracts	
	<i>Threats</i>	Over-regulation particularly environmental – both compliance and cost burden	Profit risk Compliance risk Cost risk
		Input price pressures esp. feed and oil	Cost risk
		Unfair pricing and profit taking in supply chain Stability of contract price	Relational risk Profit risk
<i>Strategies</i>	Disease (esp. TB) Adverse weather Cost and availability of herd replacements	Capability and operational risk	
	Access to capital for investment Availability of skilled labour Availability of large animal vets Cheaper commodities from global market	Input and resource risks Competition risk	
Dairy Processors	<i>Focus and concerns</i>	Hope that greater interdependency with processor could deliver better contracts Higher yielding herds – technology/targeted feed systems Minimise input costs/increase efficiencies Switch to grass systems Exit industry	
		Inherent market advantage of fresh milk Processed dairy products facing more competition from imports Quality and consistency of milk supply Need to meet retailers specifications Continuity of milk supply	

		Asset utilisation	
	Threats	<p>Lack of investment in assets and processes</p> <p>Ability of producer base to meet legislative/welfare requirements</p> <p>Competition from imports Competitiveness of commodity dairy products vs imports</p> <p>Milk price increases without capability of passing costs on</p> <p>Food safety concerns Health concerns over fat/salt content of dairy products</p> <p>Tensions between milk co-ops and smaller dairy companies/tensions with producers</p> <p>Contraction of UK dairy producers and ability to secure volume of milk required</p> <p>Over-capacity in processing</p> <p>Lack of innovation and investment in value-added products</p>	<p>Input and resource risk/capability and operational risk</p> <p>Compliance risk</p> <p>Competition risk/cost risk</p> <p>Profit risk/relational risk</p> <p>Compliance risk Market risk Reputational risk</p> <p>Relational risk</p> <p>Supply continuity risk</p> <p>Structural risk</p> <p>Input and resource risk</p>
	Strategies	<p>Direct relationships with producers (away from co-ops)</p> <p>Direct relationships with retailers</p> <p>Provision of more security for producers/build in need for profitability for farmers</p> <p>Contracts to match retail demand patterns and quality specifications</p> <p>Internal and supply chain efficiencies</p> <p>Consolidation of companies and facilities</p> <p>Concentration in producer base</p> <p>Develop more value-add products/branding</p> <p>Provenance as brand (UK/local)</p> <p>Innovation in products/packaging</p> <p>Reformulation (reduction in milk content/reduction in fat/sugar/salt)</p> <p>Use of dairy alternatives</p> <p>Health concerns as opportunity</p>	

Table 6.1 Concerns, threats and strategies for the dairy sector

Wheat producer	Focus and concerns	<p>Cropping plan based on future market prices (as to whether to grow wheat or not)</p> <p>Wheat quality based on end usage</p> <p>Wheat price and profitability</p> <p>Wheat yield</p> <p>Volume of production</p> <p>Quality assurance</p>	
	Threats	<p>Adverse weather conditions</p> <p>Climate change</p>	<p>Operational risk</p> <p>Market</p>

		<p>Increase of mycotoxins/ reduction in quality</p> <p>Increased regulation of chemicals which could limit volume/yield</p> <p>Increased environmental regulation and associated cost burden</p> <p>Cost and availability of inputs – labour, fertiliser and oil</p> <p>Access to capital for investment</p> <p>Access to technology, breeding and process innovations</p> <p>Over-production in UK wheat</p> <p>Threat from imports</p> <p>Lack of co-ordination of supply chains</p>	<p>risk/operational risk</p> <p>Capability and operational risk/compliance risk</p> <p>Input and resource risk/Capability and operational risk</p> <p>Competition risk/profit risk</p> <p>Governance risk</p>
	Strategies	<p>Bio-fuels market as opportunity – absorbs UK surplus</p> <p>Central storage (co-operation between farmers) to meet end use specifications through blending</p> <p>Increase wheat cropping area</p> <p>Marginal land put into production</p> <p>Efficient management of inputs (esp. fertiliser)</p> <p>Call for GM acceptance</p>	
Wheat trader	Focus and concerns	<p>Reliable trading partners</p> <p>Security of supply</p>	
	Threats	<p>Increased competition for wheat</p> <p>Lower wheat quality/ability to secure correct wheat specifications</p> <p>Government intervention in market</p> <p>Availability of cash/credit</p>	<p>Supply continuity risk</p> <p>Compliance risk</p> <p>Profit risk</p> <p>Input and resource risk</p>
	Strategies	<p>Risk management through financial instruments</p> <p>Strategic relationships</p>	
Wheat milling and processing	Focus and concerns	<p>Balance of cost of inputs/price</p> <p>Wheat quality meeting specification for customer</p> <p>Securing wheat volumes</p> <p>Transparency of price</p>	
	Threats	<p>Threat from imports of processed products</p> <p>Price volatility (global price)</p> <p>Fall in wheat and food prices</p> <p>Cost of inputs</p> <p>Access to global markets to secure wheat imports</p> <p>Lower UK wheat harvests or poor quality harvests/availability of wheat imports</p>	<p>Cost risk/Competition risk</p> <p>Cost risk/profit risk</p> <p>Cost risk/profit risk</p> <p>Supply continuity risk</p> <p>Supply continuity risk</p> <p>Cost risk/Compliance</p>

		Over-capacity in processing Disconnected supply base Cash availability for investment in assets and processes especially to drive efficiencies	risk Structural risk Governance risk Input and resource risk/capability risk
	Strategies	Product reformulation Develop of value-add products Better strategic relationships More longer term contracts with producers	

Table 6.2: Concerns, threats and strategies for the wheat sector

Brand manufacturers	Focus and concerns	Meeting consumer needs Brand competition Market growth Grow margins Cash for investment Product pricing and costs Supply chain efficiencies Sourcing of ingredients Strategic location of facilities	
	Threats	Pressure on costs Unable to sell value of product to consumer in time of higher prices Lack of money for investment Lack of traceability in up-stream supply chain Food safety/food fraud Food health concerns How to secure competitive raw materials	Cost and profit risk Market risk/competition risk Input and resource risk/Capability and operational risk Governance risk/compliance risk Reputational risk Supply continuity risk
	Strategies	Brand investment Reformulation of products – reduce sugar/fat Substitution for cheaper ingredients Consolidation/migration to lower cost geographies More supply contracts	
Retailers	Focus and concerns	Price competition with other retailers Supply continuity On-shelf availability Ability to compete for supplies Maintain acceptable product and production practices but increasing supply How to absorb/pass on increasing costs	
	Threats	Reduction in consumer demand due to price rises Price rises	Market risk/Profit risk

		<p>Not being able to justify price rises to consumer</p> <p>Food safety/food fraud Upholding food standards in supply chain</p> <p>Food health concerns</p> <p>Availability of products Power shifts to suppliers when scarcity</p> <p>Shortages tipping into food crisis</p>	<p>Profit risk/Market risk</p> <p>Reputational risk/compliance risk</p> <p>Reputational risk</p> <p>Market risk/ Supply continuity risk/cost and profit risk</p> <p>Governance risk/market risk</p>
	Strategies	<p>More integration with suppliers</p> <p>Direct relationships with producers</p> <p>Investment to spread best practice</p> <p>Single sourcing</p> <p>Competition on other values rather than just price</p> <p>Bifurcation of market – more own brand/value lines vs value-add products</p> <p>Pressure on supplier base to reduce costs</p>	

Table 6.3. Concerns, threats and strategies for the retail and manufacturing sectors

Emerging here was the connection between the area of concern, the specific threat, and therefore risk, along with a set of strategies employed to counter the perceived threat. This starts to create an understanding of how risk is conceptualised by actors – in that it is articulated in known threats that are seen to have a direct and negative impact on actors’ operations. Here also there are a common set of strategies that echo across all of the sectors as ways of mitigating these threats. These are:-

- Reduce usage of inputs
- Increase process efficiencies
- Creation of value-added or branded products
- Product re-formulation
- Increased use of supply contracts
- Strategic or integrated supply relationships
- Consolidation of facilities and assets

These mitigation strategies are more commonly associated with reducing cost and improving profit margins. This indicates that risk is conceptualised by actors' as impacting predominately on their ability to compete economically. This point is discussed further in the subsequent sections.

6.4 Categories of risk

The process of level 2 coding revealed a set of 12 categories of risk as conceptualised by actors. These are summarised in table 6.4. The next section takes each risk category in turn and explains how these risks were articulated and conceptualised by actors, at a more generalised level.

Risk type	Definition
Cost risk	Risks that impacts negatively on the cost of operations
Profit risk	Risks that negatively impact the profit margins available for each organisation
Input and resource risk	Risks that limit the availability of, or restrict access to, inputs such as labour, skills etc. or environmental resources such as water and energy
Supply continuity risk	Risks which limited the ability of the organisation to serve the market through the acquisition of ongoing, constant supplies
Reputational risk	Risks which negatively impacts the perception of organisations by consumers and undermines trust and confidence
Market risk	Risks which impact the ability of the organisation to meet target consumers' expectations of variety and price and therefore limits their market share and potential growth
Capability and operational risks	Risks which either limit the ability of the organisation to service the market, often expressed in terms of volume capability, or drastic changes to current production, processing and other methods of operation
Competition risk	Risks from alternative sources (both UK and imports) and/or alternative products which could steal market share and limit potential growth
Compliance risk	Risks which create difficulties for organisations to meet regulatory or quality standards
Governance risk	Risks arising from the control and co-ordination of supply chains and the system as a whole
Structural risk	Risks arising from the organisation of assets and structures across supply chains and the system as a whole
Relational Risk	Risks arising from the nature of relationships across the chain, the application of power and the fair sharing of profit, benefits and risk

Table 6.4 Categories of risk

6.4.1 Profit risk

Ongoing financial sustainability of organisations is based upon the ability of organisations to compete and create sufficient margins to satisfy shareholders. Profits are vital to provide opportunities for investment in facilities/technology in order to continue to compete. Here, risks which drove higher input costs and those which potentially reduced profits emerged as core categories. These risks are interwoven as higher inputs costs were perceived as impacting profitability, especially where they could not be passed onto either to customers or consumers. The biggest threats to profitability were seen as:

- 1 – price volatility
- 2 – inflationary pressures on costs
- 3 – affordability of food and consumer expectations of cheap food

Price volatility

The exposure to global economic pressures underlines the market structure in the UK – i.e. this is an underlying dynamic of the food system in the UK, in that it closely relies on global pricing signals. From a farming perspective, the decoupling of CAP has meant that price signals from the market are now one of the principle drivers of price. There is less protection or buffer between global prices and farm income. Price volatility, as seen in reactions to *Just a Blip* and *Food Inflation* poses a significant threat to all supply actors. Prolonged periods of volatility create uncertainty which prevents longer term planning and potential investment and has a tendency to reinforce short termism within the industry.

Inflationary pressures and affordability of food

In one sense, inflationary pressures, as in upward pressures on food prices, were perceived as a positive for the food system – as shown by reactions to the *Food*

Inflation scenario. This underlies the feeling that prices had been depressed for too long. However, the risk expressed here is the balance between upward pressures on input costs and the ability of the supply chain to either absorb these costs (through efficiency savings) or pass on the costs up the chain, ultimately to consumers. This is compounded by the pressures exerted by retailers on the supply chain to keep prices low to allow them to compete and attract consumers; therefore meeting consumers' ongoing expectation of affordable food. The fierce price competition between the four dominant retailers reinforces a depression of prices, creating further pressure on the supply chain to absorb cost increases. This in turn drives strategies for processors/manufacturers to put pressure on suppliers – farmers – to keep prices low. Tensions exist therefore between the recognition of the need for affordable food (from a societal perspective) and the ability to charge prices high enough to cover the actual cost of UK food production. If the pressure between the two opposing forces becomes too much, then this could become a breakpoint which tips the system into crisis mode; creating a social crisis in particular for those who are on lower incomes. This indicates a vulnerability of the system in terms of pressures on input costs and the ability of the end market to bear price rises to match these.

Dairy producers are very vulnerable to this type of risk. The structure and nature of their product (perishable and requiring daily disposal) limits producers' choice as to which markets they can sell to, based on transportation costs and their proximity to processing facilities. Their inferior power position forces them into contractual supply agreements (minimum a year or season) which make them vulnerable to competitive pricing which undercuts their actual costs of production. Wheat producers however, are less vulnerable in that the cost of wheat is better absorbed within the supply chain – both because the contribution of wheat price to overall end product price is less than milk and producers have more market choice.

6.4.2 Cost risk

Cost risks were explicitly stated by actors as threats which impacted negatively on their cost base. This risk emerged from supply chain specific interviews

but also was prominent in response to *Food Inflation*. Where actors' concerns were focused was dependent on their position within the supply chain. Both wheat and dairy producers had concerns about input costs for oil, fertiliser and in particular labour. These costs represent the significant proportion of their cost base. Dairy has, in addition, a further added cost of animal feed in the case of intensive systems (i.e. non-grass based). Any volatility or inflationary effects therefore (as in *Just a Blip* or *Food Inflation*) has a direct and significant impact on their overall costs and ultimately profitability.

Processors, both wheat and dairy, were concerned about prices of their raw material – wheat and milk (although this is less of an issue for wheat as it accounts for less than 10% of the total price of the end product). Here, as with producers, energy and labour costs make up a significant proportion of their cost base. Cost of transport is cited by grain traders and agri-input organisations as a key driver of costs in the supply chain. This is linked to the oil price but also to restrictions in UK road infrastructure capacity and the unsuitability of the rail network (as the infrastructure currently stands) to help to ease pressures. Retailers, in turn, have concerns about the cost of their supplies; here they tend not to want to pass on these costs to the consumer and therefore exert pressure on their supply chain to contain or reduce any rises.

Cost risk also was associated with the increasing regulatory system governing the food system. In all scenarios, this was seen as a cost burden and a threat to profitability. While there is recognition that regulation has helped to drive higher standards, particularly in food safety, it is the tightening further of this, and in particular environmental legislation, where actors perceive the most threat to the cost base.

Pressures on the need to keep end prices low against a backdrop of higher production costs could see the UK system tied into a cycle of constant search for efficiencies and rationalisation in order to maintain acceptable profit margins. This

could drive even more concentration and consolidation and potentially more tensions in supply relationships.

6.4.3 Input and resource risk

This category of risk arose from a tendency for actors to articulate risk in terms of sustainable access to their businesses' key dependencies. *Food in Crisis* presented an extreme example but it helped supply chain actors to pinpoint a set of inputs that are essential to the operation of their business and the food supply chain. This revealed a set of inputs which seemed to apply to all actors independent of their position in the supply chain:-

- Cash and cash availability to trade
- The availability and ability to secure input supplies (e.g. fertilisers)
- Availability of skilled and unskilled labour
- Access to research and development/technological innovation

The restriction of these inputs poses a threat to the food system in its normal functioning state. Access to these inputs therefore, at the right cost levels, can be dependent on the size and relative power of the organisation; smaller entities were thought to be more vulnerable. While a crisis situation made the scarcity of these resources more acute, in effect these also reflect ongoing threats to the food system as it is now.

Farming, in general, was viewed as more vulnerable to this type of risk. External threats, such as extreme weather events or disease outbreaks would put severe and acute pressure on these resources. A disease crisis affecting dairy herds for example, would shut down many farms and restrict the ability of other producers to source replacements and therefore would severely restrict output. But in effect, access to these resources poses a significant threat to the ability of both sectors to sustain capability and the ability to compete in the marketplace.

Over the long term, threats were also posed by the availability of environmental resources. While constraints on global resources could see restrictions on the availability of commodities, direct threats to the UK were seen as water and the supply of clean, cheap energy. Agriculture has a key dependency on water and some actors, producers and processors, saw the potential for climate change or change in weather patterns to create some constraints on water in the future. All of the supply chain has a dependency on oil and its derivatives. The ongoing availability of relatively cheap energy underpins the cost structure of the whole system. The main preoccupation of direct supply actors was the rising costs of energy. However, actors with a more systemic, peripheral view of the system recognised the potential conflict between the need to reduce the carbon footprint and the lack of the volume supply of viable clean alternatives.

6.4.4 Supply continuity risk

Supply continuity risk is closely associated with input and resource risks in that it reflects threats which restrict supplies. However, while input/resource risks are concerned with the base elements and commodities that the system relies upon, this risk is much more focused on products and the ability of organisations to meet end user demand. Retailers, being at the further end of the chain, therefore express any potential shortages as supply continuity risk rather than in terms of raw materials or input/resource shortages. Any disruption to continuous supplies of products to the retail supply chain was seen as a threat to the ability to supply customers, reducing market share and therefore impacting on potential revenue growth. As seen in the *Food in Crisis* and potentially *Into A New Era*, where actors saw a tightening of supplies, this threat would trigger changes in retail and processor/manufacturers behaviours towards suppliers. Any significant shortages or the risk of shortages have the capacity to change the power dynamic of the system, as power shifts back down the network towards producers. This would trigger more integrated supply chain strategies, with retailers and/or processors co-ordinating their own supply chains more, using contractual agreements or even in extremis seeing vertically integrated chains, hence altering the structural nature of the

network. The dairy network has already seen some of these structural changes. In a sense, this risk poses an opportunity for producers to capitalise on this restricted market.

6.4.5 Reputational risk

Actors here recognised the potential damage to their market share if their reputation is besmirched with consumers. Cost pressures (as in *Food Inflation*) or acute supply constraints (as in *Food in Crisis*) could increase the risks related to poor food standards and even food fraud. The core issue highlighted here was food safety; any food scares with media focus are acute threats to any processors and retailers as well as a public health issue.

However, more intangible, was the potential risk to the trust built between a retailer and/or a manufacturer's brand. That is where claims made about a product, or the way in which their business is conducted, is exposed as false or where consumers demand a higher standard than is currently being met. Animal welfare is one such case, and producers and dairy processors highlighted this as an area which generates risk, particularly if, through the continued need to reduce costs, there are moves to more intensive dairy production systems. GM also represents a threat, for both dairy and wheat industries due to the prevalent anti-GM sentiment in the media and consumer populations. As many actors stated, both the animal feed chain and the lengthy processed food chains are likely to contain GM ingredients, despite EU regulations. This issue presents a tricky tightrope for retailer and food manufacturers to tread, especially if they trade on a non-GM basis.

This highlights specific risks for long complex chains, typical for processed foods, where there isn't full traceability or visibility. Trust between supply partners is important here and retailers often rely on manufacturers to enforce standards further down the chain. However, manufacturers often only deal with their more significant suppliers, and even here it is impossible for companies to fully investigate all of their suppliers' processes and inputs. It is interesting therefore that actors,

from both the dairy and wheat sector, as a conclusion to the workshop, called for a 'chain of custody' and a raising of standards across the whole system – in response to this very issue.

6.4.6 Market Risk

This risk arises from the dynamics of demand and the need to meet expectations of the consumer base. This manifested itself in multiple ways. One of which was affordable food. Actors across the board highlighted the problems of rising food prices set against a consumer expectation of, at least affordable, if not cheap food. In *Food Inflation, Into a New Era* and *Food in Crisis* the potential for higher food prices was seen as a major risk. This obviously has wider social implications. However, from a supply chain perspective, some retailers or branded manufacturers may struggle to demonstrate value in light of price rises and consequently see a reduction in market share as consumers switch to lower cost alternatives or lower cost imports. Retailers overall may fare better as they have the opportunity to switch from sourcing in the UK to elsewhere, as long as product quality and costs can be met. This reflects the wider market opportunity that retailers have, and hence their power position.

It is therefore not surprising, that other supply actors look to combat this power by calling for better consumer education, jointly managed by government and industry, to educate consumers on the reasons why food prices were increasing; hence looking to keep the same UK based supply routes but at higher price levels. This indicates a level of fear within the food network of not being able to demonstrate clearly to consumers the value associated with UK produced food and so losing out to competition from cheaper, global sources.

Another aspect of market risk is not responding to changes in consumer preferences in demand. If shifts in consumer preferences are not capitalised on, then organisations risk missing out on or losing market share to competitors. The UK dairy industry was felt by some actors to be behind the curve in development of health-

based products (e.g. probiotic yoghurts) and therefore has become more vulnerable to imported sources. The wheat sector, both producers and processors, seemed to be less concerned about this particular aspect of market risk, which reflects their relative disconnection from the end consumer. There is also the opposite issue; that of pushing consumers too far outside their comfort zone. This seemed a significant issue for retailers as the risk of losing customers by radically changing products and pricing (e.g. to create more environmentally sustainable choices) is too high for fear of a consumer exodus and market share loss. Consumers and the supply system therefore seem locked into particular patterns of behaviours where neither can move position very easily or quickly. This was underlined by the reaction of actors to *Into a New Era* which represented such a shift. The concept therefore of a radical shift was seen as a high risk scenario – with possible high gains but also large losses. This gives rise to a sense of conservatism associated with the food system.

6.4.7 Capability and operational risks

These risks were principally articulated as threats to the capability to maintain or increase food production levels in the UK. At one level, this risk encompasses disruptive events which could impact on an organisation's ability to supply. This is very pertinent to producers where adverse weather conditions and disease present major threats to harvests, yields or milk volumes. This therefore emerged strongly as a risk in *Food in Crisis*.

However, from a wider perspective, this risk also represented the concern of producers as to their ongoing ability to maintain yields and volumes within current farming systems and processes – inherently more intensive based systems. Here, environmental and food safety regulations were seen as major constraints to current operations. The Water Framework Directive and the banning of a range of pesticides were cited as impacting the ability of producers to maintain yields and increase volumes. Any further tightening in regulation to limit carbon or the use of certain chemical families would present a significant challenge. This again reinforces the idea that there is an inbuilt stasis in the system with producers locked into their current,

mostly intensive, methods of production. This again was borne out by reactions to the alternative (*Into a New Era*) which was rejected as infeasible without a significant drop in the food volumes produced.

Linked to this were wide ranging concerns over the lack of investment in public and private R&D. Technology here therefore is the solution for many actors to counter the perception of restrictive environmental regulation. Supply actors therefore called for the need for investment in the development of technology to allow crops or animal products to be produced with fewer inputs while maintaining or increasing yields. In effect, sustainable intensification. This however is contested by those actors (NGOs especially) who believe the food system to be fundamentally unsustainable in its current form.

6.4.8 Competition risk

This risk encompasses threats from the global market and the ability of UK supply chains to compete. This risk emerged most prominently in the supply chain specific interviews but was present across all of the scenario workshops. The level of competition risk for each sector is dependent on a range of factors including the relative cost base of the sector, its level of exposure to the global market and the availability of competing products. It also changed depending on the position of the organisation in the supply chain. The main protagonist in the market is predominately the retailers. It is their buying decisions which dictate a switching of products away from a particular UK source if deemed necessary on price (and or quality), although brand manufacturers also have this power. The interdependency between processing and food production can mean that any switching in processing sources will also affect the UK farm source.

Some sectors are more vulnerable than others. In dairy, there is inherent market advantage in the supply of fresh milk, given that it is more costly (with current technology) to import. However, the UK is not the lowest cost producer in the EU and therefore there are significant threats from lower cost commodity

products such as basic cheeses. The wheat sector is less vulnerable; higher yields and good quality grains create a more competitive offering than some imports.

There is a further dimension to competition risk; inter-firm competition within the UK. This is present in all sectors but is the main source of competition risk for retailers. Here the main competition is with other retailers with a UK presence and the risk becomes the ability to source price competitive products and/or differentiate on brands in relation to other retailers.

6.4.9 Compliance risk

Compliance risk is the ability of an organisation to meet quality and safety requirements for their target market along with the necessary regulatory legislative standards. This is linked both to operational risk (and the increasing burden of regulatory requirements) and to cost risk. Increasing regulation, the need to encompass more sustainable practices and public scrutiny of the food system creates the need for more investment and higher skill levels to allow organisations to comply.

It is not just public regulation; private-led regulatory frameworks are also a factor. First tier suppliers into the retail chain –processors and manufacturers – are expected to comply with retailer-specified sets of quality and delivery standards. Organisations unable to meet these specifications will fail to renew supply contracts. It is this balance, between keeping costs low and the ability to comply with often increasing expectations of these standards, where there is some threat. Compliance is often left to trust and the ability and willingness of retailers and manufacturers to oversee end to end supply chains is limited. Further cost pressures could see this compliance to either legal or private food standards suffer. This could have wider implications for public health.

Into a New Era prompted a debate over the need for higher product quality standards specifically those associated with the environment. This included higher

standards of animal welfare, lower carbon emissions and more efficient use of resources throughout supply chains. If enforced through regulation or even through a move by consumers towards higher standards, under the current structures and processes, actors would struggle to comply.

6.4.10 Governance risk

Governance risk exists for actors on two levels; the control of individual supplies into the retail chain and the overall policy framework that governs the UK food network. In the main, retailers' category management practices often only result in governance and control of their immediate supply chain rather than further down the chain. In a stable market, actors saw the threat here predominately as the abuse of power by retailers, driving more cost burden down the supply chain. There is, as with most supply chains, no real end-to-end governance. Where this becomes a specific concern is in times of heightened uncertainty, supply constraints or market volatility (e.g. *Food in Crisis* and *Into a New Era* are examples of this). This limited span of governance was therefore judged as a potential breakpoint. Wheat actors saw the fragmentation of supply chains in their sector as a particular threat. There is very little co-ordination or integration of activities between wheat processors and producers (supply can often be based on a spot market basis through grain traders). This lack of governance creates risk in terms of quality assurance, traceability and prevents opportunity for joint planning to manage demand, quality and to help put in place contingency plans to mitigate for supply availability and price volatility.

Governance of the UK food network as a whole, however, was seen as a greater risk. Reactions to all scenarios saw actors highlighting the lack of a coherent, joined-up UK government policy on food supply as a major problem. There was seen to be a lack of co-ordination across different policy areas such as agriculture, health (nutrition and obesity), environment (carbon, resource management, waste, and bio-diversity), food security, food safety, and fair trade and competition laws. The feeling

from actors that the government's bias towards environmental-led interventions [at the time this was the Labour government of 2008] would inhibit the food supply chain in meeting other social and economic outcomes.

6.4.11 Structural risk

This risk applies at a sector and industry level and relates to how the network is organised. This is specifically related to the size and organisation of the asset base, how product flows through these to consumers and how information (demand) and cash flow back down to trigger supply. Investment strategies in the wheat and dairy sectors over the last 30 years have been driven by economies of scale and both sectors have seen greater centralisation and consolidation; large scale assets, large processing plants, fewer actors and streamlined supply networks. This is also true of the retail asset base and distribution networks. Investment in larger plants is based on the need for process efficiencies to maintain margins, which also implies the need for a volume outlet i.e. the size of the market that they sell onto. Both the wheat and dairy processing sectors still suffer from overcapacity which continues to undermine the ability to maintain margins. Higher concentration, through mergers and acquisitions, has been the core strategy in both these sectors (especially dairy) to decrease oversupply and strengthen price negotiating positions with retailers. The highly concentrated, centralised nature of assets however were tested in *Into a New Era* where smaller organisations in more diverse supply chains and routes to market were thought to fare better. *Food in Crisis* also saw a breakdown in centralised systems. This revealed a potentially hidden risk built into current structures. However, as actors struggled to envisage a move towards a less centralised, dispersed system with a smaller asset base, this suggests that there is an in-built stasis in the system as it is now, driven in part by the level of investment in current infrastructure but also by an accepted set of strategies and behaviours.

6.4.12 Relational risk

The issues of relationships within supply chains emerged from the data time and time again. This was a specific concern of those in the upstream elements of the

supply chain – namely processors and producers. These concerns revolved around how the retailers wield their power with suppliers, namely how they continually look to squeeze cost out of the supply chain, and often look to push risk (such as inventory holding, increased payments days) away from their operations and back down the supply chain. This behaviour was seen as a major threat, creating unsustainable pressure on the UK food supply which could drive many organisations and producers out of business, thus creating more pressure on supply. There is linkage here to compliance risk, as discussed, with the potential to encourage behaviours not conducive to food safety i.e. encouraging food fraud and shortcuts to meet cost pressures.

Antagonistic behaviours between supply chain partners were also seen as a threat. This was primarily a concern for those associated with the dairy industry – poor relationships between farmers and processors, over contracts and pricing, puts pressure on supply (e.g. through farmers direct action etc.). Across wheat supply chains, the tendency for transactional relationships and the lack of integration and co-ordination across chains were seen as risks in making it difficult to exchange information, particularly to help joint activities to manage demand, introduce new projects or even to co-ordinate contingency actions to mitigate risks.

6.5 Risk profiles and interconnections

Table 6.5 shows a summary of the risk profile for each of the sector groups. It must be noted here that where the risk is judged to be present, this is based on whether actors had articulated this type of risk for their sector; it may be that risks not articulated do exist in that sector but may not be as prominent. As can be seen, some risks are common across the sectors and groups – that of cost, profit risks and compliance risk. Actors tended to articulate threats and possible outcomes in terms of the impact to cost or the impact on the ability to create profit margins. Relational risk features for dairy producers and processors alone – this reflects the antagonism that exists in that dynamic – while governance risk is more pertinent to the wheat producer and processor dyadic. This reflects the disconnection of the upstream

wheat supply chain. Risks which are closely associated with the end consumer, such as market and reputational risks, were prominent in the downstream supply chain as expected.

	Dairy producers	Wheat producers	Dairy processors	Wheat processors	Grain traders	Brand manufacturers	Retailers
Profit risk	•	•	•	•	•	•	•
Cost risk	•	•	•	•	•	•	•
Compliance risk	•	•	•	•	•	•	•
Relational risk	•		•				
Input and resource risk	•	•	•	•	•	•	
Capability and operational risk	•	•	•	•		•	
Competition risk	•	•	•	•		•	
Market risk			•			•	•
Reputational risk			•			•	•
Supply continuity risk			•	•	•	•	•
Governance risk		•		•		•	•
Structural risk			•	•			

Table 6.5 Profile of risks by actor groups

While disruptive, one-off events were of concern, the majority of threats were articulated as ongoing pressures and continuous risk to operations. Ultimately, actors characterise the outcomes of potential threat through the overriding lens of profit and growth. While there are direct threats to profitability and market growth, other risks feed eventually through to both of these areas. Actors therefore think how a specific threat could manifest itself, what aspect of their organisation or supply chain it could impact and what the likely outcome would be. The threats expressed potentially contained an implicit comprehension of external environment – globally and the UK market – but were explicitly articulated as a direct impact or concern for their sector and organisation. Here, actors also assess the level of impact. This indicates that the constructs of risk are interwoven with the context within which each actor and their organisation operates and the impact on specific outcomes relative to their organisation.

Boundaries between the risks are somewhat fuzzy and it must be acknowledged that these boundaries have been imposed by the author. For example, cost risk blends into profit risk, relational risk blends into governance risk. However,

the risks as a whole represent the landscape as presented by actors. Each of these risks therefore inter-connect, forming a complex arrangement of potential threats and outcomes. Risks in this sense are not conceived as isolated entities but are linked together to create a chain of possible cause and effect – these interlinkages are shown in figure 6.1.

The framework demonstrates how these risks are associated with each other. For example, at an organisation level, if there are threats to the capability, because of lack of investment in the latest processing technology (input and resource risk), this could directly impact the cost profile of the organisation (cost risk) and impact the ability of the organisation to comply with the required quality or regulatory standards (compliance risk). This in turn creates a potential threat which could impact profits and market share. This analysis suggests also that the categories of risk arise and are dealt with at different levels of the network; for individual organisations, for dyadic relationships, across the supply chain or at the level of the network. While risks such as those affecting cost and profit can impact across supply chains and the network, they tended to be characterised by actors as impacting on individual organisations. This contrasts with relational, structural and governance risks which are concerned with the network structure, the co-ordination of supply and inter-firm relationships, therefore existing primarily at a dyadic or cross chain level. These interact to exacerbate or reduce the other risks within the system.

From a supply network perspective, these interconnections betray further risk. While some risks exist and are visible at an organisational level, the interconnected nature of the chain and network itself means that not mitigating a specific risk could then see the risk impacting other members of the network. This demonstrates that risk is systemic. This starts to evoke questions over how well a network or supply chain is able to contain risk at an organisational level or whether the risk is vulnerable or not to the transmission across the supply chain or even across the network.

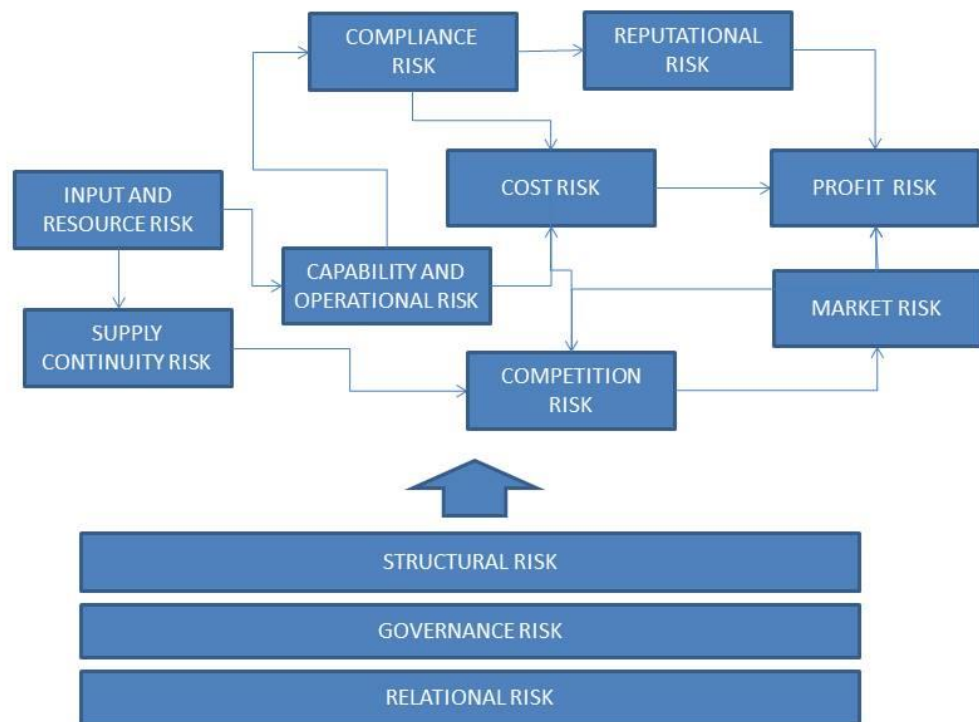


Figure 6.1: Interlinkages of risk

6.6 Conclusions

This chapter has dealt with the concepts of risk as perceived by food system actors. It presented prominent themes that arose from the supply chain sector interviews. Analysis of the combined data set revealed a set of concerns, threats and strategies that interacted to inform how actors conceptualised risk. Here, 12 categories of risk emerged which directly related to an area or function of actors' organisation or supply chain that could be negatively impacted. This led to the following main conclusions for the chapter:-

- Actors tend to conceptualise risk in terms of their context, their strategic priorities and how it negatively (generally) impacts their organisation

- Risk is often expressed in economic terms and how it effects either profitability or market growth
- How risks are perceived is highly contingent on the sector and position within the supply network. Risk profiles differ by each sector and by supply chain echelon
- There are complex interlinkages between the different categories of risk, one risk can escalate to another type of risk
- Risk is systemic. It can arise at an organisational level, at a supply chain or network level but is able to be transmitted across all levels

Chapter Seven: Conceptions of vulnerability

7.1 Introduction

In the last chapter, actors' perceptions of risks and their interconnections were explored. In this chapter, the concept of vulnerability will be examined more fully. This chapter is focused primarily on research question two.

RQ2: How do the endogenous characteristics of the UK food supply system, in terms of its structure and dynamics, contribute to the perceived level of vulnerability in light of global, exogenous uncertainties.

It also looks to address part of research question 1 not covered in the previous chapter – as to how do actors conceptualise vulnerability and how this interlinks with conceptions of risk.

While risk was more easily identifiable in the data and emerged as a level two concept, the construct of vulnerability was less explicit. Elements and core categories related to vulnerability emerged only through the latter stages of analysis; a process of re-coding was employed to re-examine the data in order to draw out and evidence core categories (Easterby-Smith et al., 2002). The chapter therefore presents the core categories that emerged from the data that were judged important factors for the vulnerability of the food network. This analysis revealed vulnerability to be a multi-dimensional construct. The chapter also presents findings of further core categories, how these are connected and the associated interpretation of these categories (the re-assembly and interpretation processes described in Chapter Three). The aim here is to understand how these factors impact on, and interact, with vulnerability. From this analysis emerged a definition of vulnerability and a conceptual framework to express the dynamics at play within the food system. This framework also gave rise to an understanding of vulnerability in terms of outcomes – both at an organisational level but also a wider system level. The chapter therefore discusses these outcomes and how these relate to vulnerability.

The chapter is structured as follows:-

- An exploration of the exogenous and endogenous factors that impact vulnerability
- The conceptualisation of vulnerability
- A discussion on the wider outcomes of the food system and why these are important to the concept of vulnerability
- A discussion on the relative nature of vulnerability

7.2 Exogenous and Endogenous factors on vulnerability

The examination of the data in order to understand concepts of vulnerability was problematic. Level 2 coding did not reveal substantial understanding of the concept; it only started to emerge when the data was re-coded to identify the key factors which impacted on risk and vulnerability – as part of the process to understand RQ2. However, these level two codes revealed factors which had an impact on each sector’s exposure to risk; hence its vulnerability. As the core categories started to emerge, it revealed a messy landscape of factors. To organize them, they were grouped into sets based on whether they were external to the food system network (endogenous) or internal to the food system (exogenous). They were further delineated as to whether they were :-

- *Global*: factors, external to the UK, but have a strong influence on market dynamics in the UK
- *UK socio-technical*: factors which were judged key elements of the economic and social framework within which the food system sits
- *Supply chain*: factors which characterise dairy and wheat supply chains and are judged as influences on vulnerability
- *Behavioral factors*: factors which characterise core beliefs within the mainstream food system

These level codes and how they are grouped are shown in table 7.1.

Exogenous factors	Global factors	Global supply/demand factors
		Access to global market
		Degree of dependency on global market
	UK socio-technical factors	Economic structure of UK
		Consumer expectations
		Societal value of food
		Political intervention and will
		Regulatory and policy framework
	Endogenous factors	Supply chain factors
Supply chain structure		
Level of Supply chain integration		
Sector specific factors		Cost/pricing structure
		Interdependencies
Beliefs and mind-sets		Perception of risk and vulnerability
		Faith in markets
		Faith in technological solutions
		Scale and efficiencies
		Trust and confidence
		Belief in environmental sustainability of the food system
Actions and behaviours		Strategy norms

Table 7.1 : Exogenous and endogenous vulnerability factors

7.2.1 Global supply and demand dynamics

This code reflects the recognition by actors of pressures in the global market which have the capacity to impact on the UK food system. From a supply perspective, this encompassed uncertainties, and therefore risks, related to the availability of land, water and energy along with how climate change could impact agricultural capability. From a demand perspective, rising global population, economic growth and nutrition transition is creating more demand for food. One point of vulnerability for the UK is the effect on prices e.g. higher prices for oil and other input, commodity prices and/or foodstuffs. However, this could also result in restrictions or shortages of globally sourced items, such as soya for animal feed. The global arena could also act as the source of shocks and one-off disruptive events e.g. animal disease. There is an acknowledgement that firstly, the UK does not sit in isolation and secondly, there are vulnerabilities at a global level, linked to uncertainties associated with demand-supply dynamics, which could feed through to the UK food system in the future.

7.2.2 Degree of dependency

The level to which a food sector is exposed to global uncertainties is correlated with the level to which a particular sector is dependent on inputs from the global market. Vulnerability here then is the degree of exposure to the global market. Agriculture is particularly dependent on global inputs (e.g. fertiliser, phosphorous, soya for animal feed) and this becomes a significant factor in the vulnerability of the wheat and dairy farming sectors. The degree of dependency on oil price affects all aspects of the food system and therefore no one section of the system is immune to global effects.

7.2.3 Access to global market

Here, vulnerability is whether access to the global market to purchase necessary supplies is restricted. These constraints included political interventions (i.e. the imposition of export bans) and any difficulties in trading with particular countries (due to political tensions) or the absence of trade agreements with specific countries. Specific threats were seen as bi-lateral agreements which circumvented the global market which could shut out certain supply routes for other countries (e.g. China's strategy to use bi-lateral agreements and 'land grabs' in Africa to secure agricultural inputs and foodstuffs). Access was also defined in terms of the economic capability to purchase, including the continued strength of sterling to compete globally.

Vulnerability is therefore a combination of the function of global supply dynamics, the degree of dependency and the ability of the supply chain to purchase relevant inputs. The higher the dependency and a lower level of access to market equates to a high level of vulnerability. *Food In Crisis* is an example of this.

7.2.4 Economic structure of UK

The food system is also inextricably linked to the wider UK economic environment. Aspects of this which were deemed important by actors were:-

- How the costing and pricing structure of the UK market is weighted and the level to which external costs are internalised : e.g. carbon pricing or other externalised costs related to environmental impact
- Cost of labour and energy including diesel/petrol (and how taxation policy impacts)
- Cost of compliance (regulation, legal requirements, supply chain imposed specifications)

Also articulated was the close linkages to the general policy and regulatory frameworks which govern UK markets along with taxation policies. The vulnerability here is related to how these factors are shaped in the UK, versus the EU and other competing markets and whether they adversely affect the cost base and general competitiveness of the UK food sectors. If these factors result in high costs or the price of exports is driven higher, this could result in more competition from imports or reduce export opportunities.

7.2.5 Regulatory and policy framework

This category emerges for actors as a key shaper for the food market, as indicated in the previous chapter on risk. The regulatory framework (although driven mainly by EU law) covers all aspects of regulation that directly and indirectly impacts the food system. This is multi-dimensional and covers areas from the CAP framework, waste disposal, packaging and labelling requirements, control of pesticides and waste from farms through to carbon credit schemes. The shaping of this framework drives actors' behaviours and impacts the economic structure of each sector. The vulnerability here is the level of compliance required (compliance risk) and whether the cost burden reduces organisations ability to compete (cost, profit and competition risk).

7.2.6 Consumer expectations

This category is concerned with how consumers perceive value when making food purchases and can be highly subjective based on the individual and their social

and environmental circumstances. This is then the balance between the attributes offered by food products across multiple dimensions including price, quality, availability, appearance, provenance, health, environmental credentials, production methods (organic etc.) and others. How consumers make their purchasing decisions forms the fundamental characteristic of market demand and therefore to some extent drives the overall direction of the market. Vulnerability here was characterised as large changes in demand which causes switching away from core products (e.g. switching to lower fat proteins away from cheese). *Into a New Era* saw a massive swing in consumer expectation to more sustainable products and presented a huge challenge for actors.

7.2.7 Societal value of food

This category describes how, as a society, we perceive food, how we judge its importance and how we consume it. Actors saw a direct linkage between this underlying perception of food and what consumers value and therefore will pay for. One characteristic which featured prominently was an overall expectation of cheap food, and in particular, that food spend overall will not exceed a certain % of overall disposable income. This becomes problematic for actors in the food system if food prices rise significantly and challenges this expectation. This creates vulnerabilities for UK producers and processors; the lower the value placed on food by consumers (and specifically food produced in the UK) the more difficulty actors have in justifying UK sourced products in times of higher food prices.

A low value placed on food, in relation to other policy priorities also creates a political difficulty for the UK government to justify allocation of resources, particularly money, and contributes to a lack of appetite for UK government to intervene to support the UK processing and farming base.

7.2.8 Political Intervention and will

This is the level to which the UK government feels the need to intervene in the food market and to what extent they employ policy levers or regulation to shape

it. It is highly dependent on the perception in government as to whether there is a need to intervene or not in the market and whether there is political or social capital in them doing so. Actors from the farming sector, particularly dairy, presented an argument for more monetary and indirect policy support for areas such as agricultural skills development as a counter to the erosion of the British farming base. Actors within the food system were both suspicious of, and against, further government intervention to encourage more sustainable behaviours. Actors on the periphery of the food system, along with NGOs, saw a more proactive role for government in moving the system towards more sustainable practices. This demonstrates this is a highly contested area with widely differing opinions as to whether there should be more government intervention or less. However, what was common was a sense that government did not have a joined up approach to food (from an environmental, health, economic and social aspect) and this was a potential vulnerability for the system.

7.2.9 Power and fairness

This is the level to which entities within specific supply chains exert influence or have control over the supply chain. In majority of cases, this refers to the power of the UK retailers in determining the operation and structure of the supply chains, at least at the immediate next level, and sometimes further down the chain. This power is manifested as the ongoing selection of suppliers from the UK or global market, the product range and imposition of quality and safety standards. Action taken unilaterally by suppliers outside of the remit of the retailers therefore becomes potentially difficult and often detrimental. Food manufacturers, particularly multi-nationals who have well established market brands, are able to create some balance of power with the retailers, and in turn exert power throughout their own supply chains. It is these power brokers within the supply system who have the capability and influence to enact change. It is also this buying power which could prompt switching towards global, lower cost producers and an increase in the level of imports, thus tipping the balance away from UK production and significantly eroding UK production.

A sense of fairness is important here and the concern is whether this power is abused by retailers or brand manufacturers. Vulnerability here then is correlated to relational risk where there is abuse of power or where subordinate organisations are unable to resist any squeeze on costs or excessive demands for risk sharing (e.g. inventory holding and/or increased payment terms). This is a serious concern for producers, particular dairy, due to their smaller size and relative captive need to sell into local markets. This led some actors to question whether the legislative framework, including competition laws, creates sufficient incentives to ensure that smaller organisations are dealt with fairly and to prevent abuse of power.

7.2.10 Supply chain structure

This is how supply chains within the food system are organised. The elements which emerged as important are:-

- The scale and number of separate entities within the chain
- How assets are organised to facilitate the flow of physical goods and information
- The inter-linkages between each organisation
- Trends towards consolidation and centralisation.

The structure of the system has an impact on the level of risk exposure and therefore the vulnerability of each supply chain. It also influences how reactive the system is to change i.e. large-scale, centralised assets may be more vulnerable to shock-based threats. This category also relates to ownership; whether companies are UK or foreign owned was perceived by actors to be potentially important, particularly in decisions to make further investments based in the UK or elsewhere.

7.2.11 Level of supply chain integration

This is the level to which those organisations with relative power advantages co-ordinate and control their suppliers and upstream supply chains. This has two dimensions:-

- Integration – the level to which there is specificity throughout the supply chain in terms of production and /or asset sharing
- Co-ordination – the level to which an entity controls and polices the supply chain. This could be just for one echelon of the supply chain or for multiple.

This is an important factor for supply chain actors; they saw more integration and/or co-ordination as a core strategy, for both dairy and wheat, in order to counter a number of risks including competition risk along with the need to assure quality and food safety. The lack of integration and co-ordination, particularly in wheat supply chains, is then perceived as a vulnerability.

7.2.12 Interdependencies

Interdependency emerged as a contributory factor to vulnerability. It relates primarily to supply relationships between organisations within the supply network. The level of interdependency is high between dairy producers and processors – dairy producers in particular are very dependent on a consistent market outlet for their milk. The level of interdependency is lower within the wheat network but is still a factor. While producers have more market choice for disposal of their wheat, processors are reliant on the UK market to provide a significant proportion of wheat at the right quality and specification.

A further aspect of interdependency emerged, associated with the connections between different agricultural sectors. The dairy system relies on the beef sector for the disposal of male calves. There is a mutual interdependency between the wheat and dairy sectors; dairy rely on the supply of wheat for some animal feeds while the feed market is a significant outlet for the disposal of wheat.

There was disagreement as to whether higher levels of interdependency led to greater vulnerability or not. Greater interdependency between actors or sectors could result in wider risk transmission and less opportunities to switch to more competitive sources but it could also provide opportunities for increased co-ordination between actors to mitigate for risk.

7.2.13 Cost/price structure of market sector

This category refers to the specific economic structure for each sector and the dynamics of costs and price. While this factor is heavily dependent on the economic structure of the UK, the regulatory and policy framework and consumer expectations, actors described inherent properties of each sector. This is therefore the ability of actors to be price-takers or price-makers within a particular market. It is also linked to the demand for end products, price elasticity and how well price relates to production costs. How well each echelon of the supply network is capable of, or expected to bear costs, versus the flexibility to charge higher prices has a bearing on the ability to generate sustainable profits, or not. This is also related to interdependencies within each sector and the ability of sellers or buyers to easily switch supply outlets. For example, price of fresh milk is fairly inelastic and there is no direct relation between cost of production and end price. As the producers are price takers in the market they have relatively little power to alter the dynamics and therefore often, in depressed milk markets, see farm-gate prices lower than the cost of production. The wheat sector is less vulnerable to end market pricing as wheat can contribute as little as 4% to the overall product price.

7.2.14 Perception of risks

How actors perceive risk and vulnerability has a significant impact on the actions and strategies taken to mitigate threats. Thinking in the industry tends to be shorter term so immediate threats to costs, such as changes in global pricing, are more likely to be considered and acted on, if possible. However, there seems to be considerable myopia within the mainstream supply networks. As the scenario *Into a New Era* demonstrated, greater uncertainties, with impact over the longer term such as environmental risks, do not appear on the radar unless prompted by regulatory or legal requirements.

While one-off major disruption events have the potential for significant impact on the food system, it is extremely difficult to predict these events. In

addition, if a risk is not perceived, or not seen as likely, then it is not acted upon. This was clear from the risks presented in *Into a New Era*, which actors did not accept as plausible. To counter any perceived threats unilaterally was also seen as costly (prohibitively so) and often excessively difficult for individual organisations to do on their own. This raises questions over the level of contingency planning in place, how adequate it is across the network and the need for collaborative, co-ordinated planning efforts from supply actors and government.

For supply chain actors, there are set of beliefs which seem to inform the thinking about risk at a fundamental level. These therefore influence the strategies that organisation undertake in order to mitigate any variance or risk in achieving their organisational goals. Emerging from the data were five specific categories which were:-

- Faith in markets
- Faith in technological solutions
- Scale and efficiencies
- Trust and confidence
- Belief in the sustainability of the food system

7.2.15 Faith in Markets

This is the extent to which actors believe in the capability of the market to balance food supply, ensuring sufficient supply at affordable prices. This is a complex area. At some levels, many supply actors believed that markets are capable of functioning to achieve this goal up to a point. However *Food Inflation* revealed a point of vulnerability; in a period of high inflation with pressures on input costs, food prices could rise to an unaffordable level for some consumers. This would also put pressures on the farming base. The conflict here then becomes the level of appropriate government intervention, or not, to support consumers or the UK farming base. There is an inherent reluctance for government to intervene further in the market with the more favoured option being for government to allow the

markets to operate under fewer constraints – i.e. reducing the level of regulation, particularly environmental.

7.2.16 Faith in technological solutions

This is the belief in the ability of the application of technological innovation to solve the future problems of food supply. This belief was common among many food supply actors. It manifested itself strongly in the arguments for the adoption of GM. Technology was articulated strongly as the way to achieve environmental sustainability. This manifested itself in calls for a step change in technology to produce energy to create a move away from fossil fuels and the use of GM, plant breeding technologies to increase yields while reducing the level of inputs required (e.g. water usage). This underlies the sense that solutions lie through process and product innovation rather than any radical shift in structure or practices. Peripheral actors to the food system saw this narrow application of innovation as a vulnerability, locking in reductionist behaviours into the food system and shutting out other types of innovation, practices and structures which could be part of a more sustainable solution.

7.2.17 Scale and efficiencies

The majority of the conventional food supply system is predicated on the notion of efficiencies; the more efficient a supply chain is, the more competitive it is. Efficiency here is defined as the lowest cost process through the use of fewer resources for more output – more for less. From a farming perspective, yields are the main driver of cost effectiveness, for both dairy and for wheat.

Associated with this are concepts of scale; economies of scale drive strategic thinking in the network. Efficiencies are inherently delivered through larger, more concentrated organisations and networks. There is some myopia here, periphery actors voiced concern over the sustainability of large scale systems in light of resource pressures. While *Into a New Era* exposed these potential vulnerabilities to concentrated, large scale systems (and to some extent this was true of *Food in Crisis*),

this structure is seen as the most effective allocation of resources rather than small scale, disaggregated systems. This therefore informs the current trajectory of food supply chain systems in the UK.

7.2.18 Trust and confidence

Actors saw consumer trust and confidence in food supply as an implicit but fundamental factor. Consumers expect that the food they buy is safe and that any claims made of products' origins, ingredients and characteristics are authentic. Brand integrity for retailers and manufacturers is particularly important and sales are often based on them being seen as a trusted source for consumers. The horse meat scandal of 2013 proved that where this trust is undermined, it has a direct impact on sales as consumers lose their confidence and buy elsewhere. While maintaining trust is a core responsibility to avoid reputational risk, there still remains a lack of traceability through the supply chain, particularly for highly processed products with multiple ingredients. Actors expressed concerns that the system is vulnerable to dishonest practices leading to unsafe food, food adulteration and even fake foods. This raises questions also of governance of the chain and who is ultimately responsible for monitoring and enforcing food safety. Actors strongly called for the industry as a whole to create more integrity but also called for stronger action by the Food Standards Authority.

Actors were critical of government's role in building trust. The media were criticised for promoting confused messages on food to consumers, particular on health and environmental matters which potentially masks some of the bigger concerns over food. It was a strongly held belief that government has a role to play in presenting clearer information to the consumer and becoming a trusted source of information on food matters. Actors however highlighted a lack of trust between the consumer and the government, and also between the consumer and the scientific community. This lack of trust creates a block in opening serious debates over the use of science in the food system and the need for any consumer behavioural change.

7.2.19 Belief in the sustainability of the food system

This is a highly contested area, with a range of beliefs. Actors peripheral to the food system (NGOS, academics and scientists) were more likely to express concerns over the longer term sustainability of the food system. This was in response to other environmental issues including carbon emissions and animal welfare but also wider social concerns (such as health and affordability of food). Dairy actors articulated awareness of the impact of livestock emissions and the need to address them but overall did not consider the longer sustainability of the system as a threat. Wheat actors were more concerned about the use of inputs – water, energy – and potential constraints to these resources. For producers, while there is obvious recognition of the reliance on nature and the need to work with it, environmental factors are coloured by the need for compliance to EU regulations. There is therefore a tendency for food supply actors to underplay the impact of environmental factors where the global impact is often disconnected from the impact on UK food supply itself. How actors perceive threats arising from environmental concern would seem to drive a belief as to what extent change to the system is needed and ultimately drives the need (or not) to act.

7.2.20 Strategy norms

The data revealed a suite of policies and strategies that were commonly upheld by actors as the ‘accepted way’ of mitigating cost and profit risks. The two core strategies were either to become the lowest cost producer or to create value add through product differentiation. The common suite of strategies are:-

- Product reformulation – either to assuage consumer/government concerns over ingredients i.e. sugar, fat salt or to reduce costs (e.g. reduction in packaging size)
- Product range reformulation – cutting down on the number of products
- Product innovation – increase the level of differentiation and value add to increase price points

- Process efficiencies and improvement in yields
- Concentration of assets

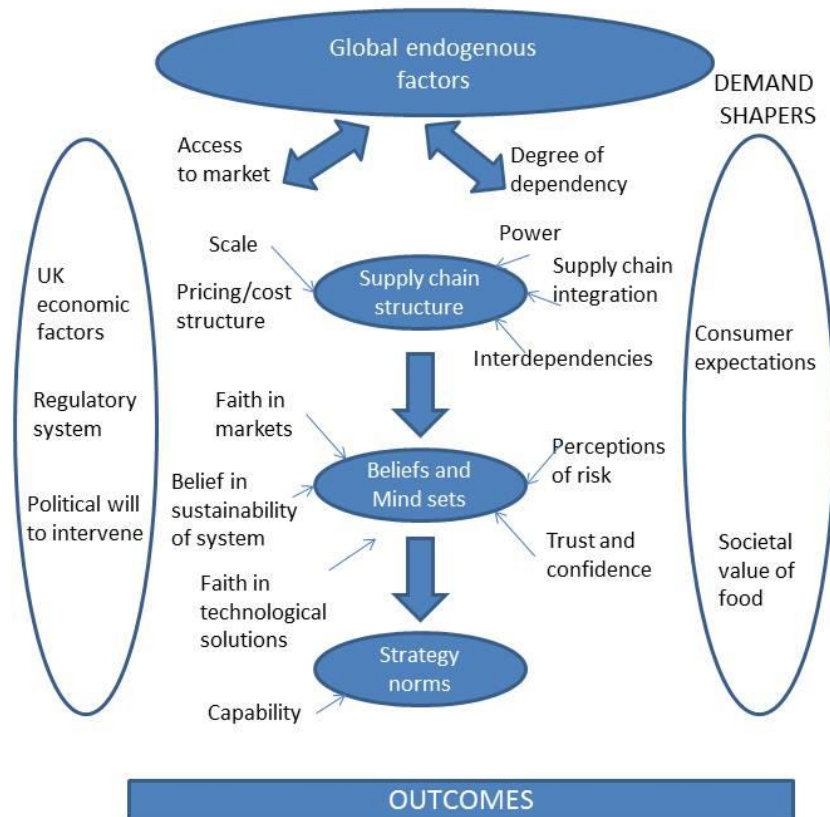


Figure 7.1 : Conceptual framework of interlinking vulnerability factors

7.3 Interconnection of vulnerability factors

All of these factors emerged from the data as significant in light of the construct of vulnerability. The conceptual framework in figure 7.1 shows the interconnection between these different factors and how, ultimately they combine to deliver a set of outcomes for the food system. The food system sits within the global arena but the extent to which global endogenous factors impact on the food system is based on each sector’s dependency and access to the global market. This access is dependent on the buying power of the organisation, whether or not there are

political barriers (such as export restrictions or trade agreements) and whether the quality or specification of inputs complies with standards (e.g. non-GM soya). Of course, the UK does not exist as a separate eco-system outside of the global one, so there is direct exposure to environmental threats such as climate change.

The economic structure of the UK and the regulatory (EU and UK) system are key factors in shaping the overall competitive environment of the system. They inform, in part, the cost base that UK organisations have to work with in order to do business. This plays a large part therefore in how organisations seek to make profits and create sustainable businesses. On the demand side, the UK food market is underpinned by the societal value placed on food, which in turn informs consumers' expectations of food, which ultimately drives market demand.

The food system is therefore set within this framework. Here, the structural elements of the supply network along with the beliefs and behavioural norms combine in order for actors to achieve their desired outcomes. How the supply chain structures itself is in principle based on how each organisation views the best way to service its demand base and balance the demands of the economic and regulatory cost framework. However, this is set within the constraints of the asset base (based on previous investment decisions and a set of beliefs and mind-sets) that:-

- the economies of scale deliver lower costs and bigger profits
- large scale trumps small scale
- less political intervention and freer markets will deliver better value to consumers
- technological innovation will provide solutions to many of the global problems facing the food system.

Power is a key driver; the retailers hold the majority of power and therefore influence the shape, structure and performance of the supply chain. Cost and pricing structures unique to different product types, when combined with this power, dictate how costs and profits are shared out among the different echelons of actors. Actors' concerns over the lack of trust along supply chains highlights a tension here

but also indicates that behaviours and actions throughout the chain are predicated by this lack of trust – i.e. unwillingness perhaps to disclose true costs, or hide potential problems. How actors perceive risk and vulnerability, and the level to which they feel the food system is facing threats, leads to a set of behaviours and strategic responses. Often these strategies have a common underpinning – either cost reduction or value-creating – which deliver a set of outcomes for each of the organisations in the supply chain as well as for the food network as a whole.

7.4 Conceptualisation of Vulnerability

7.4.1 Definition of vulnerability

All of these factors therefore, when combined in this conceptual framework, describe some of the key dynamics of the UK food network. The framework presented here describes the core elements that were both articulated by supply actors, but also elements that were less explicit (such as faith in technological solutions) but were judged to be important by the author as impacting the overall concept of vulnerability. However this framework was judged to be incomplete; it does not describe the interlinkages with risks (as identified in the previous chapter) or how these factors could combine in order to create vulnerability. This led to a second examination of the data in order to answer the question, how do these factors relate to the construct of vulnerability?

The data itself was messy and the connections between these factors and vulnerability complex and multi-dimensional. Vulnerability itself emerges at a higher level of conceptualisation. For supply actors, vulnerability was articulated through risks that could threaten their ability to generate profits and sustain market growth; i.e. their desired outcomes. The concept of ‘outcomes’ is therefore a vital element of the conceptualisation of vulnerability. It is therefore the variance to these desired outcomes that presents itself as the concern. On one level therefore vulnerability can be characterised as *‘the potential for variance to expected or desired outcomes’*. Variance here therefore is dependent on how risks present themselves within the food system and how they interact with the system to change expected outcomes.

This suggests a further element of vulnerability; that not only is it the presence of threats or risk to the food system but it is *the level of exposure* to them. The potential for variance is therefore a function of the types of risks threatening the food system, their likelihood of occurrence tied up with the level of exposure which impacts on the outcomes of the system. This is a static definition; it suggests that there is a certain level of vulnerability inherent and built into the system. However, supply actors are not mere observers in the system, they act through strategies and exhibited behaviours in order to ensure they achieve their organisational objectives and outcomes. Sets of strategies and behaviours are therefore designed to counter any perceived risks to their desired outcomes. They therefore influence the residual level of vulnerability in the system. In the case that the impact of a risk is not thought to be significant, then no action is taken to mitigate it. The resultant vulnerability in this case could still be high as it may be that the risk is a particular blind spot for that organisation.

There is a dynamic and interactive element of vulnerability – that is actors’ perceptions of how risks impact on outcomes combined with actors’ will and capability to act to mitigate these risks. This is the interactive element; that actors can intervene to change the properties of vulnerability in the system. Vulnerability is therefore a combination of:-

- risk and threats to the food system, some of which are not completely known
- the actual level of exposure to risks
- how the level of exposure is perceived by actors
- the capability and power to be able to act to mitigate the perceived threat

The definition of vulnerability that emerges is therefore ***‘the level of exposure to risk and the capability to respond to reduce variance to desired outcomes’***.

Chapter 6 explored the types of risk which could create vulnerability. However, there are other characteristics of risk which play in to vulnerability (see table 7.2). The source of the risk, its nature (whether a shock or an ongoing, continuous threat), the scope of the potential impact and its scale all have an impact on the level of vulnerability.

Source	Nature	Scope of impact	Scale of impact
Internal or external	Shock, continuous threat	Single organisation, supply chain, supply network	Low, medium, high

Table 7.2 : Characteristics of risk

Secondly, a re-examination was undertaken to group further these factors as to how they contribute to vulnerability. This analysis revealed a number of groupings important to vulnerability as shown in table 7.3.

Classification of factors	Description	Example
Risk sources	Factors which themselves generated risks for organisations	e.g. CONSUMER EXPECTATIONS: expectations of cheap food was seen as a source of risk in time of high inflation
Risk amplifiers	Factors which exacerbate the exposure to risk	e.g. REGULATORY FRAMEWORK: environmental regulations (such as the water directive) were seen to magnify the exposure to cost risks for producers
Risks dampeners	Factors which lessen the exposure to risk	e.g. SCALE: consolidation of processing capacity in dairy industry to reduce over-capacity and improve efficiencies
Enablers	Factors which helped organisations to act to mitigate risk	e.g. POLICY FRAMEWORK: government policies to invest more in public R+D in efficient production methods was seen as supporting the ability to mitigate cost of inputs
Constraints	Factors which stopped or limited the ability of organisations to act to mitigate risk	e.g. POLICY FRAMEWORK policies to limit immigration of non-skilled workers reducing labour pool for producers

7.3 Categories of vulnerability factors

However, trying to impose a taxonomy on the factors proved difficult. A re-evaluation of the data revealed that factors were interpreted in multiple ways; they exhibited pluralism. Many were simultaneously conceptualised as either sources of risk, dampeners or magnifiers of vulnerability or constraints and enablers to the capability of organisations to act. The way each of the factors is shaped, how important it is for sectors or supply chain echelons changes how its effect manifests itself on the system. This suggests a much more complex interplay with these factors and vulnerability. In turn, different elements of each factor may act in different ways on vulnerability. For example, while the majority of the regulatory framework for environmental sustainability was judged by supply actors as a potential constraint,

regulations on food safety were seen as a mechanism to reduce exposure to food safety risk i.e. a dampener. This plurality in the contribution of factors to vulnerability indicates the difficulty in conceptualising it as a whole.

7.4.2 Dynamics of vulnerability

The vulnerability factors emerged as level two constructs. While they helped to understand aspects of vulnerability, they did not fully explain the dynamics of how these factors interacted with actors' perceptions of risk and how their actions altered the vulnerability profile of their supply chain, or not. When the data was re-examined as part of the interpretation phase of the analysis (as explained in Chapter Three), a number of higher level core categories emerged (Appendix G). The conceptual framework shown in figure 7.2 shows the theoretical relationships between these categories, thus forming a more holistic picture of vulnerability, both at a supply chain and network level. This framework emerged directly from 11 of the 13 identified Level 3 core categories, thus integrating the emerging concepts into a formulated theory (Randall and Mello, 2012). These relevant categories are listed below.

- Perception of risk
- Exposure to risk
- Capability to respond
- Power to act
- Strategies
- Enablers
- Constraints
- Amplifiers of risk
- Dampeners of risk
- Competitive outcomes
- Wider supply network outcomes

Drivers of change and innovation also were identified as core categories. However, these emerged as different dimensions of vulnerability, conceptualised as dealing with system transition at a network level and did not neatly fit into this framework. These are therefore dealt with separately in Chapter 8 (section 8.6)

The framework shows the interlinkages between risk, the level of exposure to risk, actions and outcomes. If actors perceive risks as having the potential to impact their organisation, this will trigger a response. This response is however dependent on whether they have the power to act and whether they have the capability and/or resources to act. If this is the case for both conditions, then actors will put in place strategies to address these vulnerabilities. However, if this is not the case then the outcome will remain vulnerable. For example, the wheat yields are judged vulnerable if neonicotinoid insecticides are banned. However, wheat actors feel they do not have the power to act and alternatives, in their eyes, to maintain current yields are not available. The outcome here of higher yields is therefore vulnerable. There is also significant vulnerability where the risk is unknown, where it is not well articulated or where there are blind spots in recognising the existence of risk. Here, again, no action will be taken. These circumstances could pose even greater risks as this could result in unpredicted variance to outcomes. This is an important element of vulnerability – that there will always be unknown risks and therefore unknown consequences. This is an inherent property of risk, particularly when looking into the future.

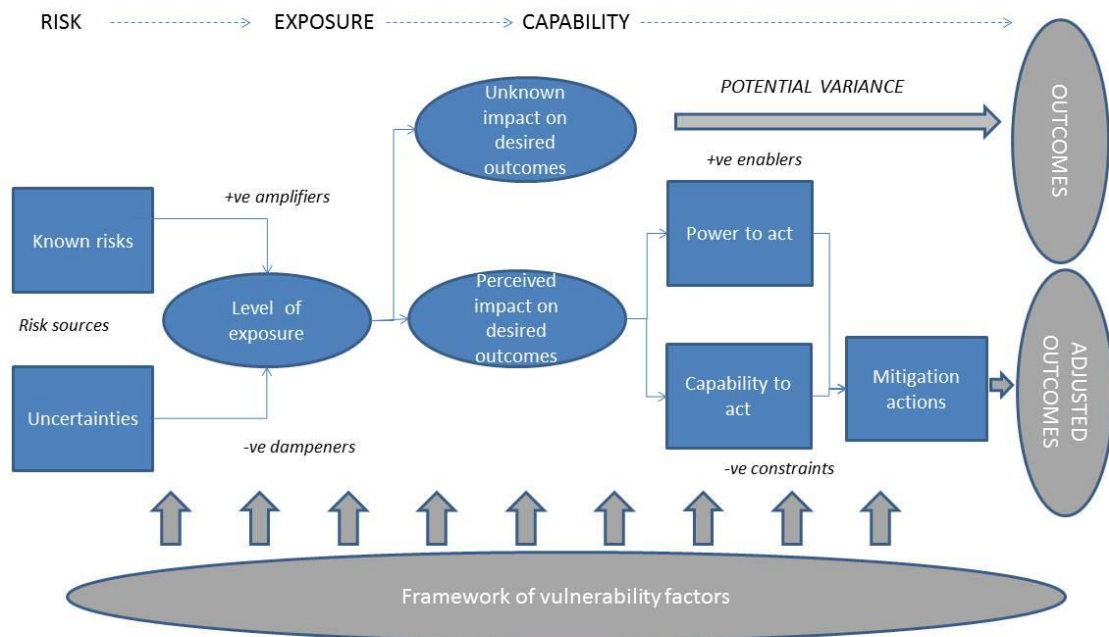


Figure 7.2: Dynamics of vulnerability

This framework therefore interacts with that shown earlier of the interlinking of vulnerability factors. These factors, related to the economic, social and political framework along with the structure, operation and relationships within the supply network, impact vulnerability in multiple and complex ways at all levels; in potentially being a source of risk, in amplifying or dampening exposure and in constraining or enabling the capability to act.

This conceptual framework therefore suggests that the way these factors are shaped creates inherent properties of the food supply network and therefore a built-in profile of vulnerability. This profile may vary dependent on the different sectors. The dairy sector has a different profile than that of the wheat sector as its level of exposure may be different based on whether the factors are shaped favourably or not. For example, the cost and pricing structure of dairy ultimately mean that dairy farmers are more exposed to reductions in the price of fresh milk; wheat farmers on the other hand are less vulnerable to this risk. Within this profile, changes to system factors will alter how risks manifest themselves but also the level of exposure of each sector. However, this vulnerability profile can be adjusted by actors, through their actions, therefore enforcing a more dynamic, interactive aspect to the conceptual framework. However, this action is very dependent on whether actors can see these risks and vulnerability and whether they can and or are capable of acting. This presents issues where there are levels of uncertainties surrounding risks and where there are blind spots. Where these risks affect longer term outcomes, such as environmental sustainability, or where there is need for more joined up intervention, vulnerabilities may go unaddressed and therefore cause unintended or unforeseen consequences to desired outcomes.

At an organisational level, any blind-spots or limits to action could ultimately end up impacting adversely the ability to compete and ultimately maintain economic sustainability. However, blind-spots or a lack of ability to co-ordinate action for more systemic risks pose an even greater threat for the whole network. This brings into question what the ultimate outcomes of the UK food system are and whether these are also vulnerable.

7.5 Wider outcomes of the food system

Taking a wider societal perspective it could be argued that the food system, at a very basic level, needs to be able to provide nutrition and calories to feed the population adequately and safely in order to promote economic growth and social stability. There are therefore a set of wider food system outcomes, outside of the main focus of supply actors. These were identifiable in the data primarily as :-

- Availability of food
- Affordability of food
- Quality and safety of food

7.5.1 Availability of food

This emerged as a core outcome of the food system; the ability to provide sufficient food for the UK population. On a global scale, this constitutes a real concern and from the scenario workshops and interview evidence, the majority of actors see this as a significant threat that demands global focus. The UK food system itself was thought by actors to be resilient in its capability to provide the volume of food. The range and choice of food on offer creates a certain level of resilience; if there are shortages of one particular food stuff, there is likely to be availability of alternatives. Larger-scale manufacturers or processors, based in the UK, were judged capable of competing globally in times of reduced food supply, with enough economic power to secure alternative supplies. Even with restrictions on global trade (e.g. *Food in Crisis, Into a New Era*), the strength of UK sterling was thought capable of maintaining its ability to purchase enough food globally. Any impact of risks to availability was in the choice of foods on offer rather than a lessening of the overall amount of food available. Only in very extreme circumstances as in *Food in Crisis*, was it thought possible that there would be any severe shortages felt by the UK on a wider scale. This outcome is therefore seen as vulnerable at a global level but not necessarily for the UK.

7.5.2 Affordability of food

Actors consistently expressed this both as a core outcome of the UK food system and as a future concern. It is therefore affordability, more so than availability, that was seen as the potential breakpoint of the system. One of the core factors here is consumers' expectation of low food prices, and pre -2008, this expectation was met with continuing food price deflation. This expectation remains in force, especially with higher inflationary pressures on household expenditures. *Food Inflation, Into a new Era* and *Food In Crisis* all resulted in significant pressures on this outcome. In a situation where there is continued inflationary pressures on food production and input costs, along with pressure from retailers to keep costs low, supply actors feared there would be insufficient flexibility in the UK system to continue to absorb costs. The options for retailers are therefore to either pass on prices or initiate a greater switch away from UK production and processing towards lower cost imports. This balancing act could be seen as a point of vulnerability if further global cost pressures are felt (and seen as a major tipping point as discussed in *Food in Crisis*).

There is a wider societal impact that was also highlighted by actors. The consequence of higher prices could create a bi-furcation of the market; between those that can afford higher priced, value-added products and those who are reliant on cheaper, and potentially lower quality, volume mass-produced food-stuffs. From a government perspective, there is an expectation that retail competition, especially with the entry of low cost retailers, will act to dampen down any inflationary effects. The market here is seen as the mechanism to regulate food prices, whether that is through efficiency within the UK production and supply or through lower cost imports. However, there is a sense of pressure within the market and therefore the food system; pressure from global inflationary effects, pressure from retailers to preserve their own margins, pressure on the availability of cash and investment capital that despite a competitive retail sector could spill over into significantly higher food prices and the social consequences that this would entail. This potential vision of a more divided society, between those who can continue to have choice and

eat a healthy, balanced diet and those who may struggle to buy sufficient nutrition, presents a significant challenge to government and UK society as a whole.

7.5.3 Quality and safety of food

One of the basic outcomes of the food system is to provide safe food. This outcome also includes the ability to provide a certain level of product quality as expected by the consumer. This is in terms of its appearance, shelf-life, taste, labelling and packaging. The regulatory system is important in promoting better safety and food quality standards across the UK system. Supplementary to this are farm or quality assurance schemes as specified by retailers, manufacturers and processors. In reality much of the auditing and monitoring of standards in the network is now left to the retailers and their suppliers, rather than government bodies. This relies on trust between consumers and retailers that they will provide safe food but also are honest about product attributes. The food system therefore is contingent on both compliance but also traceability at all stages of the network to ensure quality and safety standards are upheld. However, actors highlighted insufficient traceability across parts of the system, especially for complex long, multi-national supply chains. This is a serious problem for processed foods and ingredients supply chains. Actors identified this outcome as vulnerable, impacted by threats from food inflationary effects (cost and profit risks). Increasing cost pressures could see corners being cut and lower standards within UK production and for imports. At worst, there could be more instances of adulteration of foods and/or food fraud, again with potential harmful consequences. A lack of governance across chains exacerbates this vulnerability.

7.5.4 Health outcomes

While availability, affordability and quality have been seen as the primary objectives of any food system, the linkages between food and health outcomes are just as important. Thus health is seen as a desirable outcome of the overall food system. While supply actors saw this primarily as a market opportunity (in the

development of 'healthy' styled products), there was collective concern over the consequences of over-consumption and unhealthy choices. There was tension as to how far the market on its own will deliver the outcomes desired by government and how much there is a need for shaping and intervention by government. Government looks predominately to the food industry to deliver healthier eating through social responsibility means rather than through policy instruments such as taxation on the fat, sugar and salt content of food. However, the evidence here suggests that the industry will only go as far as the consumer demands on this issue, and then, sometimes only if there is commercial benefit in doing so. This conflict of commercial issues against wider societal concerns is then a point of vulnerability.

7.5.5 Environmental outcomes

A further outcome is that of environmental sustainability. However, this is where significant tension and conflict exist even in terms of its definition and the desired goals. As with health, there is a debate as to how achievable an agreed end state is. From a supply actors' perspective, there was general recognition that more needed to be done to make the food system more environmentally sustainable. However there was significant divergence as to what this actually meant. From supply actors' perspective, these discussions often focused on the need to reduce food waste and more efficient use of inputs (fertiliser), energy and water – in effect better resource utilisation. Even though *Into a New Era* sparked recognition of the potential impact of climate change, there was significant disagreement as to whether carbon needed to be controlled and to what level. Other aspects such as bio-diversity were viewed as at best a side issue and at worst as something which would need to be sacrificed. The reactions of supply actors to *Into a New Era* revealed an underlying view that structure and operation of the current system can be made sustainable. This is in contrast to periphery actors who start from a polar opposite position that the food system, as it is structured and organised now, is fundamentally unsustainable. This is based on concerns over levels of carbon emissions, soil

degradation, animal welfare issues, erosion of bio-diversity and the over-use of chemicals, principally driven by intensive production methods.

There are also conflicts between how this change should be driven; either through consumer choice and pressure, through self-regulation in the food industry or through increased government intervention in policies and regulations. Again there is a question over how much is achievable by private organisations and supply chains, in light of their primary focus on growth and profits. The full cost of resources used by the food system, such as land, water, energy and carbon along with any negative environmental actions tend to be externalised (in that supply organisations do not fully bear all these costs) therefore acting as limits to the extent to which organisations will look to drive sustainability. All of this points to a level of stasis in the system, between consumers' expectations, the pressures within the supply chain to grow market share and profits and the government's reluctance to directly intervene. Environmental sustainability then, as an outcome of the food system, could be said to be highly vulnerable.

7.5.6 Secondary outcomes

There also exists a set of secondary outcomes of the food system. The UK food system contributes to the economy as a whole through exports and through the generation of employment. However, there are more implicit, often hidden, contributions which are difficult to quantify. The importance of farming to land management is one such example; how rural land is managed and cared for is predominately in the hands of producers. Farming is also a contributor to rural communities.

Critical mass, in relation to the farming base, also emerged as an important outcome, for producers and UK processors at least. This refers to the erosion of a particular sector past a certain point prompting a complete collapse with the associated loss of skills and expertise. This would create significant barriers (in terms of cost, skills and for dairy, herd replacements) that would create difficulties in resurrecting that particular sector in the future. If a sector collapses, or becomes

niche, it poses difficulties for other sectors e.g. the collapse of the dairy sector impacts on the beef sector. This again highlights the interdependencies across farming sectors. This question of the 'right size' for the UK farming base provides a fundamental debate for UK producers and processors. While this is often couched as the self-sufficiency debate, no supply actors were arguing for 100% self-sufficiency but raising the question as to what the right balance is. From a producer and processor perspective, the higher the level of UK production, the better. However, this is less of an issue for multi-national manufacturers and retailers. They have the capability to source globally, if required, to meet cost and quality demands. This reinforces the schism within the network – the farming base and producers inherently are more vulnerable to global competition and the effects of erosion on their sectors than manufacturers and retailers.

7.6 Relative vulnerability

This line of argument points to a property of vulnerability; that it is *relative*. How vulnerability is conceived is dependent on the position of actors within the network and whether the desired outcomes are expressed in terms of individual organisations, their supply chains or at a network-wide level. Dairy producers are more vulnerable to input costs rises as they are unable to pass on costs to processors, due to the embedded cost and price structure of the industry. This causes a further vulnerability, if erosion in their industry continues. However, from a retailer perspective whether this is a vulnerability or not is dictated by their ability to source fresh milk elsewhere at reasonable costs and quality acceptable to the consumer.

Whether or not the network is judged vulnerable is also dependent on the perspective taken. From a retailer perspective, network vulnerability is the ability of the UK food system to reliably produce the required volume at competitive costs and at the right level of quality. Wider societal outcomes, while not ignored, are not retailers' primary concern and therefore any risks related to these outcomes will not be considered or generally acted on. However, looking at the system from a

government perspective, this lack of consideration means that longer term threats may impact negatively on the desired outcome of a population able to access affordable, healthy and sustainable food supplies. The system is therefore vulnerable from this perspective.

There is also the question of trade-offs between outcomes and this was a theme present in the data. This is based on the premise presented by actors that it would be impossible to achieve the desired outcomes for all aspects of the food system principally due to limited resources (money especially) but also due to inherent conflicts between some of the outcomes. For example, actors portrayed the consequence of pursuing environmental sustainability as resulting in higher food prices, thus impacting adversely on affordability. Sacrificing bio-diversity is seen here by some supply actors as a necessary evil in order to ensure that the food system was able to continue to provide sufficient availability of food. Other trades-offs were characterised as the inevitable acceptance of GM (to help develop more resource efficient crops and increase yields), a loosening of environmental regulation, especially on the restriction of chemicals.

7.7 Conclusions

This discussion therefore underlines the complexity of the concepts of risk and vulnerability. Vulnerability emerged as a multi-dimensional construct, composed of an interaction with risk, and whether this risk is perceived coupled with the ability of actors to mitigate impact. It is defined as ‘the level of exposure to risk and the capability to respond to reduce variance to desired outcomes’.

Vulnerability is a function then of risk, risk perception, the relative level of exposure and the capability of actors to mitigate this risk to achieve desired outcomes. A set of exogenous and endogenous factors have a pluralistic effect on vulnerability, acting as either sources of risk, amplifiers or dampeners to the exposure to risk and constraints or enablers to the ability to act. Any risks which are not either visible or understood, which do not impact their organisation directly and/or they do not have the capability to mitigate pose significant threats. Ultimately

it is the expected outcomes as perceived by each actor, which drives how vulnerability is conceived or acted on.

Vulnerability is also relative, based on actors' perspectives and the desired outcomes associated with this perspective. For supply actors, actions to mitigate risk and reduce vulnerability are typically motivated predominately by perceived risks to market growth or profitability. However, there are wider outcomes of the system – those of affordability, availability, quality, safety and environmental sustainability. Threats to these outcomes are not likely to be addressed by single supply actors or supply chains.

Chapter Eight: Frameworks of risk and vulnerability: Towards New thinking?

8.1 Introduction

This chapter critically assesses the findings and conceptual frameworks presented in the previous chapters by comparing them to the body of SC risk, vulnerability and resilience literature. This therefore looks to address research question three:-

RQ3: How adequate are these conceptual frameworks of vulnerability, resilience and adaptive capacity in light of global phenomena?

It must be re-emphasised at this point that the research itself followed a grounded approach, rather than following a full grounded theory framework. In many instances of grounded theory, researchers are advised not to familiarise themselves with the literature prior to the empirical data collection and analysis (NB. There are multiple variations of grounded theory and Strauss and Corbin (1998) take a less strict view on this). As explained in Chapter Three, the use of grounded theory was not a feasible prospect as there was no opportunity for theoretical sampling and the researcher had already some understanding of the literature in the SCRM field (as part of the CH project). That said, the analysis of the data was performed without an a priori framework derived from the literature and this chapter therefore looks to compare the findings to existing frameworks of risk and vulnerability in the fields of SCRM, SCV and SCRES. Comparison of case findings to the literature, in the interpretative tradition, helps to support the generation of theory (Gill and Johnson, 2002).

The chapter starts by comparing the types of risk explored in Chapter Six, along with the framework which shows their interrelationship. It then moves to examine the vulnerability factors identified in Chapter Seven with other frameworks as presented in the SCV and SCRES literature. The conceptual framework of

vulnerability presented in Chapter Seven is explored in some detail as to how each element contributes to the fields of SC risk, vulnerability and resilience and how well, overall, this framework describes the dynamics of vulnerability.

The chapter then presents a discussion on the implications of defining SC vulnerability at a network level. Here, a key finding is presented on how innovation and adaptive capacity is enacted in the food system, emerging from both the data and from the field of ecological resilience. It then moves to examine how the theory of system transition can support a wider understanding of the concepts of system change in the context of SC risk and vulnerability.

8.2 Conceptualisations of risk

The thesis has uncovered a number of key findings in relation to risk within a supply chain or network context. Each of these findings is shown in table 8.1. The first finding, that risk is difficult to quantify and often the outcomes unknowable, gives an insight into the difficulty, and often nonsensical nature, in trying to attach probabilities to risk. This finding runs counter to a significant portion of SCRM literature, which looks to measure risk and ascribe a level of probability. The number of factors at work, and how they interact with each other, complex supply chain structures and levels of uncertainty make measurement, and even accurate prediction, an almost impossible task. Despite this, there was still some propensity among actors to want to attribute probability and likelihood of occurrences to the factors; often these arbitrary attributions of numbers gave a level of certainty or not to the risk under examination. However, even where there were sets of clear, known risks (e.g. such as animal disease), which actors seemed comfortable in articulating, the specific outcomes were in essence still uncertain. This perhaps chimes with the work of Taleb (2008) in that there is tendency to underestimate the probability of particular events and their impact. Models of risk, and vulnerability, which look to pin down the types of risk faced by organisations and supply chains by using of lists of risks and their probabilities do seem to tap into actors' need for certainties and therefore could be seen as a good 'rule of thumb' when thinking about risks.

However, they must be used with caution as they can skew actions and mitigation towards obvious, less complex risks. The findings of the thesis here therefore agree with Peck (2005) and Trkman and McCormack (2009) that single, threat-based approaches (along with a measurement of risk) do not eliminate the risk entirely, only that specific manifestation of the threat.

Recent literature in the field indicates a tendency for researchers to focus on operational risk rather than disruptive events (Sodhi et al., 2012). However, this also seems true of supply actors. When not presented with scenarios, actors tended to think about elements or factors which would create ongoing difficulties in their day to day operation to supply their chosen market. This aligns with research of Vlajic et al. (2012), who observed this phenomenon when examining a red meat supply chain. From a farming perspective, there is more appreciation of disruptive events – the experience of TB in herds is a particular example in dairy. However, it was only in response to *Food In Crisis* that the wider set of actors were drawn to the possibility of event based threats and how these could impact the supply network. This backs up the premise that operational risk is the primary focus of actors, sometimes at the expense of disruptive risks. However, both categories of risks need to be considered for any research or framework to be viable, particularly with actors' potential blind spot towards disruptive events.

The scenarios revealed a number of risks and outcomes which had not been considered by some actors. *Into a New Era* particularly challenged actors and, though the risks presented here had a rational logic, they were rejected as 'unlikely', possibly because they did not fit with the world view of some supply actors. This is related to the thesis finding that risk is subjective. Actors tended to ignore those risks which they thought implausible i.e. a wholesale shift in consumer purchasing towards green choices. This again highlights the difficulty in this area of research, which is that risk is somewhat amorphous and difficult to quantify or confirm. However, this also seems to confirm the view of March and Shapira (1987) that managers only tend to recognise those risks associated with plausible outcomes rather than those they thought unlikely. The findings also concur with Zsidsin et al.'s (2004) definition of risk which exists only when an event is perceived as highly likely and with an

associated high impact and/or cost. It confirms the view held by Khan and Burnes (2007) that managers are pre-occupied with the negative concepts of risk. This research also reinforces the argument put forward by social scientists as part of the Royal Society report into risk (1992) that emphasised that risk is a socially constructed phenomenon which does not lend itself to objective measurement. As it would seem that there will always be non-quantifiable risk, uncertainties and unknowns, there needs to be recognition that there will always be ambiguity about the presence of risk and therefore difficulties in mitigating against it (Ritchie and Brindley, 2007, Trkman and McCormack, 2009).

Chapter Six indicated that supply actors tended to articulate risk in terms of outcomes, expressed as negative impacts on cost, on profits or on revenue. This chimes with the findings of Tang and Musa (2011) and Vljajic et al. (2012). This may seem an obvious finding, as the organisations in the wheat and dairy sectors are ultimately commercial entities which rely on being cost competitive and having profits to sustain longevity. However, in the SCRM literature, this connection to economic outcomes is not always immediately obvious. This is an important point when trying to understand risk in relation to supply chain actors, as it indicates that risk is less likely to be considered or mitigated for, unless actors can make a direct linkage to cost or profit outcomes.

Supply chain actors therefore tend to conceive risk as a loss, rather than as a variance i.e. the range of possible outcomes. This concurs with the findings of Khan and Burnes (2007), Rao and Goldsby (2009), Tang and Musa (2011). This however draws attention to one of the fault lines in SCRM as noted by Peck (2006), between the conceptualisation of risk as a loss and risk as a variance. On balance, based on the work of Knight (1921) and March and Shapira (1987), the nature of risk is variance. From an SCRM perspective, the researcher here, agrees with Juttner (2005) that risk is the variation in distribution of possible supply chain outcomes. However, the dissonance between this normative definition of risk, and the valuative one held by actors needs to be comprehended in SCRM and SCV research.

There is the implication in much of the literature that there is a linear connection between risk and outcome, a one to one relationship. However, the research here has indicated that in reality, how actors perceive risks is much more complex. It is the combination of risks, which create more uncertainty and complexity, which reflects the reality that supply chains face. Risks become even more uncertain when dealing with multiple factors and complexities at a system level rather than just for an individual organisation or supply chain. This concurs with the view of Peck (2005) and Zsidisin and Ellram (2003) that risk is a multi-dimensional construct.

Thesis Findings	Agreement with literature	Disagreement with literature
Risk is difficult to quantify and the outcomes are often unpredictable	-SCRM literature has a tendency to ignore uncertainties (Peck, 2005) (Trkman and McCormack, 2009) -Probabilities attached to risk are often underestimated (Taleb, 2008)	-Risk is measurable and quantifiable (Lockamy and McCormack, 2012, Kull and Talluri, 2008, Canbolat et al., 2008)
Actors tend to focus on operational risk rather than disruption based risk	-Supply chain risk is characterised as disturbances in operational performance (Vlajic et al., 2012)	
Risk is subjective, conceptualised by actors only when plausible and how it impacts negatively on their own organisation	-Risk exists when it is viewed as a plausible threat and is likely to cause an event associated with impact or loss (Zsidisin et al., 2004) -Risk is only perceived when considered plausible (March and Shapira, 1987) -Managers are preoccupied with the negative aspects of risk(Khan and Burnes, 2007) -Risk is socially constructed (The Royal Society, 1992)	
Risk is conceived in economic terms – negative impacts on profit and revenue growth	-Risk is conceived in terms of impact to operating costs (Vlajic et al. (2012) -Risk is conceived in terms of economic loss (Tang and Musa, 2011)	
Risk is perceived by actors in terms of loss	-Managers tend to perceive risk as a loss and focus on mitigating negative outcomes (Khan and Burnes, 2007, Rao and Goldsby, 2009, Tang and Musa, 2011)	
There are complex interconnections between risks themselves	-Risk is a multi-dimensional construct (Peck, 2005 and (Zsidisin and Ellram, 2003)	

Table 8.1 : Thesis findings on risk

8.3 The interconnections of risk

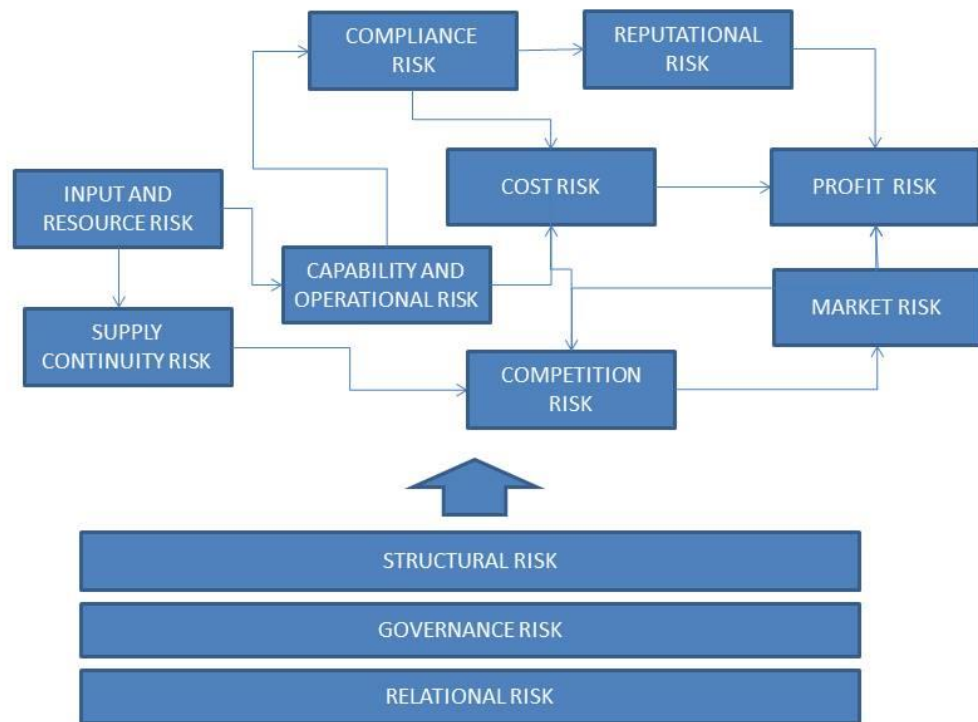


Figure 8.1: The inter-relationships between risk

The conceptual framework of risk explored in Chapter Six, and presented again here in figure 8.1, shows the categories of risk as perceived by supply actors and how they interlink. As can be seen in table 8.2, there is significant synergy between the categories of risk identified in this thesis and other prominent frameworks for the classification of risks affecting supply chains – that of Harland et al. (2003), Christopher and Peck (2004) and Manuj and Mentzer (2008a). Here it is only structural risk and relational risk which do not directly correspond. While risk arising from the structure of the supply chain is not new (see Craighead et al., 2007), there is little understanding of the impact of structure at a network level. The use of governance instruments to manage supply relations to reduce the risk associated with transaction costs or switching is well understood (Pilbeam et al., 2012, Gereffi et al., 2005); this is in effect TCE (Williamson, 1998). However, risk arising from the nature of relationships within supply chains is not well articulated or understood in

the SCRM literature. This would indicate that structural and relational risks, for food networks, are important risk categories and this research has helped to highlight this.

Risk categories – Thesis	Harland et al (2003)	Risk categories (Christopher and Peck, 2004)	Risk categories (Manuj and Mentzer, 2008a)
Input and resource, cost and supply continuity risk	Supply risk	Supply	Supply
Market risk	Customer risk	Demand	Demand
Reputational risk	Reputation risk		
Capability and operational risk	Operations risk	Process	Operational
	Asset impairment risk		
Compliance, Governance risk	Strategic risk	Control	
Structural risk			
Relational risk			
	Financial risk, Fiscal risk	Environment	Macro risks
Governance risk	Regulatory risk		Policy risks
Competition	Competitive risk		Competitive risks
Input and resource risk			Resource risks
	Legal risk		

Table 8.2 : Comparison of risk categories

These categories, emerging from actors’ conceptualisation of risk, lend weight to the use of these types of frameworks as viable ways of conceptualising risk and uncertainty and could be helpful to actors in thinking about risks to their supply chain. However, as there are a number of risk classification frameworks, all with slight variations between them (including that presented in this thesis), this perhaps indicates that the grouping and classification of categories can be somewhat arbitrary. They are also contingent on the case studies under examination (and of course the interpretative framework imposed by the researcher). Chapter Six revealed how risks become more or less prevalent in actors’ thinking, dependent on their position within the supply chain. The conceptual framework presented here therefore contributes by confirming core categorisation of risks but also by identifying those that are deemed important for the food supply system (at least for the dairy and wheat sectors). This suggests that risk frameworks, if they are to be

used to help organisations identify risks, need to be tailored to reflect the risk profile of the sector under study and the positions of actors within the chain or network.

This understanding of the need for unique risk profiling for sectors has important implications for SCRM and risk identification. The findings presented here also indicate that actors can be blind to risks which don't affect their own particular organisation. This would seem to confirm the view of Harland et al (2003) that less than 50% of risk is visible to individual organisations.

The framework presented here shows a further dimension to risk, by indicating that interlinkages exist between the different categories. Here, for example, compliance risks can lead to increased costs, which can lead to profit risk etc. Peck (2005) , along with Ritchie and Brindley (2007), highlight the interconnections between nodes/organisations in the network and how this ultimately means that risk can be transmitted up and down the supply network. The finding that risks themselves are also linked is not explicitly discussed in the SCRM or vulnerability literature. This therefore demonstrates a different dimension to the concept of the systemic nature of risk and how risks can escalate. This is important to understand as some actors may only perceive certain types of risks, based on their position within the supply network. This framework could help actors to think through how risks could escalate, both in terms of transmission through the network but also how they can transform into other types of risk.

This interconnection between different types of risks suggests there may be trade-offs between actions and strategies employed to mitigate a certain type of risk. Mitigation actions, while reducing one type of risk, could actually result in a higher prevalence of another risk. Juttner (2005) characterises trade-offs as balancing decisions of supply chain performance with that of vulnerability. However, the evidence here indicates that there may be more complexity. For example, moving from single source to multiple source suppliers may reduce risks associated with availability/supply continuity but may in actual effect increase compliance risk – in that it becomes more difficult to audit or ensure compliance for a more complex supply chain. This implies that decision making by actors has to both balance supply

chain performance with that of vulnerability, but risk mitigation strategies also need to take into account how actions may have displaced this risk to other areas of the supply chain or operations.

The risk framework presented in this thesis does not differentiate between those risks internal to the organisation or those originating externally within the wider environment. Here the drivers of risk are not explicit, only the area or operational performance at risk is manifest. There is therefore no inclusion of variables which are driving this particular risk, i.e. the risk sources as defined by Juttner (2005). It is only when the construct of vulnerability is explored that the drivers and sources of risk and uncertainty emerge. Actors also tended to extrapolate from the type of risk to a direct outcome on performance; risk was then conceptualised in terms of cause and effect (as indicated by Peck (2005)). Again, this is only implied in this framework. There is therefore a more explicit interrelationship between threats, the source of the risks and the potential outcomes. This suggests that using risk categories alone creates an incomplete picture. It also indicates that it is difficult to separate risk from vulnerability, and resilience; in essence all need to be considered to understand supply chain risk. The three conceptual frameworks presented in the thesis – of risks to the food supply network, the system factors which impact on vulnerability and the dynamics of vulnerability – are all interlinked and need to be seen together to represent the picture of vulnerability for the food system.

The tendency to focus on threats and their direct outcomes in risk literature is heavily criticised by Peck (2005) and Trkman and McCormack (2009). It is important to note, therefore, that 'outcomes' here represent the area impacted, rather than a specific detailed, predicted event. The contribution of the thesis is therefore that, while the conceptualisation of risk sources rather than outcomes is valid, it is difficult to isolate these sources from the area of impact and there is a complex, mutual interaction between the sources of risk and impacts. This therefore needs to be taken into account when conceptualising risk within supply chains and networks.

8.4 Vulnerability factors and framework

8.4.1. Comparison of frameworks

Chapter Seven presented two conceptual frameworks related to SCV. The first presented a framework of exogenous and endogenous vulnerability factors which emerged from the data, the second describes the dynamics or interactions between these factors, risks, decision making and ultimate outcomes for the food system. The next section therefore explores in turn how these frameworks compare to previous conceptualisations of vulnerability.

The first conceptual framework looks to align the differing factors which emerged from the data that impacted on actors' thinking and how they articulated vulnerability. The framework includes a mix of both exogenous and endogenous factors, structures, behaviours, beliefs and strategies. Previous researchers have also presented frameworks which look to identify factors which impact on risk and vulnerability – namely Rao and Goldsby (2009), Ritchie and Brindley (2007), Trkman and McCormack (2009) and Pettit et al. (2010). This comparison of the factors identified in this thesis to previously defined frameworks, along with other relevant factors prominent in the wider SCRM and SCV literature, is shown in table 8.3.

Vulnerability factors	Ritchie and Brindley (2007)	Trkman and McCormack (2009)	Rao and Goldsby (2009)	Pettit et al. (2010)	Other references
Global endogenous factors	X	X	X	X	Christopher and Holweg (2011)
Access to markets					
Degree of dependency (on global markets)	X				Wagner and Bode (2006), Christopher et al. (2011)
Economic structure of the UK	X		X		(Manuj and Mentzer, 2008b, Vlajic et al., 2012)
Consumer expectations		X	X		Vlajic et al. (2012)
Societal value of food				X	
Political will and intervention			X	X	
Regulatory and policy framework				X	
Power					

Level of supply chain integration					Collaboration Christopher and Peck (2004)
Supply chain structure	X			X	Craighead et al. (2007)
Cost and pricing structure	X			X	
Interdependencies	X			X	Wagner and Bode (2006)
Perceptions of risk and vulnerability	X		X		March and Shapira (1987), Zsidisin et al. (2004)
Faith in markets					
Faith in technological solutions					
Scale and efficiencies					
Trust and confidence (between partners)					
Belief in sustainability of the system					
Strategy norms					

Table 8.3: Comparison of factors to existing frameworks of vulnerability factors

As can be seen from the table, there is no single framework which maps exactly onto the factors identified in this research. It must be noted that the frameworks presented in the literature tend to be generic – not industry specific. The research here is novel as it is the first research which looks to identify the specific factors which impact on vulnerability in the food supply system that have been grounded in the experience and perceptions of actors in the supply chain under study. This is therefore an ideographic framework (Gill and Johnson, 2002) which presents those factors that actors perceived to have importance. In a sense, it is idiosyncratic to the wheat and dairy food networks, and partly to the food network as a whole. It is therefore not too surprising to find factors present here which have not been identified as part of other generic frameworks (and vice versa).

This again underlines the somewhat messy nature of empirical research, in that it often doesn't quite fit into previously developed theoretical frameworks. Consequently, there are also factors which are present in the literature, that are not present in this framework. Factors such as poor supplier performance (Vlajic et al., 2012), product liability uncertainty (Rao and Goldsby, 2009), technological turbulence (Trkman and McCormack, 2009) don't feature. This does not mean that these factors are definitively not sources of risk for the food system, just that they

did not emerge from the data as they were not deemed as important by actors. This raises two important points. Firstly, it demonstrates the complexity associated with examining risk and vulnerability and the difficulty in identifying core factors which drive these. It is therefore difficult to bring together comprehensive frameworks of factors. Secondly, while it is important to understand which factors are more important in particular supply networks, it may be difficult to differentiate between factors which are either not present or whether there is a blind spot in actors' perceptions.

However, despite this idiosyncratic nature of the conceptual framework, there are still notable exceptions where a particular factor is not present or explicitly discussed in the literature. In particular, the framework draws attention to specific values and mind-sets which seem to characterise, at least, some of the thinking in much of the mainstream food industry (for wheat and dairy). These are faith in markets and technological solutions, beliefs as to whether the food system is environmentally sustainable which all contribute to how actors perceive risk. These are therefore drivers of vulnerability as they are important influences on actors' thinking and clearly emerged from the data. This suggests a gap in previous frameworks and the need to understand how inherent beliefs and norms within an industry can impact on risk and vulnerability.

Often missed in conceptualisations of vulnerability are the relationship between power and risk, integration and the role of trust and confidence. Power is a core concept for SCM, as are trust and confidence (as antecedents to collaboration and integration) but there seems to be little or no conceptualisation of how this plays into SC risk and vulnerability. Power in the food network was seen as vitally important by supply actors and how business partners interact with each other was viewed either as a source of resilience or vulnerability. The perceived abuse of power by retailers, and the lack of trust in dealings with supply partners, is seen as a particular vulnerability by processors and farmers, especially in the dairy sector. How integration impacts on vulnerability is also not explicit in the SCRM and SCV literature, although Christopher and Peck (2004) along with Juttner and Maklan (2011) highlight collaboration as a core way to mitigate risk. Again, integration forms

a fundamental core of SCM but is not prominent in SCV literature. The treatment of integration, along with the role of power, trust and confidence in influencing vulnerability, is a perceived gap in the SCRM and SCV literature.

8.4.2 Interaction of factors on vulnerability

Chapter Seven explored the interaction of these factors with vulnerability. Findings revealed that the factors can interact in multiple ways on vulnerability. They can be sources of risk, act as dampeners or amplifiers to risk exposure or be enablers or constraints to the capability to mitigate risks. Dependent on how each factor is shaped, they can act in some circumstances as risk sources, as a dampener, as an amplifier or even, in some cases as constraints or enablers. This therefore revealed the plural characteristic of these factors.

Again, it is difficult to directly map this finding onto previous research. No previous framework has classified factors in this way. Previous research has referred to factors as either framework factors (Rao and Goldsby, 2009), uncertainties (Trkman and McCormack, 2009), risk drivers (Ritchie and Brindley, 2007), drivers of vulnerability (Wagner and Bode, 2006) or risk sources (Juttner, 2005). While Juttner(2005) clearly defines risk sources as ‘variables which cannot be predicted with any certainty and from which disruptions can emerge’ (pg.122 Juttner, 2005),the definition of the other classifications of factors is less clear. This suggests that there is ambiguity and confusion between these classifications, with each term used interchangeably. This is a view supported by Peck (2005).

However, it is how each factor interacts with vulnerability that matters more. While Peck (2005) identified that actors do not generally distinguish between risk sources, risk and risk drivers, the research shows that actors do distinguish between the factors acting as enablers, constraints, amplifiers or dampeners of risk. Previous researchers have articulated how the shaping of the legal, economic landscape can impact the risk profile of an industry and that the operation within the supply chain itself will also act to increase or dampen vulnerability (Wagner and Bode, 2006,

Juttner and Maklan, 2011). Craighead et al. (2007) postulate how structural characteristics of supply chains can amplify the severity of disruptions, while better abilities to detect disturbance act as enablers to reduce the impacts of events. This demonstrates that the conceptualisation of factors acting in these ways is not new. However, this finding contributes to the literature by providing a clearer classification as to how factors can interact with both vulnerability and resilience. It also contributes by postulating that it is how each factor is shaped, with reference to the supply chain context, that results in these different interactions with vulnerability and resilience. Thus, each factor can exhibit a plurality of characteristics and can combine in unique ways to impact the relative vulnerability or resilience of a system.

The interaction between the characteristics of factors and their effect on vulnerability and resilience reflects Peck's 2005 conceptualisation of vulnerability. Here she characterises the complex interplay between sources, dependencies and drivers that ultimately result in manifestations of risk and vulnerability at multiple levels of the network. This research here reinforces the systemic nature of vulnerability, and agrees with Peck's (2005) comment that reductionist research approaches to SC risk and vulnerability will struggle to encompass this complexity and interconnection. Only from a network perspective and from a multi-dimensional examination of factors can a more complete picture be drawn of the potential vulnerabilities of a supply chain and its wider system.

8.5 Definitions and dynamics of vulnerability

8.5.1 Definition of vulnerability

The definition of vulnerability that emerges from the research is that it is *'the level of exposure to risk and the capability to respond to reduce variance to desired outcomes'*. That vulnerability is the exposure to risk is in agreement with the literature on SC vulnerability. However, the second conceptual framework presented in Chapter Seven and shown again in figure 8.2, demonstrates the multi-dimensional aspect of vulnerability. This definition also aligns with both Juttner's 2005 definition

and that of Rao and Goldsby (2009) that it is also the variance in expected outcomes that defines vulnerability.

In addition, the definition presented here combines concepts of resilience, in that it encompasses the capability of the system to respond (Ponomarov and Holcomb, 2009, Ponis and Koronis, 2012). While resilience is a separate concept in its own right, this definition indicates that there is a direct linkage between the response taken and the level of exposure to risk. This aligns with the conceptualisations of Pettit et al. (2010) as their framework directly links vulnerability (and factors which drive vulnerability) to capabilities (the abilities of the supply chain to respond i.e. resilience).

This definition underlines the systemic linkages between vulnerability, risk and resilience (Peck, 2005). Here, vulnerability is bound up in the interconnections and complexities involved in the identification of risk and uncertainties, the level of exposure and the impetus to act to mitigate or control. Thus there is an inherent interrelationship between risk, vulnerability and resilience where each element cannot be isolated and examined independently of the others. This is often not taken into account in the literature in this field. The findings in this thesis indicate that, while research undertaken to further the understanding of each construct is important, the systemic interlinkages between the three must also be taken into account to support and build a more holistic understanding.

8.5.2 The dynamics of vulnerability

The conceptual framework in Chapter Seven, and presented again here in figure 8.2, looks to demonstrate the dynamics of risk, vulnerability and resilience. The core dynamics of the framework are:-

- Exposure to risk and uncertainties
- The agency to act
- The capability to act
- Variance between actual and desired outcomes

Exposure is a function of risk and uncertainties and how vulnerability factors are shaped to amplify or dampen this exposure. The agency to act is whether actors see the need to act. Resilience is a function of whether actors have the capability to act and whether the desired outcome can be achieved. Again, vulnerability factors could be acting at this stage to constrain or enable resilience.

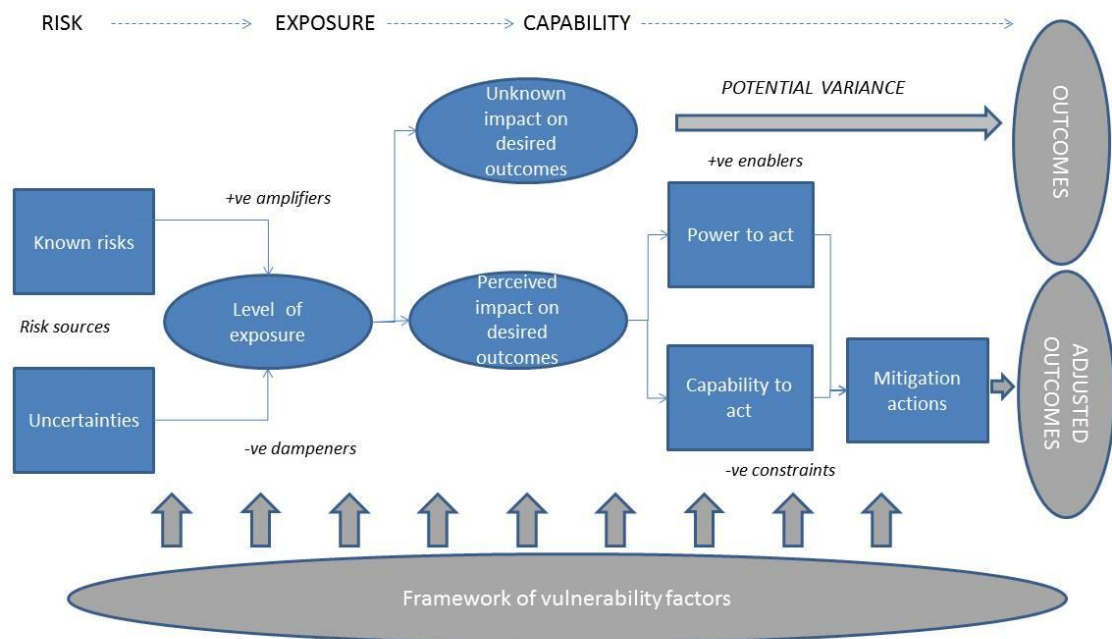


Figure 8.2: Dynamics of vulnerability (thesis findings)

This conceptual framework has synergy with that of Pettit et al. (2010), shown in figure 8.3. Here, their framework conceptualises resilience as a function of both vulnerability and the capability to respond. It also reinforces the linkage between vulnerability, resilience and levels of outcomes, in this case supply chain performance and/or impact on profitability. Here, capabilities are defined as ‘attributes that enable an enterprise to anticipate and overcome disruption’ (pg. 6 Pettit et al., 2010). Their framework therefore emphasises the important of managerial capabilities in building resilience, in that resilience arises only when capabilities are matched to vulnerabilities. Pettit et al. (2010) view capability building as a direct response to resilience and therefore outcome. As the thesis’ conceptual framework emerged from a grounded approach, rather from a literature review, it provides a level of external validity for Pettit et al.’s framework; in that actors’

conceptualisation is aligned to this theoretical representation. However, the framework presented in the thesis develops a more holistic view, linking the likelihood of actors perceiving and acting on risk (agency) to capabilities and the types of actions undertaken to support resilience. The next section deals with these elements of the framework in turn.

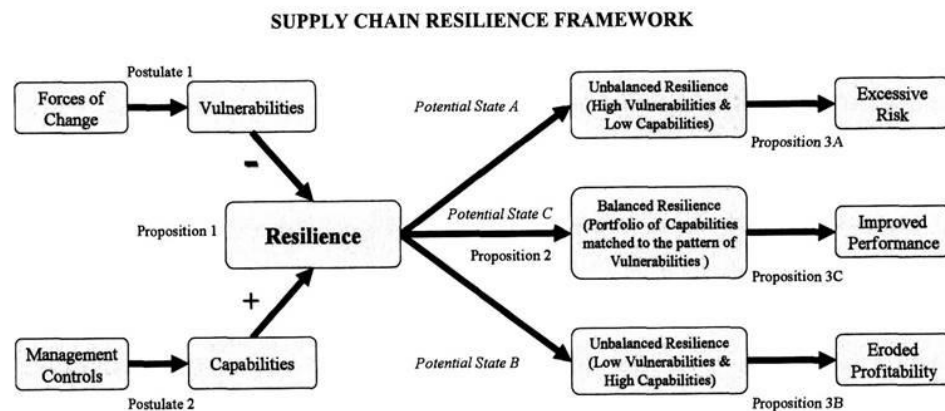


Figure 8.3 : Supply chain resilience framework (pg.8 Pettit et al., 2010)

8.5.3 The agency to act

The importance of agency on vulnerability is highlighted in this framework. Here it is a function of whether or not a risk is perceived both as likely and having the potential to significantly impact on desired outcomes, along with the control or power to act. Agency in this conceptual framework is therefore a combination of:-

- perceiving risks to have a likely, significant impact on organisation's supply chain and operations

- a perceived clear benefit to putting in place mitigation actions or strategies to increase resilience
- the power to act being within the organisation's control

Here the conceptual framework confirms a number of different aspects of agency which occur throughout the SCRM and vulnerability literature namely:-

- Decision makers are hampered by the lack of information and the complexity of interactions between risks (Chopra and Sodhi, 2004)
- Actors often do not have influence over risks arising from the supply chain (Ritchie and Brindley, 2007)
- Actors have a tendency to extrapolate the future from past events – in that the future, in their thinking, looks very much like the present and past (Taleb, 2008, Snowden and Boone, 2007)
- Decisions to mitigate are based on knowledge of the risk environment, rules and procedures of the organisation and bounded rationality of the decision makers (Rao and Goldsby, 2009)
- Actors will only look to mitigate if they can see a cost-benefit in their favour or there is an agreed collaborative and risk-sharing agreement between supply partners (Bakshi and Kleindorfer, 2009)

However, the data suggests that the perception of risk and therefore agency, is also affected by the beliefs and mind-sets within the industry e.g. belief in the sustainability of the system. These mind-sets seem to act as further filters to recognising or accepting the possibility of risk and its potential impact. If the risk is not articulated, if there are significant uncertainties, or where there is disagreement as to the extent of the risk, organisations will not act to mitigate the risk or develop resilience. There is therefore a dissonance between the actual potential for loss and the perceived potential for loss. If these two factors are significantly out of step, then this creates a blind-spot. This dissonance is not widely discussed in the SCRM or SC vulnerability literature but could be a major contributor to these fields.

8.5.4 Capabilities to support resilience

The core category identified as the capability to act, aligns with much of the literature on resilience. Here, capability to act is characterised as the strategic capability to deal with or mitigate for risk. These capabilities include:-

- having a strategy to build resilience into the organisation or supply chain (Sheffi and Rice, 2005)
- fostering a supply chain risk management culture (Christopher and Peck, 2004)

However, here the data revealed further aspects to capability, namely whether there were sufficient skills, sufficient investment or cash and in some cases, access to appropriate technologies. These are acute issues for the farming base and smaller processing plants, but were expressed as general concerns by all actors across the food network.

8.5.5 Actions to support resilience

This part of the conceptual framework relates to the actions undertaken to either mitigate any vulnerability or to increase resilience. Here there is a high level of synergy in the literature as to the types of actions and strategies that organisations can undertake. These predominately revolve around increasing redundancy (Sheffi and Rice, 2005, Peck, 2005, Kleindorfer and Saad, 2005), flexibility (Juttner and Maklan, 2011, Christopher et al., 2011, Sheffi and Rice, 2005) visibility (Christopher and Peck, 2004, Juttner and Maklan, 2011) and collaboration (Juttner and Maklan, 2011, Christopher and Peck, 2004).

These elements seem undoubtedly important to develop resilience within a supply chain. Collaboration and visibility both emerged from the data as contributors to resilience. Actors from the research highlighted both the need for greater transparency through the chain and better sharing of risk related information. They also called for greater co-ordination along the chain. What was not evidently present

in the data were the concepts of flexibility or the velocity and pace of response or adaptation, also missing was how quickly supply chains were able to learn from previous experiences in order to adapt structures. Some actors did draw attention to the slower cycle of response inherent in the farming process; therefore indicating a lack of flexibility at this end of the network. Wheat farmers operate on a yearly planning cycle while dairy farmers consider a longer cycle, of between 2-5 years. These longer planning cycles are out of step with the rest of the supply chain and underline the differences inherent in understanding vulnerability and resilience concepts at a farming level.

As discussed in Chapter Seven, there was also significant resistance to the concepts of redundancy. In contrast, opposite strategies were employed to reduce over-capacity and further concentrate assets. These were seen as necessary to counter any future expected squeeze on profits and inflationary effects on costs. In most cases, mainstream supply chain actors called for even more concentration which suggests that the trajectory of the industry is to become even more interconnected, with less redundancy.

Innovation emerged as a strong theme, perceived as supporting increased resilience within the food system. This was primarily articulated as technological innovation directed at either products (including the biological manipulation of seeds and/or animals) or agricultural and food manufacturing processes. Firstly, innovation to create value-adding products was seen as a core strategy to reduce the level of market, profit and cost risk. Secondly, innovation to reduce resource utilisation but increase efficiencies and output - sustainable intensification – was seen as both a counter to cost and profit risks but also to any potential environmental constraints on inputs. Innovation features as part of ecological resilience and both novelty and innovation are inherent properties of an adaptive system (Allen and Holling, 2010). However, its connection to resilience is not mentioned in the traditional SCRM, SCV and SCRES literature.

8.5.6 Wider consequences of vulnerability

The findings revealed that vulnerability is in effect relative, to the position in the supply chain and on the perspective taken. This is coherent with the literature. Trkman and McCormack (2009) and Ritchie and Brindley (2007) both see risk (and hence vulnerability) as being contingent on the industry, the position within the network and on individual organisational performances. However, there is no comprehension in the traditional literature as to how vulnerability profiles can be perceived as being different, dependent on the perspective taken. Perspective, as defined here, has two elements. Firstly, whether vulnerability is being assessed at a supply chain or at a network level and secondly, related to the motives and intentions of actors who are assessing vulnerability.

The conceptual framework developed here can be used at an organisational, a supply chain and at a network level, and from different perspectives. While this is potentially true of other frameworks, these levels of assessment are not explicitly discussed. In particular, taking a policy and network perspective of vulnerability radically changes the profile. Here the wider outcomes of the food system become important – those of availability, affordability, quality and safety of food, health, environmental and other secondary outcomes. This finding links to a subsequent finding, that the constructs of risk and vulnerability go beyond the normal economic-technical definitions and encompasses the social and environmental dimensions of supply networks. This confirms the view of Peck (2006). This conceptual framework therefore supports both the widening of the constructs of SCV and SCRES and provides a conceptualisation at this level.

8.6 Ecological resilience, network vulnerability and adaptive capacity

8.6.1 Network vulnerability and ecological resilience

The thesis findings, at a network level, have synergy with models of ecological resilience and these provide a useful way of conceptualising issues at this level. The food system can be described as an ecological system. The prevalence towards strategies of economies of scale and concentration of assets to create larger, more centralised plants and distribution centres highlights the continued high level of accumulated capital tied up in the system, creating a more interconnected network. Capital in the system can also be described as the level of resources such as land, water and carbon, which are tied up in food production, whether the food is produced in the UK or elsewhere. There is also a significant level of cash and capital needed to fuel the system, to facilitate the flow of products to meet demand from farm through to retail. These findings reveal a UK food system which is mature, highly inter-connected and asset rich; it therefore can be seen as in a 'conservation phase' (Allen and Holling, 2010). From an ecological sense, the UK food system, at a network level, can be described as brittle. This concurs with the findings of Fraser et al. (2005).

The tendency for actors to have blind-spots has a significant, and potentially severe, implication at a network level. Highly connected flows and centralised assets are perceived by mainstream supply actors as necessary to maintain competitiveness. The potential fragility associated with these structures is therefore a blind-spot, and as the conceptual framework in figure 8.2 demonstrates, what is not perceived as a risk, is not acted on. A further blind spot is related to the schism between supply actors and periphery actors over the inherent environmental and social sustainability

of the current food system. In particular, supply actors did not perceive the extent of risk associated with environmental factors (the potential impacts of climate change is an example of this). This serves to indicate that there are potentially significant vulnerabilities at a network level that the field of ecological resilience can help to articulate.

8.6.2 Adaptive capacity and innovation

Ponomarov and Holcomb (2009) define adaptive capacity as the ability of supply chains to recover from major disruption by maintaining 'continuity of operations at the desired level of connectedness and control over structure and function' (pg. 131, Ponomarov and Holcomb, 2009). This implies a need for rapid agility and flexibility within the supply chain. Christopher and Holweg's concept (2011) of 'structural flexibility' suggests that there is also a need for supply chains to be able to re-configure operations in response to turbulence in the business environment. The definition of resilience offered by Ponis and Koronis (2012), which deals with the adaptability of the supply network, suggests that the ideal goal for any network in dealing with disruption is to create competitive advantages in the post-event state. This suggests that there is an element of proactive design and management to create more competitive structures and processes. These definitions, however, do not consider fundamental re-configuration at a network level. From an ecological resilience perspective, different structures could potentially deliver better performance in terms of wider social and environmental outcomes (Gunderson, 2000). This then has implications for the concept of adaptive capacity, innovation and its role in supporting resilience.

Innovation emerged as a key strategy for resilience and for adaptive capacity. However, innovation within the mainstream food system is narrowly interpreted as product or process driven. Supply actors tend to pursue strategies to innovate and increase efficiencies within the current framework of processes and products, rather than look to fundamentally change structures and process.

The evidence suggests, however, that this narrow interpretation of innovation is not sufficient to develop adaptive capacity as actors are locked into what are, in effect, reductionist strategies. There is little support for experimentation and innovation in the way in which food can be produced and delivered. For example, experimentation to change farming systems, such as organic systems, is dismissed by mainstream supply actors as niche; it is believed that organics are not able to deliver the yields needed to meet growing food demand. Here, the concepts of ecological resilience, in that the system could have multiple steady states, are not considered. Any switch towards a different end-state, with different organisational and behavioural properties, would be considered as a failure of resilience by most mainstream actors.

This insight leads to a further significant finding of the study. There emerges, from both the data and the concepts of ecological resilience, a framework which shows how innovation interacts with adaptive capacity. This is shown in the conceptual framework in figure 8.4. Each axis represents an increasing level of change. The horizontal axis represents change at a product and process level, while the vertical axis indicates change in the systems and structures. This then identifies two core stages along each axis:-

- *adaptation* – gradual evolution or minor adjustments to product/processes or structure
- *innovation* – where there is radical change in product/processes or structures.

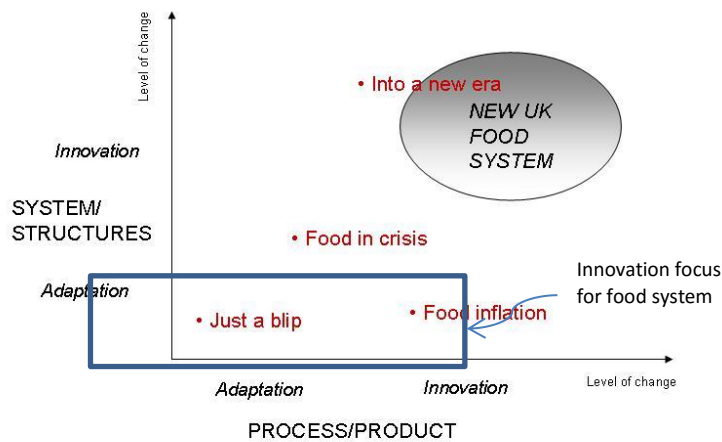


Figure 8.4: Dimensions of adaptive capacity

To illustrate the dynamics of this, mapped onto this framework are the four different scenarios. *Just a Blip* created an environment in which there was no need for rapid or significant innovation, while *Food Inflation* demanded innovation in processes and products. *Food in Crisis* required a rapid response and triggered some temporary changes in the network structure. *Into a New Era*, however, represented an operating environment which required significant innovation, and therefore change, in both structures and processes. From an ecological resilience perspective, *Into A New Era*, represents a potentially less vulnerable and more resilient way of organising the food system. This is due to the focus on smaller scale organisations, more diversity with more producers and processors, less concentration and less interconnectivity between nodes.

The blue rectangle on the graph represents the core area of focus for innovation in the UK food system (as identified in the data). This has significant implications for adaptive capacity, and therefore resilience and there are questions as to the dangers of this widespread focus on one dimensional, process-orientated innovation. This framework suggests that adaptive capacity needs to feature both types of innovation to support a more resilient system.

Recent research into antecedents to resilience does not cover the potential importance of innovation. While the concepts of adaptive capacity are still implied through the definitions of resilience, there is little comprehension of how innovation plays into this concept. Here, then the contribution of the thesis remains pertinent in postulating that innovation is a key component of resilience and that both structural and process innovation are need to support adaptive capacity. This conceptual framework therefore provides a way of conceptualising adaptive capacity at a network level and demonstrates linkages between innovation and adaptive capacity. This is a significant contribution to SCRES and starts to build theory as to the nature of innovation and its important interaction with resilience and adaptive capacity at a network level.

8.7 System transition and network vulnerability

An important insight from the thesis analysis is the inter-changeable nature between risk and change at a network level. The data revealed that for some actors, global risks had the potential to trigger change. For example, if there was a continuation of a more volatile global market, and therefore volatile pricing, some actors saw this as heralding a new set of trading conditions, which would require organisations to employ different strategies. Shifts in consumer preferences, global market conditions or supply availability were also seen as potential triggers for change. Here, change was often conceptualised as gradual rather than as sudden and large-scale. This is akin to the definition of turbulence (Trkman and McCormack, 2009) where there is an element of continuous risk and volatility, either in terms of marketplace, technology or in the wider environment. The data revealed an inherent fuzziness as to how and when risk morphs into change and whether the changes needed were gradual or transformational. There is also the risk that the impact of ongoing turbulence will trigger sudden, shock based changes to the network and therefore the need for regime transformation.

The theory of system transition, as developed by Geels (2002), was found to be a useful way of trying to articulate these issues and generate a more systemic

understanding of the linkages between change and vulnerability. This theory offers a different way of organising the vulnerability factors, as identified in Chapter Seven, and their interlinkages (see table 8.4). Here, Geels' landscape pressures are akin to global factors (higher food demand and potential for global supply constraints) along with UK macro-economic, political (regulatory) factors, societal and consumer expectations (in effect the range of exogenous factors identified in Chapter Seven). The socio-technical regime, i.e. the food network, is shaped by the supply chain structure, beliefs and mind-sets including faith in markets and technological solutions and the set of actions and behaviours exhibited by actors.

System transition elements	Vulnerability factors
Landscape pressures	Global demand/supply factors Economic structure of the UK Consumer expectations Societal value of food Political intervention and will Regulatory and policy framework
Socio-technical regime	Power (esp. retail power) Supply chain structure Level of supply chain integration Cost/pricing structures Interdependencies Perception of risk and vulnerability Faith in markets Faith in technological solutions Trust and confidence Belief in environmental sustainability of system Strategy norms
Technological niches	Product/process based innovations (including GM and bio-technologies)

Table 8.4: Comparison of system transition elements to vulnerability factors

Only those technological niches seen as primarily supporting process or product based innovation were articulated by mainstream supply actors. GM was one of the most cited technological niches, along with bio-technology and nanotechnology (to support product innovation). However, these types of technological advances were not perceived as threatening, or having the ability to create turbulence or indeed having the capacity to trigger fundamental regime transformation. Instead, these niches were seen as vital as responses to concerns over environmental sustainability, supporting the need to produce a greater volume of food more efficiently with fewer inputs i.e. sustainable intensification.

This again supports the premise that process and product innovation is more prevalent in the food network. It is also an indication of actors' confidence in the current arrangement of rules and structures, and how innovation at a process/product level, is seen as the most likely mechanism to help ease landscape pressures – without the need for socio-technical regime change. This narrow support for process led innovation only, could pose a threat by stifling any innovation to find new ways to organise food supply chains. Tying this in with ecological definitions of resilience, there is a need for any system to be sustainable through the encouragement of widespread innovation and experimentation. It is often through the support of technological niches, as described by Geels (2002), where the potential for new structures and behaviours can be tested and piloted. More proactive support for experimentation in new structures at a niche level, could test any potential solutions to help with a wider transition of the mainstream regimes. If the system becomes inherently unsustainable, and future pressures trigger change – either through catastrophic changes or as a gradual decline – having a broader base of innovation can support a more managed, less damaging transition to new structures and operating models.

While actors articulated a range of global landscape pressures, there is dissonance as to how they believe these will affect the UK food system. It is either that they do not believe that the pressures will build so much as to trigger a system change, or that they cannot perceive a different system to the one already in place. This is partly driven by a lack of an agreed vision of a sustainable food system. There is also a sense, therefore, of mainstream food actors' belief in the adaptive capacity of the current system to cope with risks associated with this turbulence. This is also perhaps linked to a natural inbuilt expectation which often expects the future to look similar to the past. Berkhout et al. (2004) describe this as 'teleological' transformation, informed by previous experience of change within the system.

Whether supply actors accept the need for change, and how this change is conceived, is a key determiner of whether there is any transition enacted (Smith et al., 2005). If there is not a commonly agreed and articulated need for change, there will be not a co-ordinated response within the regime to adapt to landscape

pressures (Smith et al., 2005a). Where there is some consensus (i.e. that global dynamics could result in price volatility and pressures on input costs) there is more impetus for actors to take action; this can be seen in the type of strategies currently employed (e.g. cost reduction, product innovation). Where there is dissonance – the debate over climate change or the extent to which change is need to create a more sustainable system and the shape of this system – there is an overall lack of co-ordinated action for change within the regime.

Power here is a key factor. Where there are coalitions of actors who are technically, financially and politically powerful, they are able to influence the development of the regime, which in some circumstances could present a level of inertia against changing in the face of extreme pressures (Smith et al, 2005). The retailers, along with brand manufacturers, wield power sufficient to dictate the operational requirements for their immediate supply chains. However, from their perspective resilience, and consequently vulnerability, is more about how they can protect their ability to trade, create profits and grow, rather than achieving the wider outcomes of the food network. Perceptions of risk at a network level, particularly those which may trigger regime change are either not seen or are not seen as important to act upon.

Adaptive capacity, in relation to system transition, is conceptualised as the available resources at actors' disposal in order to be able to maintain a status quo or enact a change (Smith et al., 2005). It could be argued that from this context, the UK food system has a low level of adaptive capacity; in that it has an inbuilt resistance to regime change, both structural and behavioural. From a wider system perspective, this in-built stasis creates a level of vulnerability, both in the ability of the system to adapt to external pressures but also in delivering the desired social, economic and environmental outcomes from the food system. This demonstrates that the concepts of socio-technical regime transition help to build a better understanding of vulnerability at a supply network level.

There is no research to date that examines the cross-over points between supply chain vulnerability and the concepts of system transition. The research here

highlights gaps in the current frameworks of conceptualising vulnerability as change, particularly system/regime change and the ability of the industry network to meet wider societal – economic, social and environmental – outcomes. This transcends the mainstream SCRM, SCV and SCRES literature and lives in the realm of system governance and policy interventions.

8.8 Conclusions

This chapter has explored how the key findings and conceptual frameworks developed as part of this thesis relate to the literature in the fields of SCRM, SCV and SCRES. It has identified a number of contributions to these fields, these are summarised in table 8.5 below.

ACADEMIC FIELD	FINDING AND CONTRIBUTIONS
Risk	Risk is difficult to quantify and the outcomes are often unpredictable
	Actors tend to focus on operational risk rather than disruption based risk. However, both types of risk are present in supply chains and conceptual frameworks need to comprehend this.
	Risk is subjective, conceptualised by actors only when plausible and how it impacts negatively on their own organisation
	Risk is conceived in economic terms as impacts on profit and revenue growth
	Risk is conceived by actors in terms of loss. However, the true nature of risk is variance to outcomes (both negative and positive).
	There are complex interconnections between the categories of risks.
	Risks can be transmitted through supply networks, one category of risk can morph or escalate into another. Strategies to mitigate one type of risk may inadvertently increase the presence of another type of risk
Vulnerability	A framework of seven exogenous factors and eleven endogenous factors impacts on the vulnerability of the UK food network
	These vulnerability factors can be characterised as risk sources, risk dampeners, risk amplifiers, enablers or constraints.
	There is a complex interaction between vulnerability and these factors.
	These factors have plurality – in that some factors can be either a source of risk, amplifiers or dampeners of vulnerability or an enabler or constraint on resilience, depending on how they are shaped
	Vulnerability is a function of risk, the relative level of exposure to risk and the capability to respond.
The concepts of risk, vulnerability and resilience are inter-related and cannot be	

	<p>separated if a holistic understanding is to be reached</p> <p>Vulnerability is also dependent on risk perception, agency and the willingness to act, the capability to act, the types of mitigation strategies undertaken and ultimately whether desired outcomes of the supply chain are met or not.</p> <p>Vulnerability is a relative concept, dependent on supply chain position, on the perspective taken (either at a supply chain or network level) and on expected outcomes</p>
Resilience	<p>The importance of innovation as a key driver of resilience. This is a gap in the SCRES field.</p> <p>A conceptual framework of adaptive capacity at a network level, which is both a function of process and structure innovation. Both are needed to support a resilient network.</p> <p>There is very little understanding of vulnerability at a network level in the fields of SCV and SCRES.</p> <p>The field of ecological resilience helps to characterise vulnerability at this level in terms of level of connectivity, the accumulation of capital and the level of novelty and innovation.</p> <p>Vulnerability, and hence resilience, can be interpreted at a network level as the capacity for system change, while maintaining an acceptable level of outcomes.</p> <p>System transition theory provides a way of framing the concepts at this level.</p>

Table 8.5 Summary of key findings and contributions

Chapter Nine: Framing of the debate and implications for stakeholders

9.1 Introduction

This chapter examines the implications of the research for the stakeholders in the food system. It is guided by the research questions:-

RQ4: What are the implications for stakeholders and policy makers in their aims to reduce vulnerability and encourage a more robust UK food system?

RQ5: What are the implications for future research into concepts of vulnerability, resilience and adaptive capacity?

As the thesis was conducted over a lengthy period of time, this section also serves to provide an update to the landscape for the food network context. For the food system context, as the data was collected in the 2007/2008 period the update here provides key changes since this time (up to April 2015) and post the 2008/2009 food crisis.

The chapter starts therefore with the update of the food landscape post the 2008 food crisis, examining briefly the global context but then moves to cover key changes in the UK system since then. Following this update, the chapter discusses the implications for first policy makers, then supply actors.

9.2 Global food security post 2009

Since 2009, the issues associated with global food security have partly abated; this has been due to a fall in overall food prices (although not below their pre-2008 levels). As it stands in 2015, food production per capita continues to rise (at about a rate of 1% per year according to FAOSTAT, 2015). However, this is not

necessarily an indication that this trend will continue into the medium or longer term. Post the food crisis, there still remains some underlying optimism that the current system will be capable of meeting demand in the short term. The 2014 OECD-FAO outlook (OECD-FAO, 2010) expects a switch from wheat and rice towards more growth of animal feedstuff and grains for biofuels; this reflects an expected rise in demand for dairy, meat and biofuels in the next decade. Consequently, wheat prices are expected to fall a little, while for dairy prices are expected to stay higher than historical levels (i.e. pre-2008). The emergence of India as the largest milk producer in the world (overtaking the EU in 2013) means that supply will potentially be sufficient to stop higher price hikes. However, despite these more optimistic trends, the World Bank point out that 33 countries are now classed as being 'food insecure' and food crises for these economies are highly likely (World Bank, 2015).

In the longer term, global population growth is still the core concern even though, due to the economic downturn, rates have started to slow. While this eases some of the pressure on future supply, the World Resources Institute still estimate that production will need to increase by 69% by 2050 (World Resources Institute, 2013). The ability of agriculture to respond to this challenge still rests on a number of uncertainties. Debates still rage as to how much land is available globally for agricultural expansion, with water increasingly being considered the main constraining factor with growing concerns over water security (Wouters, 2010). Based on an expectation that (by 2030 at least), 20% of the required food production increase will come through land expansion with 80% through yields and cropping intensity, there is wider acceptance that there could be sufficient land to support agricultural production expansion (DEFRA, 2010c).

Food production per capita growth is very dependent on a corresponding growth in yield and efficiencies (World Bank, 2009). Crop yields have steadily grown since the 1970s but over the last 10 years have started to tail-off (FAOSTAT, 2015). While this in itself is not a signal that current technology and practice is exhausted, there is recognition that proactive action is needed to invest in agricultural research, rural infrastructure and agricultural extension services, particularly in developing

countries to deliver this growth (World Bank, 2009). Much of the debate is now focusing on how to deliver these yield improvements across global agriculture.

There is now greater understanding of the dependency of the food system on oil – reasons for the food price spikes in 2008 have been partly attributed to the high oil prices of that time (FAO, 2009). The emergence of the bio-fuels market has created further inter-linkages between food and oil prices. Back in 2009, there was a growing swell of opinion that peak oil was becoming a real risk – the US Army warned that a shortfall in output could be conceivably reached by 2015 (JFCOM, 2010). However, since then, the slow-down in global economy and the surge in extraction of shale gas in the US have seen an increase in supply, prompting a 40% drop in price (The Economist, 2014), in effect lessening concern over supply constraints.

Recent developments and thinking therefore, reflects a more optimistic outlook (as of early 2015) as to the short term availability of food; albeit with more volatility in markets. However, there remains real concern over the longer term capability of agriculture to respond to greater food demand at affordable prices, particularly for those areas globally that are already food insecure or in vulnerable positions.

9.3 UK context changes post 2009

9.3.1 Government response

On the back of the increased concern over food security and sustainability, DEFRA, under the Labour government at that time, published a comprehensive strategy for food in January 2010, known as Food 2030 (DEFRA, 2010a). The document was unique in the fact that it was the first to set out a vision and strategy for the whole UK food system since the 1970s. The UK government formulated a vision of a system which focused on increasing production but in a more sustainable manner. The strategy strongly articulated the convergence between sustainability issues and food security, voicing concerns over the ecological foot print of

agriculture, the need for more sustainable approaches but also the need for a cross-government response, recognising the multi-functionality of food.

However, this policy did not survive the transition to the Coalition government in 2010. Current policy aims are much narrower in focus. They state the need to create an efficient agricultural sector in the UK, reducing pressure on land use in agriculture while continuing to adapt to and mitigate against climate change (DEFRA, 2015).

As a direct result of the global food crisis, a major Foresight project was launched in 2009 to examine future global food security risks. The findings of the Foresight report – *The Future of Food and Farming* (Foresight, 2011) – become one of the major influences on government policy and thinking. The report highlighted five challenges for the global food system:-

1. Balancing supply and demand sustainably
2. Addressing threat of future volatility in food supply
3. Ending hunger
4. Meeting the challenges of a low emissions world
5. Maintaining biodiversity and ecosystem services while feeding the world

This was a significant recognition of the real challenge facing food systems – the need to both produce more food but to do this in a more sustainable way. It also put agricultural production and its methods as the critical focus of attention and coalesced opinions among academic, scientific circles and even within the industry, that the current pre-dominant intensive system of agriculture is ultimately unsustainable (The Royal Society, 2009, Cabinet Office, 2008). However, rather than creating more space for arguments for different approaches (e.g. organic), this report and the growing recognition of the need to globally produce more food has in fact added weight to proponents of intensive farming but with a new emphasis on the adaptation of the system to become more sustainable (DEFRA, 2010a, The Royal Society, 2009) i.e. sustainable intensification. Science is seen as a primary deliverer of this solution and this is reflected by the direction of public based research in the UK.

This has primarily manifested itself through the Technology Strategy Board's new Sustainable Agriculture and Food programme which has £75 million to invest over the next 5 years. While this shows a greater commitment to agricultural investment, the programme is heavily weighted towards science-based solutions for carbon reduction and waste (TSB, 2010).

Influenced by the Foresight report, food security issues have now been framed as being 'global' rather than specifically affecting the UK; it is felt that the UK is in a position to support and help the global need to produce more food rather than food security being a specific issue for the UK food supply system. However the issue of food security in the UK is still of concern to some politicians and EFRA initiated a new inquiry in 2014. Their report (EFRA, 2015b) highlighted, again, the multi-dimensional nature of food supply and security. They again highlighted the lack of co-ordination across government on this issue. They also expressed concern over the resilience of supply chains, particularly for longer, complex supply chains and the lack of traceability and transparency. They also highlighted how UK is dependent on the import of animal feed and called for a strategic plan to source alternative supplies.

Food prices in the UK have increased in real terms by 18% since 2007, although this has reduced in the last year to around 8.6 % (to June 2014, DEFRA, 2014b). Correspondingly, household spending on food rose to 11.6%, while it is nearer to 17% for lower income families. This pressure is manifested through the increased use of charitable food donations and food banks to support households struggling to access adequate nutrition (EFRA, 2014). The Trussell Trust (2014) reported a rise of 54% increase in their provision of food aid from 2012/2013 to 2014. While a recent government review indicated that there is not enough research to directly link rising food prices with the increase in food aid (FEC/Warwick University, 2014) - there are other factors such as access to benefit payments, housing and energy costs - there remains significant concern over the affordability of healthy food and the slide of more households into food poverty (Trigg, 2014).

9.3.2 Regulatory landscape changes

2013 saw the announcement of the CAP agreement which changed the Single Payment Scheme previously in force. The main difference for England is the introduction of greening rules, in that 30% of direct payments are allocated on mandatory activities to preserve the environment. In practice, this means farmers have to maintain a percentage of land either as grassland or enforced crop diversification (DEFRA, 2014a) . Arable set-aside has been abolished, dairy quotas are due to be abolished in 2015 but some level of price intervention mechanism will remain for wheat, butter and skimmed milk powder.

Further EU regulations have included an agreement to introduce stricter food labelling criteria from 2016, including comprehensive listings of allergens and mandatory listing of origins of meat and poultry ingredients (EC, 2014). More controversial, however, was the agreement to ban a range of pesticides (neonicotinoids) with plans to ban further ranges by 2020 (Heap, 2014a).

Further government responses have been in the form of either regulatory and legislation action (on sustainability issues) or voluntary targets (e.g. on health). Particular focus has been on frameworks to support EU/UK commitments to carbon reduction targets. 2008 saw the UK's legally binding commitment to at least an 80% reduction in carbon by 2050 (CCC, 2008). This has been followed in 2010 by the introduction of the CRC Energy Efficiency Scheme in April 2010, a pilot in effect, for a full UK carbon emissions trading scheme.

The FSA has been the main driver of policy on health and consumer choice. The FSA published more stringent voluntary targets in 2009 for the reduction of salt in products (FSA, 2009), and has announced recommendations for saturated fat reductions (FSA, 2010). A further voluntary scheme to unify front-of pack labelling, with guideline daily amounts and a 'traffic-light' scheme for fat, sugar and salt was agreed and retailers signed up to the code in 2013 (Triggle, 2012). However, there are questions as to whether the voluntary schemes are enough to force manufacturers to sufficiently reduce salt, sugar and fat content, with calls for legislative action such as taxes on fat and sugar (Campbell, 2012).

9.3.3 Retailer response

The power of the UK retailers over the food system has been the subject of many debates but their influence cannot be overstated. The major 4 retailers had a market share of 77% in 2010 (DEFRA, 2014b) but have seen a slight decline to around 74% in 2014 (IGD, 2014). This decline has been due in part to the rise in low cost retailers. Aldi and Lidl have a combined market share of 8.5% (DEFRA, 2014b)(Defra b, 2014), with market growths of 21% and 14% respectively since 2014 (IGD, 2014). Tesco, once one of the UK's business stars, has seen a marked fall in profits – a 6% fall in 2014 (BBC, 2014b) and has had to curb expansion plans and close stores to meet further profit challenges (Goodley, 2015). The economic crisis and higher food prices created the space for Aldi and Lidl to entice shoppers with their lower prices, consistent value and quality messages. As with other discounters, their business model differs from mainstream retailers in that they carry a much limited product range (600-1500 SKUs as opposed to around 20,000 for a mainstream retailer) with a high percentage of private label products. This enables them to operate a streamlined supply chain system – less suppliers, bulk buying, cross docking through use of pallets straight from suppliers to store – plus a lower cost store model – less staff, less need for shelf replenishment activities etc. (CCRRRC Europe, 2005). However, the growth of Lidl and Aldi is potentially not good news for UK based manufacturers and producers as sourcing tends to be from the EU or global markets and hence UK sectors are missing out on market share gains (Stones, 2015).

Despite this, the four major retailers still dominate the retail market. While 50% of the total food sales are through the food service sector, retailers exert a skewed influence over the farming and processing bases, with around 75% of all products processed in the UK destined for the retail supply chain (DEFRA, 2009b).

The Competition Commission introduced a new code of practice for retailers in 2009; the Groceries Supply Code of Practice (Competition Commission, 2009). This code established a stronger framework for fair practice dealings within the supply chain, with suppliers able to raise complaints through a new independent adjudicator, appointed in 2013. Her current powers are limited to investigations into

any breaches of codes and fines. The role also only has the power to deal with direct suppliers to retailers and therefore does not extend back down the chain (DEFRA, 2013).

Concerns over price volatility and the availability of supply have driven retailers to forge more direct relationships with producers. The last few years has seen the establishment of more direct retailer-producer groups (Morrisons, 2010, Marks and Spencer, 2010). Retailers have started to work proactively with farmers to promote more sustainable practices such as a reduction in pesticides, controls of emission in dairy/meat farming, improvement in animal welfare standards and increased traceability from farm to fork.

However, the loss of market share to discounters, along with higher overall food prices and the squeeze on household budgets have seen the 'big four' enter into a fierce price war throughout 2014 (Felsted and Aglionby, 2014). Retailers continue to exert cost pressures down the supply chain - only around 36% of retail price goes to UK farmers (DEFRA, 2009a). This is prompting concern in the manufacturing and farming sectors that these pressures will force many food manufacturers to quit. Two independent reports from accountancy and insolvency firms have highlighted a higher rate of insolvency among food processing firms and more entering financial distress (BBC, 2014a, Stones, 2015).

Accusations of bullying suppliers have been levelled at Tesco (Williams, 2015) and an investigation launched into potential breaches of the grocery code (Weaver, 2015). The price war, as it stands in 2015, looks set to continue as the discounters are expected to see the largest growth in the next five years, forecast to double their market size by 2019 (IGD, 2015). This demonstrates the power and influence the retailers have over the food system in the UK; how the retailers respond and behave effectively dictates the direction of travel of a large share of the UK food system.

In 2013, the horsemeat scandal struck, when 29 processed food products marketed as beef products were found to contain high levels of horsemeat (in some cases 100%) (Lawrence, 2013). This brought the complexity of long processed food chains to the public attention as the trail led back through France, Netherlands, and

Luxembourg and to abattoirs in Romania. It highlighted the lack of traceability and auditing along these long complex processing chains. It also raised questions as to how retailers governed these chains. The breach was labelled as ' food fraud' (HM Government, 2014) rather than a food safety issue and prompted the government to launch an investigation as to how to prevent food crime in UK food supply chains – the Elliot review in 2014. This review (HM Government, 2014) focused on the need to develop shorter supply chains and encourage local sourcing within longer term partnerships as key mechanisms to ensure food safety and reduce the probability of food crime. It identified that price pressures in the system encouraged companies to take short cuts and warns that this could continue unless practices are changed. It places responsibility for this at the door of the retailers, calling for a mind-set change in the industry to reward responsible procurement rather than focusing on the cheapest price available.

9.3.4 Dairy Sector Changes

Dairy farmers have seen a mixed picture since 2008/2009. Farm prices for fresh milk rose on the back of the food crisis but the market has seen huge volatility, reflecting variability in global demand for dairy products. 2015 have seen prices drop, also initiated by the retail price cutting war, played out in the reduction of the retail price of fresh milk (Bawden, 2015). This, combined with increased volatility, is accelerating the rate at which dairy farmers are exiting the industry – the number of farmers in England and Wales stood at 9,914 in February 2015 (AHDB, 2015). This has initiated again the arguments over farm gate prices and whether retailers and manufacturers are unfairly pressuring dairy producers (EFRA, 2015a).

While both farms and herds have been reducing, yields per cow have been steadily increasing – in 2008 the yield/cow was 6900 litres, by 2014 this had increased to 7700 litres (DEFRA, 2014a). The level of milk production has also increased accordingly. Milk production in the UK in 2008 was 12.8 million litres, by 2014, this was £13.6 million litres (DEFRA, 2014a). The outlook for milk demand globally is also positive. Global demand is expected to grow, therefore creating further export potential for processed milk products (EFRA, 2015a).

Continuing cost pressures and price volatility has continued the debate over intensive dairy farming. On the whole farms are being more intensive, with higher yields and larger herd sizes. 2013 saw the go-ahead for a 1000-cow 'mega farm' in Powys, Wales (BBC, 2013) prompting both environmental and welfare concerns.

Since 2008, the dairy processing sector has seen even more concentration activity. In 2009, there were 465 registered processing companies in 2012. In 2015 this reduced to 400, with only 8 firms responsible for 69% of the total milk processed in the UK (Milk Development Council, 2015). The milk co-operative, Dairy Farmer of Britain went into receivership in 2009 (The Telegraph, 2009) and Arla Foods merged with Milk Link in 2012 (Scotland, 2012), leaving only one major co-operative in the UK – First Milk.

9.3.5 Wheat sector changes

Since the food crisis, the global wheat price has also seen a consistent fall, which has fed through to UK wheat prices. This period has seen a drop in wheat production in the UK – from a high 17M tonnes in 2008/09 to just under 12M tonnes in 2013/2014 (DEFRA, 2014a). In 2012 and 2013, the UK switched from a net exporter to being a net importer. Poor weather conditions in 2013 and 2014 have contributed to this, although the lower prices and switching to other crops such as barley have also played a role (DEFRA, 2014a).

This, however, is not the major concern of the industry as wheat planting tends to fluctuate according to market factors. Wheat yields have levelled off (see figure 9.1) and the industry have expressed serious concerns over the EU moratorium on a range of pesticides (neonicotinoids), which could increase the level of blight and pest and reduce cereal yields (Heap, 2014b). The debate rages as to whether the science around the ban, that these chemicals are harmful to bees, is over played. The UK government itself voted against the latest moratorium on neonicotinoids (McDonald-Gibson, 2013). However, there are some who welcome it, advocating a switch to alternative methods of insect and weed control, such as companion planting and alternative chemicals (Goulson, 2013).

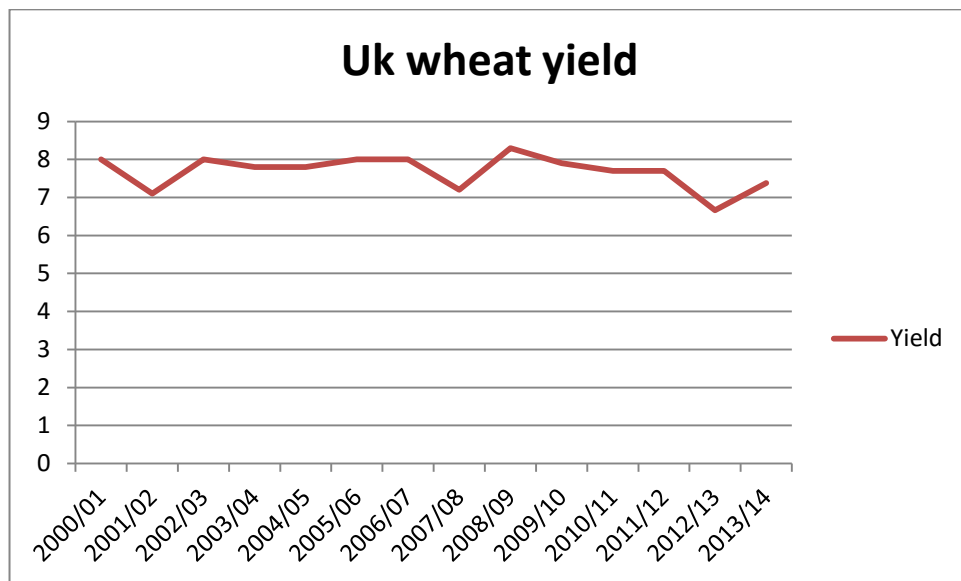


Figure 9.1 UK wheat yields 2000/01 to 2013/2104 (source: <http://data.hgca.com/archive/supply.asp>)

9.4 Implications for stakeholders

9.4.1 Implications for food supply actors

The research has clearly identified that the food system is facing a difficult future. In terms of specific threats, weather, especially climate change, remains the number one concern. The potential for extreme weather to impact UK production is high, with an expectation of extreme precipitation patterns, floods, winds and higher temperatures (Howard, 2015). As discussed in sections 9.3.4 and 9.3.5, food and commodity prices have fallen back from 2008 levels and the landscape is potentially becoming more turbulent economically. The recent years represent a vicious mix of *Just a Blip* – a fall in prices and a weakening of global demand – coupled with a version of *Food Inflation* where there is exerted and continuous cost pressure on the supply chain. The situation in 2015 represents the worst of both scenarios and reflects some of the worst fears of the interviewees.

The findings in the research show the interconnectivity between risk and factors which drive vulnerability or resilience. This suggests that typical single threat-based analysis, and associated mitigation strategies, may not be sufficient. The research findings have shown how the combination of both exogenous and endogenous factors could create vulnerability for the wheat and dairy networks, and therefore for the food system overall. The conceptual framework of vulnerability factors can be used as a guiding framework to support better decision making by firms within the industry. As vulnerability is both contingent and relative, the factors will need to be assessed and potentially broken down further into specific elements directly affecting each organisation and supply chain. Here, actors will need to understand how these elements are shaped and whether they are acting as risk sources, amplifiers or dampeners of vulnerability and which are enablers or constraints to action. This research has demonstrated the systemic qualities of risk and vulnerability and therefore any approaches to understanding vulnerability cannot look solely at direct linkages to the organisation. Risk and vulnerability can be sourced at any points within the network and therefore actors must consider the potential vulnerabilities across the supply network. This recognises that vulnerability may differ at different points in the network, but ultimately risks can be transmitted through the whole. Without this systemic thinking, mitigation strategies employed by one organisation – e.g. pressures on suppliers to reduce costs - may be sub-optimal and have a longer term negative impact on the supply chain, ultimately impacting on the source organisation's ability to serve the market.

However, the research raises a number of challenges for actors in undertaking better analysis of risk and vulnerability for their network. Firstly, the direct linkage between the perception of risk and the decision to act, along with the tendency for actors to underplay the likelihood and impact of effects, creates blind spots. This was borne out by the horsemeat scandal, where the risks associated with a lack of traceability were underplayed by both manufacturers and retailers. The scandal also demonstrated how the actual cost of impacts (when the risk is realised) can ultimately outweigh the costs in mitigating the risk in the first place. If actors do not see the need to act, then no action will be taken. Actors will also look to mitigate

operational risks first, as these can be linked directly to a cost impact on performance, while contingency planning or mitigation actions to counter disruption risks require a longer term view of benefit versus cost. This, combined with the complexity of understanding vulnerabilities for different parts of the network, makes it an even more difficult task to decide when to take action. However, to help with this, actors would need create a process to include perspectives from across the network, including actors from different echelons as part of the team, as advocated by Christopher and Peck (2004).

Increasing the visibility of vulnerability is only half the story. As the conceptual frameworks of vulnerability show, actors need to have the capability to act and more importantly, the control and power to act. The power rests with the retailers and the brand manufacturers; they have the greatest opportunity to co-ordinate their chains more effectively to mitigate risk and vulnerability. However, the competition forces at a retail level have reached critical level, as shown in section 9.3.3. This is driving producers, processors and retailers alike to search for cost-reduction mechanisms, reinforcing a locked in level of behaviour. This makes decisions to effectively add cost, through the addition of redundancy and/or flexibility to improve resilience, virtually impossible. In addition, the ability of one organisation alone to co-ordinate chains is limited and at a network level, inconceivable. The thesis findings suggest therefore that different mechanisms of formal and informal governance structures need to be developed to support a better, and fairer, way of acting to build more resilience into the supply networks.

The importance of relationships and fairness is a key factor here. Continued pressure on costs and unfair profit taking acts to create vulnerability and stifle actions to create resilience in the network. In addition, the perceived lack of fairness across the food supply chain is also recognised as a potential issue for longer term sustainability and profitability of smaller business and farms. Trust and confidence play a key role in the behaviours and actions of actors within the system. Lack of trust can result in the hiding of information and a lack of transparency across chains, and hence vulnerability. As discussed in section 9.3.4, there are still tensions in the dairy sector and the accusations of bullying levelled at retailers point to high levels of

distrust in supply relations. This continues to be a significant vulnerability for the sector which the appointment of the GCA, seemingly, will do little for.

Over the longer term, the global tightening of supply to meet rising demand, along with social and political uncertainties, has the potential to create greater turbulence for UK retailers and the food system; principally in terms of price volatility, higher costs and increased competition for food. If the response is to drive more intensification and concentration of the current system, as this thesis suggests, then this will create an even more fragile and brittle system. The issues of sustainability become a concern here too, and a potential source of increased risk and vulnerability. As section 9.3.3 summarises, retailers have looked to implement some sustainable practices throughout the network. However, this is limited to certain types of products and only in response to the pace of change as dictated by consumers. Whether or not this is fast enough or the rate of change significant enough is the question. The stasis effect of these locked-in behaviours and the narrow application of innovation create even more questions as to whether the system can cope in light of continued landscape pressures for change. Unless actors can put aside short term cost and profit concerns and start to articulate a common understanding of the issues then the possibility of a managed transition to a more sustainable network seems remote.

The research indicates however that, using the understanding of system transition theory, there are opportunities to manage such a transition. The research highlights how innovation, both structural and process could play an important part in developing greater resilience for the food network. Here, though, there needs to be greater appreciation of the need to foster and support experimentation in different structures and alternative practices. Rather than seeing new approaches to the organisation of the network as a threat, there is a real opportunity for actors to create competitive advantage by testing and experimenting with new structures, thus paving the way to become a market leader. This harnesses then both the spirit of resilience as advocated by Ponomarov and Holcomb (2009) in that the system, post disruption, returns to a higher level of performance and also the concepts of ecological resilience in that a functioning system can take many forms.

9.4.2 Implications for policy makers

At a policy level, this research raises some profound issues. Firstly, there are significant issues at a global level, and the food security debate here in the UK has clearly articulated these global challenges. The discussion has created space in policy thinking to see the UK agricultural base in a different light; both in its importance for food provision in the UK but also in the opportunity for growth to export more food. Government policy now reflects this. As discussed in section 9.3.1, the global agenda has overtaken the UK agenda in part and food security implications for the UK are not a prominent concern for policy makers. Instead, government policy is focused on technological innovation to support increased production of food (to support global supply concerns) and to reduce the level of input and emissions (to address sustainability concerns).

However, this research shows that there are real threats to the wider outcomes of the UK food system. While availability of food may have some in built resilience through diversity of supply, there are significant pressures on affordability of food which present real concerns for poorer households. The rise of food banks is an indicator of this. However, there is no coherent view as to what can be done in order to address this specific concern, especially with government reluctance for market intervention. Section 9.3.1 shows that there continues to a significant policy gap on this issue.

The research highlights the disconnect between the competitive motives of the retailers and the wider desired social, environmental and economic outcomes of the food system. For government, vulnerability can be defined as loss against these system outcomes, while for actors it is predominately about loss of profit or market share. The voluntary targets on fat, sugar and salt, discussed in Section 9.3.1, indicate that preferred interventions by government are by persuasion rather than regulatory means. However, ultimately, supply actors focus on resilience is predominately economic and for them, there is limited value in pursuing outcomes on health and the environment that either incur costs or do not chime with consumers.

Findings from the scenario workshops also revealed a significant disconnect between the articulation of the need for environmental change at a policy level and actual beliefs among supply chain actors. This is more acute at a farming level where there is little recognition that intensive farming methods could be unsustainable. Many in the industry (particularly the wheat sector) see a conflict between environmental aims and the need to grow more food (and the underlying driver for efficiencies and higher yield to increase profitability). The recent opposition to the banning of the range of pesticides is one area where this conflict is most prominent. The research has shown that any urgency of the need for change is not recognised and therefore any perceived risks and outcomes associated with potentially unsustainable practices and structures are not seen as either damaging or prescient. Policies to date have not taken into account that behaviours in the system will not necessarily balance economic priorities with that of health and environmental ones. This shows the importance of the regulatory system in shaping and limiting potentially damaging practices. However, with concerns over the cost burden associated with regulations, policies need to include more proactive levers which recognise the impact of behaviours and beliefs embedded in the system and look for ways to shift them.

While there is some convergence of these issues, there still lacks a level of cohesiveness in government policy towards these wider outcomes. The shelving of the Food 2030 policy (DEFRA, 2010a) highlighted in section 9.3.1 shows how policy has gone backwards in this area. There needs to be a more sophisticated debate over the wider outcomes of the food system – the need to integrate health, environmental, affordability, safety and environmental sustainability. This should be combined with more research to understand the factors which drive the behaviours likely to be exhibited by actors, especially those in positions of power, within the supply system. The transition model, combined with the findings from this research, could be used to give a wider understanding of the potential barriers and stasis within the system that prevent actors from taking actions to balance outcomes and create a more sustainable system. While there are increasing arguments which point to the need for significant change within the industry, there is no real understanding

from a policy makers' perspective of the barriers to this change. There seems to be an over-optimistic view that the retailer and brand manufacturers will be able to cope with steering the food system in the 'right' direction and coping with any disruption risks along the way. In particular, the large level of inherent investment and the inbuilt inertia in the current system will mean that, unless these are countered, policy interventions will struggle to make a difference.

The research shows how risk, vulnerability and resilience are interconnected, and the dangers involved in looking at any one area of the network in isolation. While different elements of the supply network have different vulnerability profiles, all need to be considered from a policy perspective. As it is, government deals with sections of the food chain separately and there is a divide between policies associated with agriculture and food production and those concerned with the distribution and sale of food. The main policy focus is that of agriculture. While there has been some research into the resilience of food chains (Peck, 2006, Grant, 2012) along with the recent EFRA report (EFRA, 2015), government does still not have any coherent policy on food chains. While there is emergent understanding that supply chains can be sources of vulnerability (from the report into the horsemeat scandal, DEFRA, 2014), there is a general lack of understanding or consideration of supply chains from a policymaker perspective. As the summary in section 9.3.1 of government policy demonstrates, there seems to be a level of complacency as to supply chain vulnerability and overly high levels of confidence in the ability of retailers to control and shape the supply chain. A lack of an overarching policy, which links food supply chains to production, remains a significant gap.

The research findings show a convergence at a network level between vulnerability and system transition. That there could be a more productive system, structured in a different way with more effective use of resources and less waste, with better overall outcomes is not a debate that is articulated. There is instead an over-reliance on strategies to make existing processes more efficient. This has the potential effect of creating more vulnerability as more capital is squeezed into fewer and fewer organisations and supply chains. The research suggests that there needs to be more diversity in terms of supply models. However, the lack of structural

innovation and the significant barriers to nurturing this innovation are potential weaknesses. The technological strategy implemented by the government is set up to support process and product innovation rather than research into other more innovative practices or food supply structures. There may in fact be many better ways of managing the food system (*Into a New Era* just being one example). However, these models are often rejected, not properly tested or funded as they are outside of the current mainstream thinking. This is a direct area where government can look to support a more managed transition, by both funding and supporting more structural innovation projects and helping to bring together actors to generate clear articulation of the issues and possible solutions.

In this context, the concepts of risk and vulnerability need to be widened to encompass all of the outcomes that the food system is expected to deliver. The findings also suggest that ultimately, system change may lay in the hands of policy makers to shape and drive. The system is too complex for one set of actors to manage and govern and this is another area where government can step in to support. Any interventions will need to be made in partnership with stakeholders, including food supply actors and consumers, with policymakers as a strong, proactive part of any consortium. This is a fundamental change to the current principles embedded in the UK government and poses a significant challenge. It is also very unclear as to which interventions and mechanisms, over the longer term would enact the desired change – more research is needed here. However, this research points to an urgent need to start to examine vulnerability for the longer term from a wider social, environmental and economic perspective.

9.6 Conclusions

This chapter has presented an update of the landscape for supply actors and policymakers. It has discussed the implications of the research for both sets of stakeholder, the key points of which are summarised in table 9.2. This research has underlined the truth of the observation of Peck (2005) that supply network vulnerability transcends traditional supply chain management and extends into wider

policy dimensions. There still remains very little research into the convergence of supply network vulnerability and policy implications. The findings in this thesis, though originally generated from data collected back in 2008, still provide valid insights in the constructs of vulnerability and risk for the food supply network today.

Policy makers	Supply actors
There are significant risks to the wider outcomes of the food system	The need to assess vulnerability factors at an organisation, chain and network level
There exists a disconnect between the competitive motives of supply actors and the need to deliver wider outcomes	The contingency of vulnerability and whether factors are shaped as sources of risk, amplifiers or dampeners of risk and enables or constraints of action
There is a disconnect between the need for environmental sustainability and the beliefs and actions of supply actors	Actions to overcome blind-spots are needed, including multi-perspective approaches and counters to the tendency to underplay the impacts of risk
Policies need to take into account how risks and vulnerability are perceived by actors	The need for increased co-ordination across chains to mitigate against vulnerability
There needs to be a more cohesive policy on how wider outcomes are to be delivered, taking into account the in-built stasis in the system	The need for fairness and better balance of power across the network to support resilience
Food policies need to take a network perspective, joining agriculture with food supply chains	The inbuilt stasis in the system and how this could create vulnerability in the longer term
Government need to take a stronger, more proactive role in creating a commonly agreed understanding of the issues facing the food system and support the governance of the system to achieve policy objectives	The opportunities to develop more structural innovation, to both increase resilience but also to harness competitive advantages
Government should look to pro-actively support structural innovation and technological niches in order to foster experimentation and wider-based innovation to support greater resilience at a network level	

Table 9.2: Summary of implications for stakeholders

Chapter Ten: Conclusions

10.1 Research objectives and summary of approach

This research thesis was borne out of increasing concern over the vulnerability of the UK food supply system exposed to a more turbulent operating environment and increased disruptions and shocks. This thesis looked to address this by re-examining the data from a SCRM, SCV and SCRES perspective. From an academic perspective, SCRM research has been very narrowly focused while the constructs of SCV and SCRES are still emerging. While SCV is characterised as the interdependency and interactions between organisations, there has been little research into how actors' perception of risk impact on these interactions. There has been very little grounded, normative research in the field to understand why supply chains may be vulnerable to disruptions. To date, there has still been little research on risk, vulnerability and resilience at a food supply network level. The overarching objectives of this thesis have therefore been to :-

- undertake research which examines risk and vulnerability at a network level for the UK food system
- to re-examine and provide a deeper analysis of the data collected through the Chatham House research project from a supply chain risk and vulnerability perspective
- to understand actors' perceptions of risks and vulnerabilities within the UK food supply system

The research took a network perspective, using a case study framework to examine the wheat and dairy supply systems in the UK. Data collected as part of the CH project was re-examined using a grounded approach. Here, actors' perceptions of risk and vulnerability were coded using a grounded analysis approach. The research was guided by a set of five questions which framed the analysis and the structure and flow of the thesis. The next section re-emphasise these findings, in relation to these questions.

10.2 Research Questions and Summary of Findings

10.2.1 Research Question One

Q1: How do actors conceptualise risk and vulnerability within the UK food supply system?

The first research question was designed to guide the analysis of the data collected through the formulation of the CH scenarios and the subsequent workshops and interviews. Risk and vulnerability here emerged as separate concepts, with Chapter Six dealing with risk and Chapter Seven dealing with vulnerability. The key findings for risk here included a categorization of the types of risk, as articulated by actors, along with their interconnections (figure 10.1).

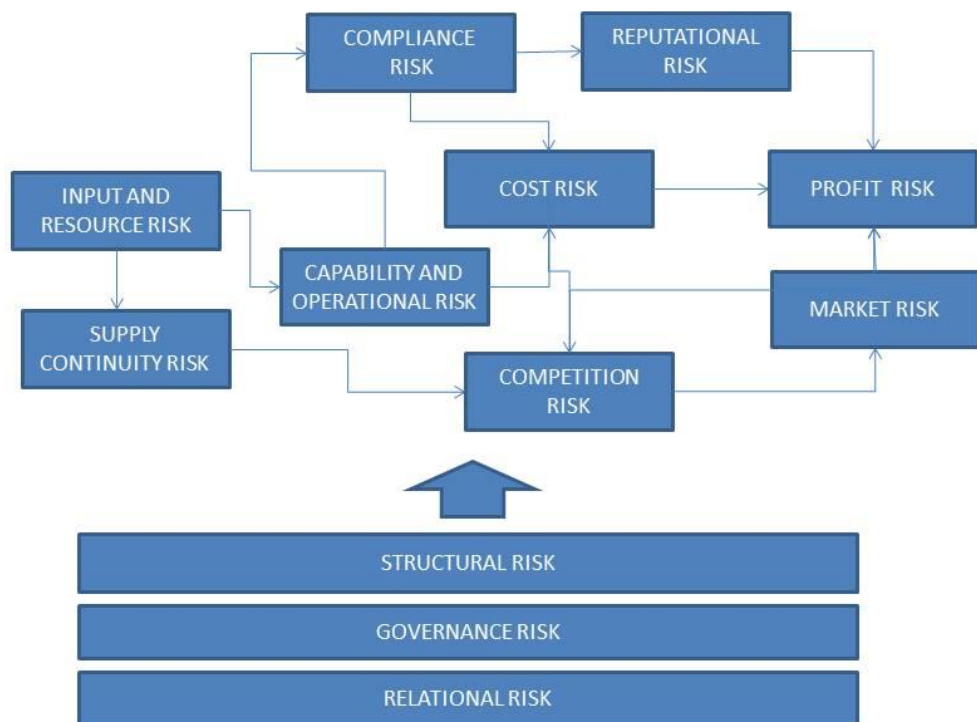


Figure 10.1: Interlinkages of risk

Findings also included:-

- Actors tend to conceptualise risk in terms of their context and how it negatively (generally) impacts their organisation
- Risk is often expressed in economic terms and how it effects either profitability or market growth
- How risks are perceived is highly contingent on the sector and position within the supply network
- There are complex interlinkages between the different aspects of risk; some arising from and impacting at an organisational level, some at a supply chain or network level

The construct of vulnerability was found to be less explicit in the data and emerged as multi-dimensional. The first part of this construct identified a number of factors that impacted the vulnerability of the supply networks. This set of exogenous and endogenous factors are shown again here in table 10.1. How these impacted on vulnerability however, needed a higher level of analytic thinking and interpretation, this was therefore explored as part of research question two.

Exogenous factors	Global factors	Global supply/demand factors
		Access to global market
		Degree of dependency on global market
	UK socio-technical factors	Economic structure of UK
		Consumer expectations
		Societal value of food
		Political intervention and will
Endogenous factors	Supply chain factors	Power
		Organisational scale
		Supply chain structure
		Level of Supply chain integration
	Sector specific factors	Cost/pricing structure
		Interdependencies
	Beliefs and mindsets	Perception of risk and vulnerability
		Faith in markets
		Faith in technological solutions
		Scale and efficiencies
		Trust and confidence
	Actions and behaviours	Belief in environmental sustainability of food system
		Strategy norms

Table 10.1: Exogenous and endogenous vulnerability factors

10.2.2 Research Question Two

RQ2: How do the endogenous characteristics of the UK food supply system, in terms of its structure and dynamics, contribute to the perceived level of vulnerability in light of global, exogenous uncertainties?

The second half of Chapter Seven therefore explored how the set of exogenous and endogenous factors interacted with vulnerability. It developed a conceptual framework to show how these factors link together – see figure 10.2.

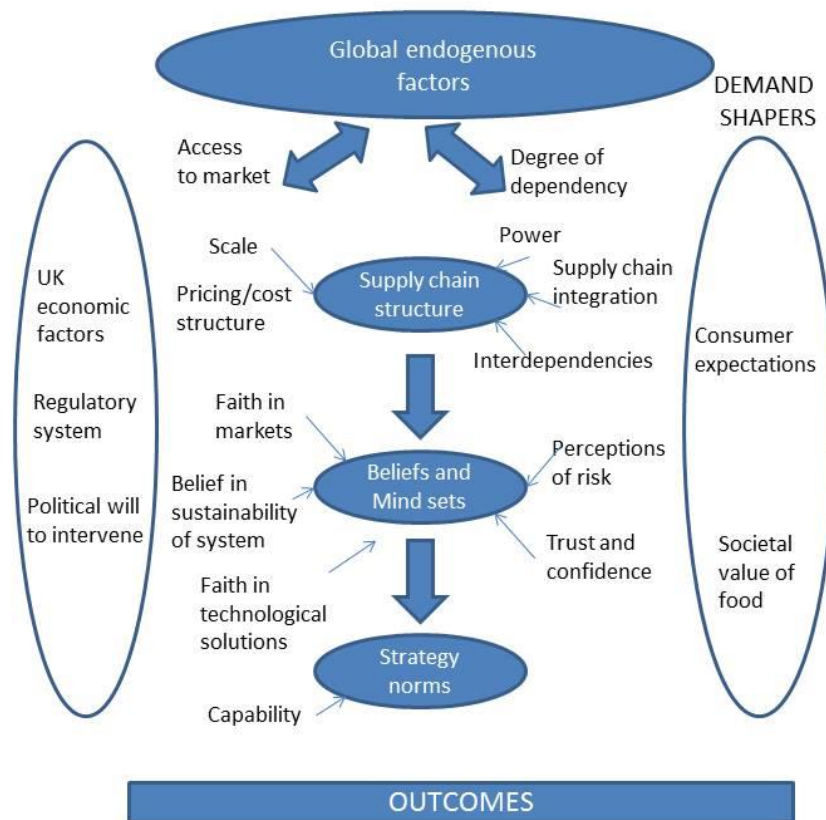


Figure 10.2 Conceptual framework of interlinking vulnerability

The findings revealed that the factors relate to vulnerability in a complex way and interact either as risk sources, amplifiers or dampeners of vulnerability or enabler or constraints to act to mitigate against vulnerability – in effect they have plurality. This led to the conceptualisation of vulnerability as interconnected with risk

and resilience, defined as ‘the level of exposure to risk and the capability to respond to reduce variance to desired outcomes’. Vulnerability here then is combination of

- risk and threats to the food system, some of which are not completely known
- the actual level of exposure to risks
- how the level of exposure is perceived by actors
- the capability and power to be able to act to mitigate the perceived threat

Here, a conceptual framework was developed to represent how these elements of vulnerability fit together (the dynamics of vulnerability). This is shown again in figure 10.3

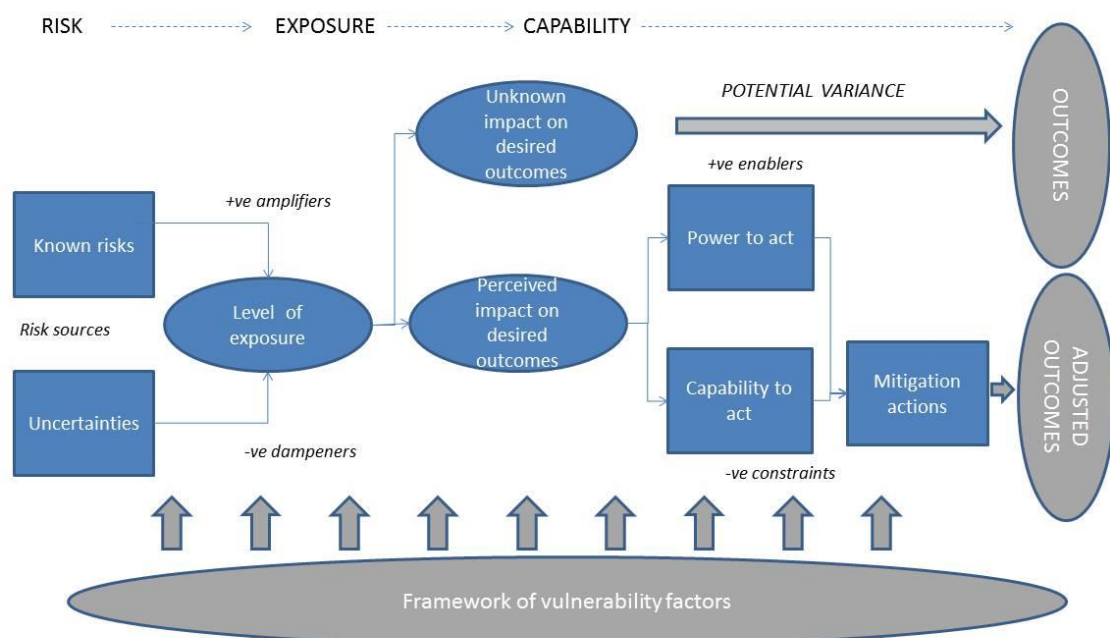


Figure 10.3: The dynamics of vulnerability

Vulnerability was found to be a relative construct. How it is conceived is dependent on the position of actors within the network and the perspective taken, whether for individual organisations, their supply chains or at a network-wide level. For food supply, at a network wide level, there are a set of wider social and environment outcomes that need to be considered when examining the relative vulnerability or resilience of the network. These are:-

- Availability of food

- Affordability of food
- Quality and safety of food
- Health outcomes
- Environmental outcomes
- Secondary outcomes including employment within the food system

10.3.1 Research Question Three

RQ3: How adequate are these conceptual frameworks of vulnerability, resilience and adaptive capacity in light of global phenomena?

This question was principally answered in Chapter Eight. As the approach taken was grounded, there had been no a priori framework applied to the data; the conceptual frameworks emerged from the data. This question was designed to locate these frameworks and thesis findings in the context of the SCRM, SCV and SCRES literature. This is an accepted way of supporting theory building within inductive based research. To do this, the conceptual frameworks and findings of the research were compared to key components of the SCRM, SCV and SCRES literature. Using transition theory to understand vulnerability at a network level also revealed the importance of innovation as a component of resilience. This led to the final key finding of the research, that both structural and process innovation is needed to balance resilience. This conceptual framework is shown again in figure 10.4.

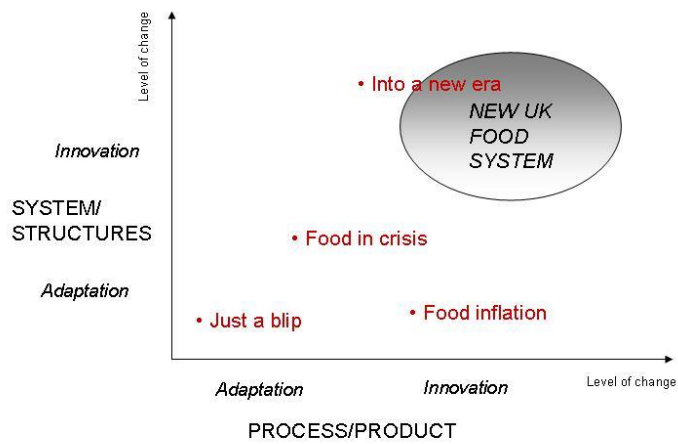


Figure 10.4 : Dimensions of adaptive capacity

Key contributions of the research findings emerged, related to risk, vulnerability and resilience. And these are summarised here in table 10.2.

ACADEMIC FIELD	FINDING AND CONTRIBUTIONS
Risk	Risk is difficult to quantify and the outcomes are often unpredictable
	Actors tend to focus on operational risk rather than disruption based risk. However, both types of risk are present in supply chains and conceptual frameworks need to comprehend this.
	Risk is subjective, conceptualised by actors only when plausible and how it impacts negatively on their own organisation
	Risk is conceived in economic terms – impacts on profit and revenue growth
	Risk is conceived by actors in terms of loss. However, the true nature of risk is variance to outcomes (both negative and positive).
	There are complex interconnections between the categories of risks.
	Risks can be transmitted through supply networks, one category of risk can morph or escalate into another.

	Strategies to mitigate one type of risk may inadvertently increase the presence of another type of risk
Vulnerability	A framework of seven exogenous factors and eleven endogenous factors impacts on the vulnerability of the UK food network
	These vulnerability factors can be characterised as risk sources, risk dampeners, risk amplifiers, enablers or constraints.
	There is a complex interaction between vulnerability and these factors. These factors have plurality – in that some factors can be either a source of risk, amplifiers or dampeners of vulnerability or an enabler or constraint on resilience, depending on how they are shaped
	Vulnerability is a function of risk, the relative level of exposure to risk and the capability to respond. The concepts of risk, vulnerability and resilience are inter-related and cannot be separated if a holistic understanding is to be reached
	Vulnerability is also dependent on risk perception, agency and the willingness to act, the capability to act, the types of mitigation strategies undertaken and ultimately whether desired outcomes of the supply chain are met or not.
	Vulnerability is a relative concept, dependent on supply chain position, on the perspective taken (either at a supply chain or network level) and on expected outcomes
Resilience	The importance of innovation as a key driver of resilience. This is a gap in the SCRES field. A conceptual framework of adaptive capacity at a network level, which is both a function of process and structure innovation. Both are needed to support a resilient network.
	There is very little understanding of vulnerability at a network level in the fields of SCV and SCRES. The field of ecological resilience helps to characterise vulnerability at this level in terms of level of connectivity, the accumulation of capital and the level of novelty and innovation.
	Vulnerability, and hence resilience can be interpreted at a network level as the capacity for system change, while maintaining an acceptable level of outcomes.
	System transition theory provides a way of framing the concepts at this level.

Table 10.2 Key findings and contribution of the thesis

10.2.4 Research Question Four

RQ4: What are the implications for stakeholders and policy makers in their aims to reduce vulnerability and encourage a more robust UK food system?

The long timescales associated with the PhD necessitated a re-examination of these contributions to understand their relevance in 2015. This was addressed in Chapter Nine, which gave an update of both landscape pressures for supply actors and policy makers. Here it was demonstrated that the research still holds relevance to both policy makers and supply actors. The food system is facing multiple challenges in the future, including more shock-based events and from a more turbulent operating environment. Supply actors tend to underplay risk, and to focus on actions to mitigate those which they perceive as impacting their economic outcomes. This, along with continual cost pressures driving strategies to focus on efficiencies, intensification and further concentration, is also driving further vulnerability. From a supply actors' perspective, more analysis is needed to understand this at a network level – the conceptual frameworks presented here can support this process. Actions to counter blind spots need to be considered including multi-perspective approaches, the use of scenarios and purposefully over-estimating the potential impacts of risks. However, issues of trust, unfair sharing of risk and poor co-ordination of actions across supply chains need to be addressed.

The goals of supply actors are potentially at odds with the wider outcomes of the system and these wider outcomes are at risk. However, framing of the issues facing the food system have continued to reside at a global level, or on single point issues, such as health. Policy needs to be more cohesive with a better understanding of vulnerability at a network level. There is a need for government to assume a greater role in articulating issues, encouraging greater co-ordination of actions across the network and creating frameworks to support higher levels of innovation, particularly to encourage different ways of structuring the food system. These implications are summarised in table 10.3.

Policy makers	Supply actors
There are significant risks to the wider outcomes of the food system	The need to assess vulnerability factors at an organisation, chain and network level
There exists a disconnect between the competitive motives of supply actors and the need to deliver wider outcomes	The contingency of vulnerability and whether factors are shaped as sources of risk, amplifiers or dampeners of risk and enables or constraints of action
There is a disconnect between the need for environmental sustainability and the beliefs and actions of supply actors	Actions to overcome blind-spots are needed, including multi-perspective approaches and counters to the tendency to underplay the impacts of risk
Policies need to take into account how risks and vulnerability are perceived by actors	The need for increased co-ordination across chains to mitigate against vulnerability
There needs to be a more cohesive policy on how wider outcomes are to be delivered, taking into account the in-built stasis in the system	The need for fairness and better balance of power across the network to support resilience
Food policies need to take a network perspective, joining agriculture with food supply chains	The inbuilt stasis in the system and how this could create vulnerability in the longer term
Government need to take a stronger, more proactive role in creating a commonly agreed understanding of the issues facing the food system and support the governance of the system to achieve policy objectives	The opportunities to develop more structural innovation, to both increase resilience but also to harness competitive advantages
Government should look to pro-actively support structural innovation and technological niches in order to foster experimentation and wider-based innovation to support greater resilience at a network level	

Table 10.3: Summary of implications for policymakers and actors

10.3 Theoretical and conceptual contribution

Chapter Seven presented a framework of seven exogenous and eleven exogenous vulnerability factors. Many of these vulnerability factors are mirrored by other authors. However, the framework was developed from a grounded approach, it is therefore ideographic and represents those factors which had a more significant effect on the dairy and wheat sectors, and therefore on the UK food network. This framework is novel, as specific factors which impact on the vulnerability of UK food system have not been developed before. This is a core contribution of the thesis. Part of this framework revealed a set of factors related to beliefs and mind-sets, common among mainstream supply actors. This highlights how cognitive aspects related to supply actors, as well as structural and other factors, impacts on vulnerability. It also suggests how common beliefs and mind-sets could drive locked-in behaviours and narrowly-based strategies, which exclude potential opportunities for experimentation and innovation to support greater resilience. This thesis

contributes to the SCV and SCRES fields here by identifying that cognitive factors have an impact on vulnerability, either at a supply chain or network level.

The research findings in Chapter Seven identified that these vulnerability factors can act on the food supply system in different ways. They can either be sources of risk, amplifiers or dampeners of vulnerability or constraints or enablers to resilience. The factors are interconnected at a system level and how they impact the network, is dependent on how each of the factors is shaped. Much of recent research has focused on isolating and defining antecedents or contributors to resilience. Here, the research reveals there are more complex, interconnected interactions between a wider set of factors and vulnerability/resilience. How each factor is shaped can change how they impact on vulnerability. This plurality characteristic of factors, along with their interconnection, is therefore an important contribution. It states that, while research into isolated factors is important, the systemic interaction between other factors may change their properties at a network level and these effects need to be considered.

Chapter Seven also presents a definition of vulnerability as '*the level of exposure to risk and the capability to respond to reduce variance to desired outcomes*'. This definition validates the conceptualisation of vulnerability in terms of capabilities and outcomes and supports evidence that vulnerability can be conceptually linked to the resource based view of the firm. Here the research goes further by identifying additional elements that contribute to vulnerability, those of the roles of both agency and risk perception. Previous research has not explicitly considered how these two elements combine to drive responses to risk or vulnerability. As the research is grounded, it builds theory by reflecting the reality of how vulnerability factors, agency and strategies play out in the food system. This is important as it provides a linkage between SCV theory and supply chain practice. The conceptual framework of vulnerability dynamics presented in this thesis, while building on existing research, is the first to combine these interactions and provide a more unified and comprehensive conceptualisation of vulnerability. This framework therefore furthers the theoretical construct of SCV.

Academic research post-2012 has side-lined vulnerability, replaced by resilience, along with robustness, as the dominant research focus for SCRM. However, this thesis has proved that risk, vulnerability and resilience are interconnected constructs. Research which does not comprehend this, is failing to understand the systemic nature of these constructs and is in danger of sub-optimisation. This is core contribution of this thesis, advocating the re-connection of vulnerability, and therefore risk, to resilience in future research.

In Chapter Eight, innovation was shown to have a profound impact on resilience. Innovation as an antecedent to resilience can play a significant part in supporting more flexible or robust structures and processes. The linkages between innovation and resilience have not previously been considered in SCV or SCRES literature, and therefore this finding presents a clear contribution to this field. The chapter also postulated a conceptual framework of adaptive capacity, as being a function of both structural and process based innovation. This represents a contribution to the SCRES field in providing a novel, grounded, theoretical framework which links concepts of ecological resilience with that of adaptive capacity and resilience. Chapter Eight provides evidence that narrowly applied innovation strategies could be a source of vulnerability for the UK food network. This framework therefore is a vital step in starting to conceptualise these issues, and provides the platform for future research into possible strategies and interventions to support greater resilience in the UK food system.

There remains a substantial gap in research at a network level. The findings in this thesis therefore further understanding as to how SCV and SCRES apply at this level. Network level vulnerability can be interpreted as a function of capacity for system change. The thesis has demonstrated a convergence of SCV and SCRES, at a network level, with system transition theory. This contributes by expanding the constructs of vulnerability and resilience at a network level to encompass more complex questions of change and the potential for network transition or re-organisation to support greater resilience. Vulnerability in the food network transcends traditional SCRM and this thesis emphasises the need for wider scope in

the SCV and SCRES fields to consider and research the social, environmental and political implications.

10.4 Research Validity and Limitations

The research took a constructionist approach, principally to build theory in the fields of SCV and SCRES. There are a number of limitations associated with this approach and the research itself.

Firstly, validity from a social constructionist standpoint relates to whether the study reflects the experiences of those involved in the research (Easterby-Smith et al, 2002). It can be argued from a relativist perspective that by including a wider range of perspectives, this enhances the validity of the research (Easterby-Smith et al, 2002). On this count, however, there will always be difficulty in generating access and data from a wide enough audience with this type of research. 40% of participants were either from government organisations, support industries or external to the food supply system (e.g. scientists, NGOs etc.) which reflected the difficulties in gaining access to supply system actors. This therefore does pose some concerns over how well their input reflected the actual behaviours and experience of those who are directly involved in the supply system. However, these actors tended to be more critical of the food system as a whole and, having an external perspective, helped to counter any bias exhibited by mainstream supply actors and provided a useful lens as to potential blind-spots. The actors were also chosen as they had experience of direct intervention within the supply system e.g. (from a regulatory perspective, from an environmental activism stance, from a scientific research stance) and therefore it could be argued that each provided a unique, but equally valid view, on the experiences and perceptions within the food system as those acting within it directly. Turning to the question as to whether the study managed to reflect accurately the experiences of those within the area of study. The scenario workshops, while slightly artificial, gave the actors the ability to explore potential different futures, capturing their reactions and thoughts unprompted by interventions from the researchers and gave rise to a direct understanding of their perceptions. However, there is one caveat; as the data was often collected in groups, this may have led to the voices of less powerful actors being ignored or not

articulated sufficiently to register in the findings. There is therefore some reservation as to whether all voices have been equally captured.

From the question of generalizability, a constructionist approach asks whether the concepts in the research have relevance for any other settings (Easterby-Smith et al, 2002). The conceptual frameworks were built from data derived from actors examining the UK wheat and dairy sectors and therefore can really only be seen to be representative of phenomena within those sectors. The research here has shown that while there is a level of homogeneity to some elements of the frameworks, some factors have more impact or significance in the dairy or the wheat sectors. While the research was explicitly focused on these sectors, there are common factors applicable the wider food system. These specifically include global demand and supply pressures, UK economic and general agricultural policies, the structure and operation of retail supply chains and relationships. The conceptual frameworks, having common elements to the food system, can therefore potentially reflect the dynamics in play across different sectors and at a network level. However, it cannot wholly be said that these conceptual frameworks can be generalised across the food system.

However, proponents of case study-based inductive research are less concerned with the generalisability of the case but more with the quality of theoretical reasoning (Bryman and Bell, 2003). This is concerned with the linkage of data to theoretical arguments and concepts. This thesis presents a clear evidence trail from empirical data (shown in Chapters 4, 5 and 6) to the level 1 and 2 codes and core categories generated as part of this research (as presented in Chapters 6 and 7). It also places the conceptual frameworks created in the context of the academic literature to further support theory building (Gill and Johnson, 2002).

A further attribute of inductively generated theory is that it remains at a modest idiosyncratic level (Eisenhardt, 1989). This is the case here. In the tradition of grounded theory, further selection cases are required in order to reformulate the conceptual frameworks and test for negative cases (Mitchell, 1983, Gill and Johnson, 2002). Further research therefore is needed to examine how this conceptual

framework applies, or not, for other food sectors such as the red meat sector and fresh produce sector. This would enable further theory building to be enacted, identifying any differences across the cases.

10.5 Future Research

RQ5: What are the implications for future research into concepts of vulnerability, resilience and adaptive capacity?

This then leads to the final research question, as to what future research is needed to further the theory building process and validation of the concepts presented here but also for wider research into SCV and SCRES.

On furthering research, cases from other food sectors need to be examined in order to determine if the conceptual frameworks are applicable here and for the wider food system. Grounded approaches again would help support linkages to the live experience of actors but also would support the building of theory around the linkages of risk, vulnerability and resilience and how these play out in the food system (in line with inductive theory building from cases). Specifically, research needs to be conducted to understand the differences in exogenous and endogenous vulnerability factors within each sector to support the construction of normative frameworks. This will be helpful from a practical sense for actors within the food system, to support thinking, widen the understanding of vulnerabilities across the system and to help build consistent articulation of the issues.

Further research is also needed to understand how the dynamics of vulnerability (the interplay between risks, risk perception, agency, capabilities and outcomes) play out across the different sectors. Further detailed investigations are needed into the individual elements of the framework to unpick its components further (e.g. the components of agency). This could also help to map this framework onto previous research findings. However, the tendency for SC research to take a reductionist approach needs to be guarded against, as the interconnections between the elements mean that their properties may be difficult to isolate. While this thesis has looked to position this conceptual framework within the SCV and SCRES fields, more research is needed to delve deeper into the differences between this

framework and those of other frameworks. There still is great ambiguity in this field and it may be that it is an impossible task to build unified, cohesive frameworks, as the nature of vulnerability and research is complex, systemic and by its nature partly uncertain. This suggests that more empirically based research is needed to test these conceptual frameworks but also to support the identification of areas of commonality between frameworks and where there are conflicts and differences. A clearer picture of contested elements would then aid thinking in the field and signal priority areas for research.

The particular concern raised in this thesis, of the disconnection between vulnerability and resilience, merits attention. While the tenet that the precise nature of threats cannot be predicted is true, whether resilience can be cast adrift entirely from risk and vulnerability needs further investigation.

More research into the nature of vulnerability and resilience at a network level is imperative. Supply chains are part of complex, messy connected networks and more is needed to understand the constructs of vulnerability and resilience at this level. More novel research methods for examining the constructs at this level may be needed. This thesis has shown that the use of scenarios is an important addition to the portfolio of SCM research methodologies. Methods built around scenarios create a safer environment for actors to think through the possible consequences of current SCM activities, while exploring potential alternative behaviours and strategies. They have also proven effective in supporting a multi-perspective approach across the supply network under study and also in helping uncover potential blind spots in actors' thinking. They are especially powerful where the research is future focused and where there is significant uncertainty in the SC operating environment; they are able to deal with a wider range of complex variables than Delphi studies. The use of scenarios in this thesis, specifically for SCM research, is novel and more research is needed to examine how scenario-based methodologies can be used to support the furthering of knowledge within the SCM field.

The research finding that vulnerability and resilience can be interpreted as the capacity for system change at a network level is a specific area for future

research. Here, more work is needed to understand the connections between system transition theory, ecological resilience and SCV and SCRES and the implications for both theory and practice. Here also, the part that innovation plays in supporting resilience and system transition needs further analysis and definition.

The issues of the food system span multiple areas and the issues of vulnerability and resilience merge with questions of sustainability (including sustainable supply chains), technological development and dispersion, resource management, supply network governance, and government policy. This suggests the need for more multi-disciplinary approaches and convergence between academic fields. Finally there are number of pertinent questions for supply actors and policymakers:-

- What governance structures and instruments are effective at a network level in co-ordinating actions to improve resilience?
- What policy instruments and interventions would be effective to support greater resilience within the UK food system?
- How can greater systemic innovation and experimentation in supply chain structures be encouraged and nurtured?
- How can the conflict between commercial and wider social-environmental outcomes be negotiated to deliver a more sustainable UK food system?

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Appendix A: Interview schedule for general interviews

PHASE 1: INTERVIEW SCHEDULE

Profile of participant

Name:

Job Title:

Brief outline of role and responsibilities:

Interview Questions

1. What do you see happening at the moment in the food markets?
2. What is your view of this situation and why is this happening?
3. What do you think is going to happen in the longer term?
4. Where do you see the future challenges for the food system?
5. What actions do you think need to be taken by:-
 - the supply network
 - policy makers
 - consumers/civil society as a whole?

Appendix B: Schedule for supply chain sector interviews

NETWORK DYNAMICS INTERVIEW QUESTIONS

Profile of company/participant

Name:

Job Title:

Brief outline of Role and responsibilities:

Corporate organisation

Organisation Turnover :

(Scale)

Number of Employees :

(Scale)

Farm-based organisation

Ha farmed :-

Location :-

Main activities :-

(inc. non-farming based)

Organisation activities

What range of *wheat/milk* products do you grow/supply to the network?

In total, how much *wheat/milk*, in volume terms, do you supply to your customers on an annual basis?

What percentage of your total business does this volume equate to?

Supply Network

Who do you consider to be your key suppliers of raw materials, products and services (supporting your *wheat/milk* products)? Where are they based and what products or services do they supply to you? (if imports, where from?)

Has this network changed over the last 10 years? If so, what have been the changes and what were the driving forces for the change?

On what basis do you do business with these suppliers? (in brief)

- Contractual arrangements
- Ordering arrangements
- Method of delivery
- Specifications/quality control etc
- Nature of relationship

Appendix B continued

Have the nature of this way of doing business changed over the last 10 years? If so, what have been the changes and what were the driving forces for the change?

In your opinion, what are the critical resources and activities in your upstream supply network which are essential to the supply of products and services to meet your delivery, cost and quality objectives?

Focal organisation and customer network

Who are your key customers and what products do you supply to them? Where are they based and what products or services do you supply to them?

Has this part of the network changed over the last 10 years? If so, what have been the changes and what were the driving forces behind it?

Briefly explain, on what basis do you do business with your customers?

- Contractual arrangements
- Ordering arrangements
- Method of delivery
- Specifications/quality control etc
- Nature of relationship

Have the nature of this way of doing business changed over the last 10-15 years? If so, what have been the changes and what were the driving forces for the change?

What are your critical resources and activities which are essential to assuring supply to meet your customers' delivery, quality and cost objectives?

Strategic Planning Process

What would you say is your organisation's overall business strategy/objective? (in general terms). Has this changed from 10-15 years ago?

What is your current supply chain strategy/objectives? (again, in general terms) Again has this changed?

When setting future business or future supply chain strategy within your organisation, what are the main considerations, assumptions and factors which are taken into account?

How far ahead in the future are plans in place for?

How is future risk taken into account and to what extent are wider, externally generated trends and uncertainties taken into account?

Appendix B continued

To what extent do you share information on/or jointly plan for these risks/uncertainties with your suppliers and customers?

Forces for change

Looking at the external environment, what factors from various political, social, economic, technological, legal and environmental perspectives influence are critical to your ongoing business success?

In your opinion what strategic trends or uncertainties in the external environment to the supply chain, could, in the future, affect your future business success/competitiveness?

Over the last 20 years what have been the significant changes within the industry as a whole? What have driven those changes?

Looking forward, what do you think the major forces for change for the industry as a whole will be in the coming years?

What do you think are the challenges are that lie ahead for the industry as a whole?

Appendix C: Templates for Initial Scenario Workshops

Dairy/Wheat : Initial Scenario Workshop QUESTIONS AND EXERCISES

Question 1

Please answer the following question for all 4 scenarios

'What are your comments and feedback on the detail of the global scenarios, plus what would you want to add or change?'

Question 2

Again, for all scenarios, please answer the following question

'What are the primary challenges and issues you think each global scenario presents for industry, government and consumers in the UK in relation to wheat supply?'

Scenario x
<i>Farmers</i>
<i>Industry</i>
<i>Consumers</i>
<i>Government</i>

Appendix C continued

Question 3

'Who are the key actors and stakeholders we need to consider in and around the food arena in the UK related to wheat supply and what happens to them in each scenario? Who does well and who is in difficulty?'

Enter core stakeholders in the horizontal axis of the grid.

Enter 'OK' if they are a winner

Enter 'X' if they are a loser

Enter 'N' if they are neutral

Stakeholders	Blip				Food Inflation				Into a New Era				Food in Crisis			
	<i>Tables</i>				<i>Tables</i>				<i>Tables</i>				<i>Tables</i>			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

Appendix D: Templates for Core workshops

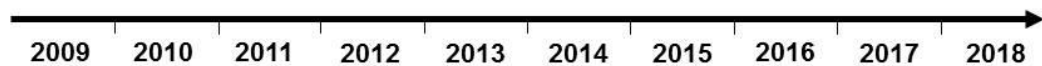
Appendix D: Template 1

1. Timeline Exercise

18 copies (16+2 spare)

Scenario: _____

UK
Scenario
Events



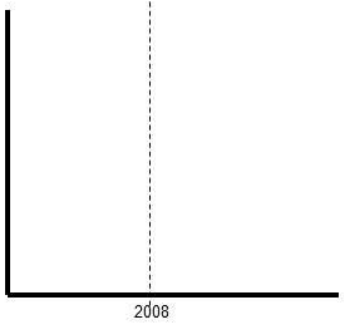
Appendix D: Template 2

2. Graph Exercise

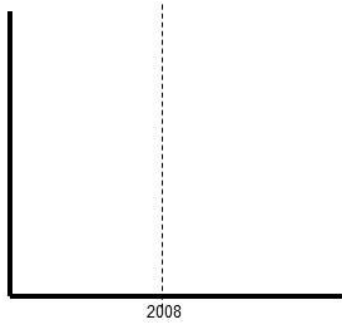
18 copies (16+2 spare)

Scenario : _____

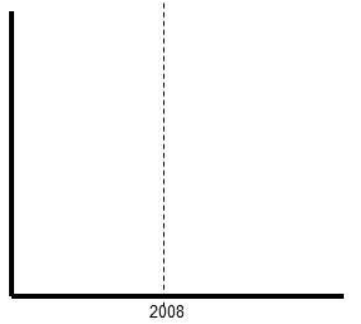
Graph Title



Graph Title



Graph Title



Why?

Why?

Why?

Appendix D: Template 3

3. Scenario Factors Exercise

18 copies (16+2 spare)

Scenario: _____

Factor	UK Situation in Scenario
Socio-cultural Ideas: health consciousness, emphasis on safety, changes in consumption patterns etc	
Technology Ideas: R&D activity, rate of technological change, types of technology, biofuel etc	
Economy Ideas: Economic growth, rates of investment, profits, employment in food etc	
Environmental Ideas: Impact of climate change, water availability, input availability, soil quality etc	
Political Ideas: new regulations,, trade restrictions, taxation, political stability etc	

Appendix D: Template 4

Scenario responses exercise

6 copies (4+2 spare)

Scenario : _____

	Farming Inputs	Farming
Overall objectives		
Market focus/priorities		
Products, Processes, Policies		
Resources, capabilities, technologies		
Relationships/ partnerships		

4

Appendix E : List of level one codes

	C : Food Sector:Food sector type = Wheat	D : Food Sector:Food sector type = Dairy	Q : Sector:Industry = Wheat	R : Sector:Industry = Dairy
1 : animal breeding	0	4	0	6
2 : availability of labour and skills	2	4	2	8
3 : behavioural change	2	6	3	7
4 : bio and nano technology	1	0	1	0
5 : bio-fuels	14	0	20	2
6 : business as usual	5	6	5	6
7 : CAP and agricultural policy framework	3	8	7	10
8 : capital availability	6	3	7	8
9 : carbon management	0	0	0	2
10 : carbon constraints on production	0	0	0	0
11 : carbon management	1	1	1	3
12 : carbon measures across supply chain	2	5	3	5
13 : carbon pricing and trading	2	1	2	2
14 : changes in competition policy	0	1	0	3
15 : changing geo-political power	3	0	4	0
16 : climate change	2	0	5	1
17 : co-location of production and processing	0	0	2	3
18 : competition between feed, fuel and food	0	1	4	1
19 : competition for resources	1	2	1	3
20 : competitiveness of UK food system	7	7	12	19
21 : concern over sustainability of food system	2	4	2	8
22 : concerns over animal welfare	1	1	1	3
23 : consolidation	2	8	3	15
24 : consumer expectations	4	4	5	5
25 : consumer preferences for value based purchasing	1	2	2	4
26 : consumer spending power	3	1	3	1
27 : contested responsibility for change	0	5	0	6
28 : contraction in Uk food production	6	14	6	25
29 : contractual arrangements	0	0	0	4
30 : dairy	0	52	0	59
31 : dairy farming as lifestyle	0	2	0	2
32 : deregulation of milk market	0	0	0	1
33 : de-urbanisation	1	3	1	3
34 : development aid for agriculture	2	0	2	0
35 : differentiation and value-add	5	15	7	25
36 : disease threat	0	8	1	9
37 : environmental issues with livestock farming	1	0	1	2
38 : EU policy disparity	0	0	0	2
39 : EU tensions	3	3	3	3
40 : expansion in Uk food system	9	1	10	5
41 : extent of change	0	1	0	1
42 : fairness in trade	0	0	0	13
43 : faith in markets	2	2	2	2
44 : faith in technological solutions	1	1	2	1
45 : flexibility and agility of supply chain	0	2	0	2
46 : food culture and dietary change	12	10	13	10

47 : food labelling	0	0	0	0
48 : food price deflation	1	0	1	0
49 : food security policy	0	3	0	3
50 : food standards	9	9	16	13
51 : food tax	4	4	4	4
52 : futures trading and speculation	2	2	2	2
53 : gap between commercial and social environmental concerns	0	0	1	0
54 : general	0	0	0	0
55 : Global environmental constraints	0	0	0	0
56 : energy availability and peak oil	0	0	0	0
57 : land availability	0	0	0	0
58 : water availability	2	0	3	1
59 : global production response can meet demand	0	0	0	0
60 : globalisation of supply chains	3	1	3	3
61 : GM	0	0	0	0
62 : Benefits of GM	0	0	1	0
63 : Gm Acceptance	2	4	3	4
64 : GM acceptance in other gobal regions	0	0	1	0
65 : GM as technological solution to supply pressures	1	3	2	4
66 : GM authorisation	4	0	4	0
67 : GM policy parity	2	0	2	0
68 : GM safety concerns	0	0	0	0
69 : GM seggregation of product	0	0	0	0
70 : GM to reduce disease	0	1	0	1
71 : Increase in GM production	0	0	0	0
72 : Government policy and intervention	3	2	4	5
73 : contested level of government intervention	14	8	14	8
74 : government crisis management	6	6	6	6
75 : Policy interventions to promote sustainability	6	2	6	2
76 : role of government	4	0	4	0
77 : Uk food policy alignment and integration	3	0	4	0
78 : growth in own label	1	0	1	0
79 : high levels of waste in supply chain	7	10	8	13
80 : high prices as driver for change	3	0	3	0
81 : impact of regulatory system	4	6	9	14
82 : impact on developing countries	0	0	1	0
83 : impact on lower income groups	4	5	4	5
84 : import export controls	3	0	3	0
85 : Importance of food as political issue	4	2	6	2
86 : importance of maintaining UK farming and food production	1	0	2	3
87 : improved seed breeding	0	0	1	1
88 : increase in global food demand	0	0	1	1
89 : economic growth of emerging economies	0	0	1	0
90 : nutrition transition in emerging economies	0	0	1	1
91 : urbanization	0	0	0	0
92 : world population growth	0	0	1	0
93 : increase in global free trade	1	1	6	4
94 : increase in regional production	0	1	1	1

95 : increased cost of agri-environmental schemes	1	1	1	1
96 : increased profits	1	0	1	0
97 : industry mindset	8	1	11	3
98 : integration and co-ordination	3	9	13	28
99 : intensification	5	12	8	18
100 : interdependencies	1	0	1	1
101 : lack of consumer awareness	2	4	2	5
102 : lack of innovation	0	2	0	8
103 : land use	7	5	7	5
104 : local sourcing	2	4	2	6
105 : Local systems vs global or centralised systems	1	6	1	7
106 : lower global stocks	0	0	0	0
107 : maintain status quo	9	4	9	4
108 : manage uncertainty	5	1	6	1
109 : management of fertilisers	0	0	0	0
110 : market bifurcation	0	7	1	11
111 : market opportunities and threats	3	4	3	7
112 : migration of production and processing	2	4	3	4
113 : motivation for system change	1	0	1	0
114 : need to develop more sustainable practices	1	0	2	0
115 : no major shift in supply demand dynamics	0	0	0	0
116 : obesity and health concerns	1	0	2	4
117 : optimism for future	0	0	0	0
118 : polarized society	5	3	5	3
119 : policy uncertainty	0	0	0	2
120 : poor producer understanding of market	0	1	1	3
121 : power balance in supply chain	2	4	2	4
122 : price and market volatility	7	2	9	3
123 : price as main competition point	2	8	2	10
124 : price inflation	2	1	3	2
125 : pricing and cost structure of market	0	2	2	6
126 : product and product offering reformulation	9	12	9	15
127 : profiteering	2	0	2	0
128 : protectionism	3	6	3	6
129 : R+D development and innovation	15	12	17	13
130 : rate of change	0	0	0	3
131 : reduction in choice	6	1	6	1
132 : reduction in food service revenues	5	0	5	0
133 : reduction in intensification	6	3	6	6
134 : reputational risk	0	0	0	0
135 : resource efficiency	0	4	0	7
136 : risk and crisis management	6	2	6	2
137 : seasonal food	1	4	1	9
138 : sharing of supply chain benefits and risks	0	3	3	12
139 : slow speed of response	0	3	0	4
140 : social responsibility	0	5	4	5
141 : strategic food reserves	4	1	4	1
142 : structural change to supply demand dynamics	0	0	0	0

143 : supply chain absorbs increased costs	4	6	4	6
144 : supply chain infrastructure	4	0	6	0
145 : supply chain ownership and structure	3	9	7	12
146 : supply chain relationships	13	8	22	20
147 : collaboration	0	0	2	0
148 : supply continuity	10	12	11	18
149 : supply demand imbalances	0	0	0	2
150 : sustainability as competitive advantage	4	6	4	6
151 : sustainability sidelined	5	4	5	4
152 : sustainable intensification	2	0	3	0
153 : sustainable packaging	0	4	0	4
154 : tension between techno and green solutions	0	1	1	1
155 : threat from imports	6	2	13	5
156 : tightening of food supply	0	2	0	2
157 : trade off between values	1	3	1	4
158 : trade off between aspects of sustainability	1	1	1	1
159 : trust and confidence	0	4	0	4
160 : UK consumption patterns	4	5	6	8
161 : UK demographic changes	1	3	1	3
162 : UK exposure to global prices	0	1	3	2
163 : UK food system capacity	2	3	7	5
164 : Uk food system resilient against global challenges	0	0	0	1
165 : UK system breakdown	17	15	17	15
166 : Uk wheat quality	1	0	2	0
167 : upward pressure on costs	6	5	7	10
168 : viability of small systems vs economies of scale	1	7	1	10
169 : vision of sustainable future	0	1	0	1
170 : weather variability	0	0	1	5

Appendix F: Level two codes

(excluding specific codes related to risk)

Level two codes	In Folder	Created On
access to markets	Nodes	27/08/2013 12:03
affordability of food	Nodes	27/08/2013 11:07
business as usual	Nodes	22/05/2013 16:28
capability and skills	Nodes	27/08/2013 13:48
consumer expectations	Nodes	16/01/2013 14:05
control and regulation	Nodes	27/08/2013 12:02
environmental impact of food	Nodes	27/08/2013 11:15
externally driven sustainability agenda	Nodes	27/08/2013 12:01
faith in technological solutions	Nodes	27/01/2013 14:44
food standards (higher)	Nodes	13/05/2013 17:38
incremental change	Nodes	27/08/2013 10:59
industry mindset	Nodes	29/01/2013 17:32
inflationary pressures	Nodes	27/08/2013 12:28
integration and co-ordination	Nodes	26/01/2013 14:22
intensification	Nodes	27/01/2013 16:03
intensification\consolidation	Nodes	16/01/2013 11:08
interdependencies	Nodes	10/05/2013 16:17
polarized society	Nodes	12/05/2013 16:52
power balance in supply chain	Nodes	07/05/2013 17:21
pricing and cost structure of market	Nodes	18/03/2013 15:58
product and process innovation	Nodes	27/08/2013 11:29
profit margins	Nodes	27/08/2013 11:20
rate and extent of change	Nodes	29/04/2013 16:59
risk adverse	Nodes	27/08/2013 11:02
risk and crisis management	Nodes	14/05/2013 11:16
Scale	Nodes	27/08/2013 11:04
social impact of food	Nodes	27/08/2013 11:15
societal value of food	Nodes	27/08/2013 13:08
supply chain flexibility and agility	Nodes	07/05/2013 17:29
supply chain ownership and structure	Nodes	22/03/2013 19:00
supply chain relationships\collaboration	Nodes	15/01/2013 16:49
supply continuity	Nodes	22/03/2013 16:07
supply system governance	Nodes	27/08/2013 11:42
trade off between values	Nodes	27/01/2013 18:57
viability of UK farming and production	Nodes	27/08/2013 11:20

Appendix G: Level 3 codes (Core categories)

Core categories (level 3)	
1	Perception of risk
2	Exposure to risk
3	Capability to respond
4	Power to act
5	Strategies
6	Enablers
7	Constraints
8	Amplifiers
9	Dampeners
10	Competitive outcomes
11	Wider supply network outcomes
12	Drivers of change
13	Innovation

Appendix H: Mapping of linkages between codes

