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Increase Supply Chain Performance by Addressing Knowledge Governance, Resilience Capabilities, and Risks: Empirical Evidence from the Agri-Food Industry

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Increase Supply Chain Performance by Addressing Knowledge Governance, Resilience Capabilities, and Risks: Empirical Evidence from the Agri-Food Industry

by

Guoqing Zhao

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Copyright statement

Dedication

To my supervisors: Prof. Shaofeng Liu & Dr. Carmen Lopez, and all my teachers

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Author's declaration

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

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

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Zhao, G., Liu, S., Chen, H., Elgueta, S., Manzur, J.P., Lopez, C. Knowledge mobilisation crossing boundaries for decision support: Insights from agri-food supply chains of Chile. ***6th International Conference on Decision Support System Technology***, 27-29 May 2020, Zaragoza, Spain

Abstract

Agri-food supply chain (AFSC) are becoming more complex due to the prevalent of lean strategy, a higher rate of innovation, and customer preference towards high quality and fresh agri-food products. AFSC can operate smoothly and efficiently in stable business environments but are highly vulnerable to various risks and uncertainties. Knowledge is a vital resource for firms to survive and to achieve sustainability and profitability in the dynamic and volatile business environment. However, according to author's knowledge, little research has been conducted to explore the interactions among knowledge governance mechanisms (KGMs), AFSC resilience capabilities, AFSC risks, and AFSC performance. KGMs are defined as the different mechanisms for sharing, integrating, interpreting and applying know-what, know-how, and know-why embedded in individuals, groups and other source of knowledge. This study aims to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks by using a multi-method qualitative approach. The research aim can be achieved through investigating different KGMs that can be used for managing knowledge, investigating different resilience capabilities that can be used for building AFSC resilience, investigating different risks that exist in the AFSCs, as well as investigating different key performance indicators (KPIs) that can be used for measuring AFSC performance.

The empirical study has been conducted in three phases. Phase one of the empirical study, semi-structured interviews were conducted with experienced AFSC practitioners from Argentina, France, Italy, and Spain, followed by thematic analysis to analyse data. As a result, themes related to KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs were identified. Then, TISM (Total Interpretive Structural Modelling) was used to build relationships among the constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs). Thus, the relations among the four constructs were defined.

Phase two of the empirical study, structured interviews were conducted with experienced AFSC practitioners to collect data. Then, prioritising of resilience capability factors and risk factors was conducted through a combination of TISM and fuzzy MICMAC (Impact Matrix Cross-reference Multiplication Applied to Classification) analysis. TISM was used to build interrelationships among different AFSC resilience capability factors and among different AFSC risk factors, respectively, through allocating different factors into different layers. Fuzzy MICMAC analysis was employed to categorise different AFSC resilience capability factors and different AFSC risk factors into different categories, respectively. The research results indicate that extreme weather conditions and political and economic instability have the highest driving power and are located at the lowest level in the TISM hierarchy. These risks have an increased tendency to disturb the whole flow of AFSC and so should be managed effectively. Furthermore, the research results also indicate that leadership should be given critical focus for building AFSC resilience, as it locates in the lowest level in the TISM hierarchy.

In the research evaluation phase, structured interviews were conducted in Chile to evaluate the research results obtained through empirical research phase one and two. All statements rated relatively positive, indicating that respondents highly agree with the elements and relationships identified in the empirical findings.

This study has a number of theoretical contributions. Firstly, it provides empirical evidence in identifying elements for building KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. Secondly, it provides empirical evidence that KGMs have positive effects in enhancing AFSC performance and in improving AFSC resilience capabilities. Thirdly, it prioritises AFSC resilience capability factors and risk factors through building interrelationships among them using TISM and categorising them using fuzzy MICMAC analysis. This study provides practical guidance for helping AFSC practitioners to strengthen knowledge sharing/transfer, build AFSC resilience capabilities, reduce AFSC risks, and improve AFSC performance.

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List of abbreviations

SCRM: Supply chain risk management

AFSC: Agri-food supply chain

KM: Knowledge management

KGMs: Knowledge governance mechanisms

GDP: Gross-domestic product

SDG: Sustainable development goal

KRRP: Knowledge, Resilience, Risk, and Performance

KPIs: Key performance indicators

KBV: Knowledge-based view

OL: Organisational learning

KG: Knowledge governance

LO: Learning organisation

SMEs: Small and medium enterprises

IT: Internet technology

JIT: Just-in-time

TQM: Total quality management

ERP: Enterprise resource planning

SCM: Supply chain management

PMS: Performance management system

SEM: Structural equation modelling

CSR: Corporate social responsibility

ISM: Interpretive structural modelling

TISM: Total interpretive structural modelling

AHP: Analytic hierarchy process

BSC: Supply chain balanced scorecard

SCOR: Supply chain operations reference model

DEMATEL: Decision making trail and evaluation modelling

ANP: Analytic network process

MICMAC: Cross-impact matrix multiplication applied to classification

IRP: Interpretive ranking process

ICT: Information and communication technology

FS-MRLs: Food safety and maximum residues limits

Chapter one: Introduction

1.1 Research background and motivation

The past few decades have been notable for significant changes in supply chains due to the growing complexity of global supply chain networks, the fast-changing and turbulent of the modern business environment, and a higher rate of innovation (Golgeci and Ponomarov. 2013; Hohenstein et al. 2015; Sabahi and Parast. 2020). Furthermore, the focus on lean manufacturing, just-in-time (JIT) in production/logistics, global outsourcing, waste elimination/minimisation, and product differentiation/proliferation have made the supply chain longer, more complex, and highly interconnected (Chen et al. 2017; Ruiz-benitez et al. 2018; Henao et al. 2019). To a certain extent, these trends have helped supply chains to improve service reliability, increase profit, and reduce order lead-time during a stable business environment (Kamalahmadi and Parast. 2016). However, supply chains are highly vulnerable to various risks and disruptions during an unstable business environment because of the dependency on few suppliers and the inability to react quickly to uncertainties (Christopher and Peck. 2004; Gunasekaran et al. 2015; Stone and Rahimifard. 2018; Zhao et al. 2020).

Supply chain risk has been defined by Ho et al. (2015, p. 5035) as "the likelihood and impact of unexpected macro and/or micro level events or conditions that adversely influence any part of a supply chain leading to operational, tactical, or strategic level failures or irregularities". Generally, there are risks hidden in all business activities from energy cost, raw material availability, and exchange rate policy (Norrman and Jansson. 2004; Pfohl et al. 2011; Munir et al. 2020). Supply chain risks may emerge from various factors such as environmental factors, industry factors, organisational factors, problem-specific factors, and decision-maker-related factors (Xu et al. 2020). The risks can have significant consequences on supply chains, including financial problems, human resource problems, and operational problems (Craighead et al. 2007; Rao and Goldsby. 2009; Rajesh et al. 2015). Although supply chain risk management (SCRM) (e.g., risk identification, risk assessment, risk mitigation, and risk monitoring) has received considerable attention from academics and practitioners (Tang and Musa. 2011; Baryannis et al. 2019), supply chain risks are still difficult to be mitigated and avoided due to inherent supply chain complexity and dynamic risk propagation (Li and Zobel. 2020). Furthermore, it is important to note that a majority of scholars (e.g., Kumar et al. 2018; Shenoi et al. 2018) has focused on the risk management of manufacturing supply chains, including automotive supply chains, electronic supply chains, aerospace supply chains, fashion supply chains, chemical supply chains, and energy supply chains. However, based on recent literature reviews on SCRM (Ho et al. 2015; Pournader et al. 2020), the risk management related to the AFSCs has not gained the needed attention.

AFSCs are the linked events in the agricultural production of food, which compromises of a set of activities in a "farm-to-fork" sequence including farming, processing, testing, packaging, warehousing, distribution, retailing, and consumption (Dani and Deep. 2010; Iakovou et al. 2010). Figure 1.1 represents the general AFSCs. Different AFSC stakeholders were described in the rectangles. Furthermore, the direction of narrows represent how agri-food products were circulated from the input suppliers to the final consumers.

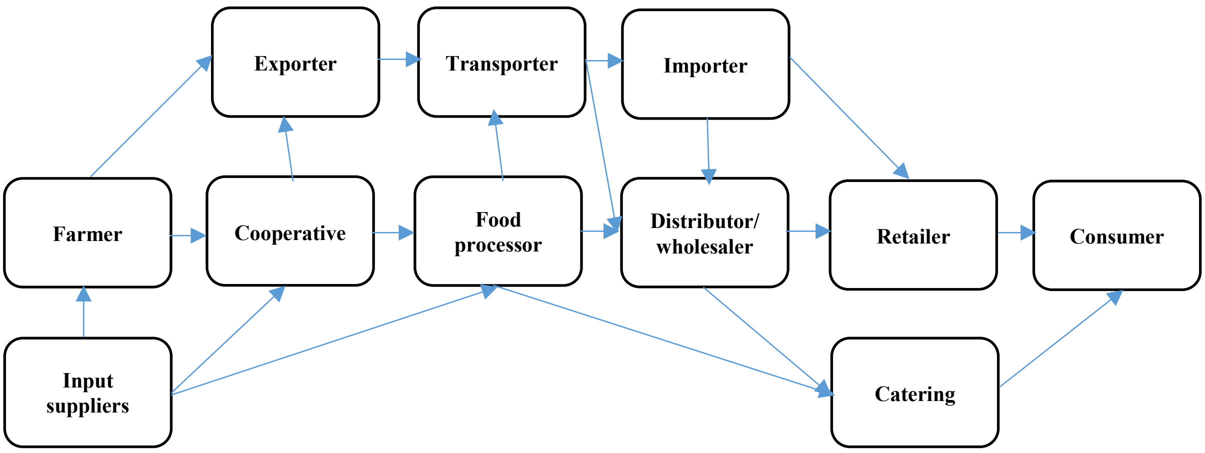


Figure 1.1 General AFSC (Boshkoska et al. 2018, p. 89)

Besides, a variety of financial, information, technology, and material flows are crossing both downstream and upstream of AFSC (Mentzer et al. 2001; Stone and Rahimifard. 2018).

Additionally, AFSCs have inherited seven unique characteristics in comparison with other kinds of supply chains (e.g., automobile supply chain and healthcare supply chain): (1) biological risks; (2) buffer stock limitation; (3) information and communication technology (ICT) influences on AFSCs; (4) food retailers have gradually become the focal company in AFSCs; (5) globalisation; (6) innovation in production agriculture having shifted from chemistry to biology; and (7) the prevalent market structure at the farm gate remains oligopoly (Sporleder and Boland. 2011). Due to these characteristics, AFSCs not only share the general risks (e.g., supply risks, demand risks, environment risks, process risks, and control risks) that exist in other types of supply chains, but also face their unique vulnerabilities such as seasonality in production, limited shelf-life of the products, trade and buffer stock restriction, pest and disease risk, and varying quantity and quality standards of products (Christopher and Holweg. 2011; Siddh et al. 2017; Behzadi et al. 2018). Furthermore, the world's population is expected to increase to 9.6 billion by 2050, thus, more high quality and heavily processed foods will be required to feed the world's growing population (Dani. 2015; Suweis et al. 2015). This will place unprecedented pressure on the global AFSCs. Traditional SCRM mainly relies on previous statistical information to identify risks and implement an appropriate strategy to avoid or control risks (Juttner et al. 2003; Ho et al. 2015; Chaudhuri et al. 2018). However, the traditional SCRM approach was assessed ineffective because many risks are unpredictable and unknowable, and statistical information may not exist (Fiksel et al. 2015).

To address supply chain risks, the idea of supply chain resilience has received much attention in recent years. Supply chain resilience was proposed underlying the assumption that not all risks could be prevented (Christopher and Peck. 2004; Juttner and Maklan. 2011). It aims at improving the adaptive capability of a supply chain to prepare for unexpected events, to resist the spread of disturbances, and to respond to disruptions and recover from them to a standard or better state (Leat and Revoredo-Giha. 2013; Kamalahmadi and Parast. 2016). Continuously adapting and developing capabilities to make a supply chain resilient has positive effects in mitigating the negative consequences of risk events. Thus, supply chain resilience can be seen as the ability to provide a sustainable competitive advantage (Hamel and Valikangas. 2003; Ponomarov and Holcomb. 2009; Pettit et al. 2013; Pettit et al. 2019). Compared to the traditional SCRM, supply chain resilience can be considered as a complement to enhance traditional SCRM strategies because it does not need to involve risk identification and quantification that can be used to tackle unforeseeable disruptions and events (Pettit et al. 2010; Scholten et al. 2014).

In the field of supply chain resilience, a number of studies considering flexibility as the most significant capability to ensure supply chain resilience. Moreover, redundancy, supply chain collaboration, agility, SCRM culture, and supply chain reengineering were all discussed by researchers as core capabilities to build supply chain resilience (Bakshi and Kleindorfer. 2009; Ates and Bititci. 2011; Hohenstein et al. 2015; Kamalahmadi and Parast. 2016; Li et al. 2020). Besides, resilience capability factors such as trust (Faisal et al. 2007), information sharing (Wicher and Lenort. 2012), leadership (Christopher and Peck. 2004), and innovation (Sharifirad and Ataei. 2012) were all assessed by different researchers to evaluate their effectiveness for building resilience capabilities in a supply-chain context. Supply chain resilience capabilities are the critical enablers for building supply chain resilience, whereas supply chain resilience capability factors are the detailed managerial practices that can be used for building supply chain resilience capabilities (Sheffi. 2005; Tang and Tomlin 2008). Although supply chain resilience has been investigated by different scholars adopting different perspectives (e.g., definitions, capabilities, factors, and performance measurement), supply chain resilience is still ambiguous and lacks sufficient understanding (Blackhurst et al. 2011; Wieland and Wallenburg. 2013; Melnyk et al. 2014; Kochan and Nowicki. 2018). In particular, the capabilities and capability factors for building AFSC resilience need to be further investigated in order to create an unbroken flow of high quality and fresh food to end consumers in the face of disruption and explosive growth of the world's population (Tendall et al. 2015; Ali and Golgeci. 2019). AFSCs need to be re-evaluated for resilience.

In the contemporary tendency, competition has shifted from between suppliers to between supply chains (Cabral et al. 2012). Knowledge, as a critical and valuable resource that has the ability to provide sustainable competitive advantage, therefore, should be given critical focus (Khamseh and Jolly. 2008; Schniederjans et al. 2020). Based on the knowledge-based view (KBV), a supply chain's ability to create and transfer knowledge can yield competitive differentiation (Blome et al. 2014). Thus, the management of knowledge in supply chains appears to be the necessary response to different supply chain risks posed by various industrial trends. Knowledge management (KM) was defined by Costa and Monteiro (2016) as a systematic process to find, create, understand, and use knowledge to create value. In the context of AFSC, organisations always require access to partner's knowledge and new skills (e.g., market preferences, pest and disease controls, seed cultivation, waste reduction, and greenhouse technologies), which they consider necessary or useful for their internal decision-making, operating performance, and the overall supply chain performance (Chen et al. 2018).

Although KM has been highlighted by various scholars as a key factor to acquire competitive advantage (Hong and Choi. 2002; Blackhurst et al. 2011; Ponis. 2012; Schniederjans et al. 2020), the role of KM in SCM still seems to be neglected (Cerchione and Esposito. 2016). This was assured by several literature review studies conducted by Barros et al. (2020) and Schniederjans et al. (2020). Their research results indicate that few of existing studies have been conducted for investigating the interactions among KGMs, AFSC resilience capabilities, AFSC risks, and AFSC performance. KGMs are associated with the adoption of governance mechanisms for the process of capturing, storing, sharing and using knowledge (Huang et al. 2013). Considering the aforementioned arguments, the motivation of this study is to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks.

1.2 Industry justification

In this research, the agri-food industry has been selected as the research context because it plays a critical role in ending extreme poverty, boosting shared prosperity and feeding a projected 9.6 billion people by 2050 (Serhan and Yannou-Lebris. 2021). According to the data provided by the World Bank (2019), agri-food industry contributed one-third of the global gross-domestic product (GDP) in 2014. AFSCs are responsible for providing sustainable, affordable, safe, and sufficient food, feed, fibre, and fuel to consumers, it is critical to ensure that these supply chains operate smoothly and successfully in the increasingly volatile business environment (Zhao et al. 2019). However, designing such a smooth and stable AFSC is extremely difficult due to the involvement of various risks and risk driving factors (Zhao et al. 2020). There is evidence that AFSCs will face more risks in the future because of an increased incidence of extreme weather linked to climate change (Allison et al. 2009; Karl. 2009; Moazzam et al. 2018). Therefore, continuously improving the performance of AFSCs and keeping AFSCs resilient to various risks is critical to fulfilling the United Nation's Sustainable Development Goals (SDGs) (World Bank Group. 2015).

1.3 Research aim, objectives and research questions

As discussed in the previous sections, more empirical investigations on the relationships among KGMs, AFSC resilience capabilities, AFSC risks, and AFSC performance should be conducted. Thus, the research aim of this study is to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks. This would be achieved by investigating different KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs, as well as exploring relationships among these four constructs. The main research objectives of this study are to investigate different themes related to the constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs), build relationships among the constructs, prioritise factors related AFSC resilience capabilities and AFSC risks, and build a KRRP framework:

- **RO1**: To investigate different KGMs that can be used by AFSC practitioners for managing knowledge;
- **RO2**: To investigate AFSC resilience capabilities and corresponding resilience capability factors that can be used by AFSC practitioners for building AFSC resilience;
- **RO3**: To investigate AFSC risk types and corresponding risk factors that can cause vulnerabilities to the AFSCs;
- **RO4**: To investigate KPIs that can be used by AFSC practitioners to measure the performance of AFSCs;
- **RO5**: To investigate the direct impact of KGMs on AFSC performance;
- **RO6**: To investigate the indirect impact of KGMs on AFSC performance through AFSC resilience capabilities and AFSC risks;
- **RO7**: To construct a knowledge, resilience, risk, and performance (KRRP) model of the agri-food industry;
- **RO8**: To validate the KRRP model in different countries across Europe and South America;
- **RO9**: To investigate key AFSC resilience capability factors and key AFSC risk factors.

Three research questions are formulated as follows:

- **RQ1**: What are the KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs that exist in the AFSCs?

- ❖ **RQ2**: What is the model that can be used to describe the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks?
- ❖ **RQ3**: What are the key AFSC risk factors and key AFSC resilience capability factors?

Research question one was formulated based on the research objectives one to four, research question two was formulated based on the research objectives five to eight, and research question three was formulated based on the research objective nine.

1.4 Key contributions

This study investigates the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks, and in doing so it makes several theoretical and practical contributions. Theoretically, this study contributes to the existing knowledge in five different ways.

- ➢ First, this study enriches the literature of KGMs exploration, risk and resilience capability factors' identification, and AFSC KPIs identification. Although many studies (e.g., Wagner and Bode. 2006; Tang and Tomlin. 2008; Esteso et al. 2018) have analysed different factors of KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs, this study identified five new factors for building KGMs, five new AFSC resilience capability factors for building AFSC resilience capabilities, six new AFSC risk factors that can cause vulnerabilities for AFSCs, and six new AFSC KPIs for evaluating AFSC performance. This research extended existing studies on new factor identification for building KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs.
- ➢ Second, relationships have been built among different constructs, including that KGMs have positive effects in enhancing AFSC performance, KGMs have positive effects in improving AFSC resilience capabilities, AFSC resilience capabilities can help to reduce AFSC risks, and AFSC risks can deteriorate the performance of AFSCs.

Previous studies (e.g., Cao and Xiang. 2012; Fang et al. 2013; Ye et al. 2020) on KGMs only confirm that KGMs have positive effects in knowledge sharing and knowledge transfer, this study makes a contribution that KGMs can help to enhance AFSC performance and AFSC resilience directly, and reduce AFSC risks indirectly.

- Third, this study develops a hierarchical model of AFSC resilience capability factors and AFSC risk factors, respectively, which can help researchers to identify the interrelationships among different resilience capability factors and among different risk factors. The interdependencies and interrelationships among various resilience capability factors and risk factors in literature are currently inadequate (Ho et al. 2015; Zhao et al. 2018), which confirms the emerging need for this research.
- Fourth, key resilience capability factor (e.g., leadership) for building AFSC resilience and key risk factors (e.g., extreme weather conditions and political and economic instability) that have the most severe effect for the AFSC have been identified. This answers the call to strengthen the research in the risk factor analysis and determine key resilience capability factors that could have an impact on a resilient supply chain, as research on these topics are still in its infancy (Sodhi et al. 2012; Kamalahmadi and Parast. 2016).
- Finally, a KRRP framework (refer to Figure 5.6) has been built, which is not only considered to be the first framework devoted to the AFSC resilience context, but also provides the relationships among KGMs, AFSC resilience, AFSC risks, and AFSC KPIs. Furthermore, key AFSC risks and key AFSC resilience capability factors, as well as the categorisation of AFSC risks and AFSC resilience capability factors, both can be identified from this framework based on the metrics developed.

Besides the contributions to theoretical research, this study also contributes to the managerial practice significantly.

- First, this study identified different factors of various terms (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs). This will help AFSC practitioners to have a comprehensive understanding in terms of the KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. Thus, AFSC practitioners only need to focus on the identified factors in this study to manage knowledge, build AFSC resilience, to reduce AFSC risks, and improve AFSC performance.
- Second, the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks are identified. For improving AFSC performance, enhancing AFSC resilience, and reducing AFSC risks, AFSC practitioners only need to focus on how to use KGMs to facilitate managing knowledge across the AFSCs. Thus, AFSC practitioners need to use market-based, reciprocity-based, trust-based, and contract-based KGMs to build relationships with other AFSC practitioners to acquire knowledge. This will have direct positive effects in enhancing AFSC performance and AFSC resilience capabilities, and indirect positive effects in reducing AFSC risks.
- Third, this study investigated the interrelationships among different AFSC resilience capability factors and among different AFSC risk factors, respectively. A more comprehensive understanding of the AFSC resilience capability factors/AFSC risk factors and their interrelationships, through a logical structure, will enable AFSC managers to prioritise and allocate the resources in an effective way. Thus, AFSC managers can focus on the key risk factors that cause vulnerabilities and key resilience capability factors for building AFSC resilience within an AFSC. This will reduce the time and effort required to mitigate the effects of risks and build AFSC resilience if the key factors are targeted initially (Zhao et al. 2020).

- Fourth, this study classifies different risks and resilience capability factors into various categories such as independent variables, linkage variables, dependent variables, and autonomous variables. Risk/resilience capability factors were categorised into independent variables meaning that these factors were driving power of the AFSC, whereas the factors categorised into dependent variables meaning that these factors required all the other factors to come together, so as to increase them in the AFSCs. Linkage variables meaning that the factors were acted as linkage of the AFSC, any change in the system might influence these factors and induce a change to the other factors. Finally, risk/resilience capability factors were categorised into autonomous variables meaning that these factors were relatively disconnected from the system. This classification helps AFSC managers differentiate different risks or resilience capability factors. For example, alleviating the effects of dependent variables will not help to mitigate any of the other variables, as dependent variables are at the top of the TISM hierarchy model. Furthermore, the classification can be used to explain, communicate, and transfer knowledge between different departments of a company, as well as between various partners within the AFSC. Thus, the empirical findings of this study can help top management to deal with the various risk types and builds resilience from both the company and overall supply chain perspectives (Zhao et al. 2020).

1.5 Structure of the thesis

The thesis consists of eight chapters, including chapter one introduction, chapter two literature review, chapter three research methodology, chapter four identifying key constructs and building relationships among the constructs, chapter five prioritisation of risk factors and resilience capability factors through the combination of TISM and fuzzy MICMAC analysis, chapter six evaluating empirical research findings, chapter seven discussion, and chapter eight conclusions (see Figure 1.2).

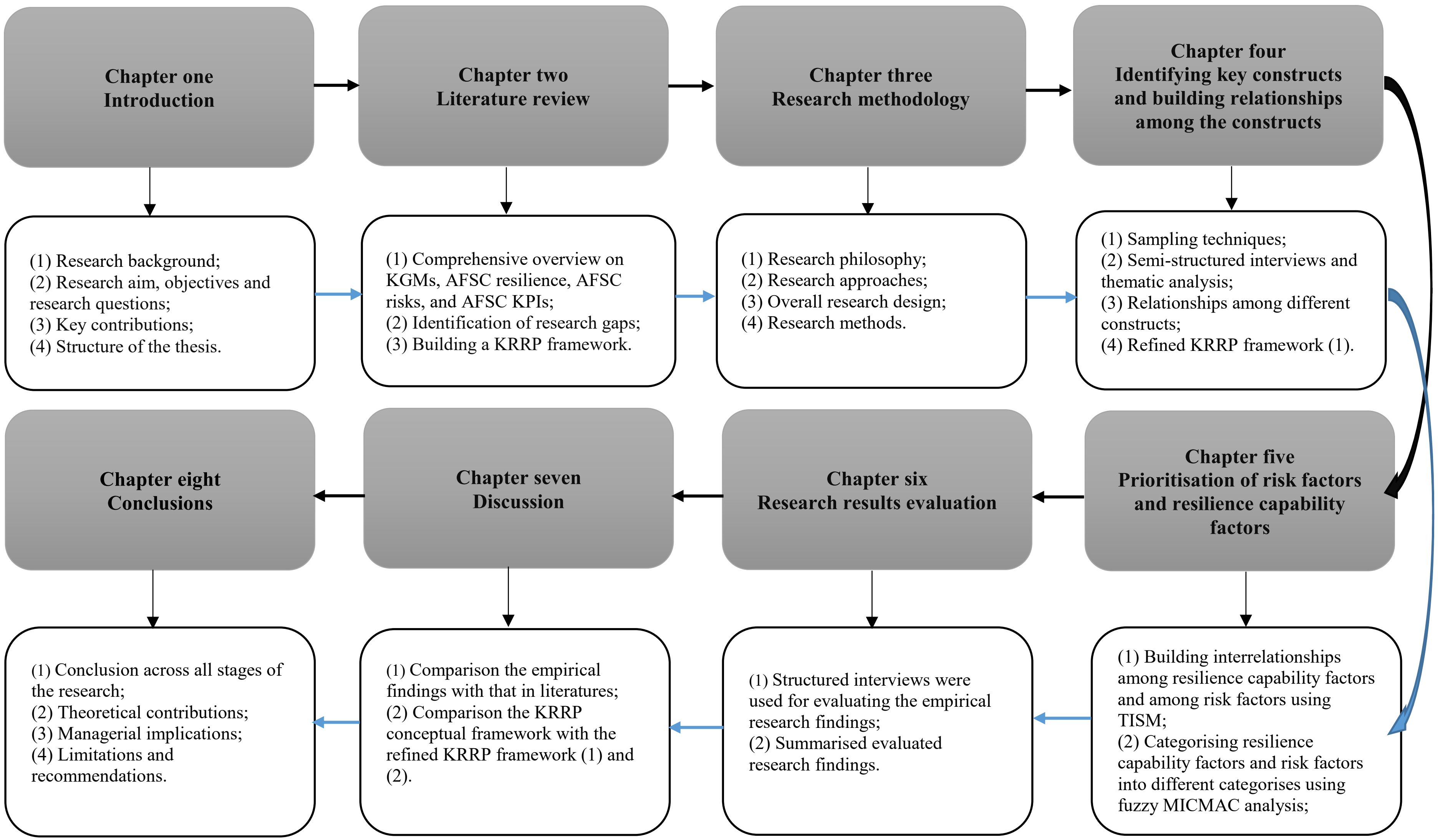


Figure 1.2 Thesis structure

Chapter one introduction starts with the research background and motivation of the study followed by the research justification. Then, the research aim, objectives and research questions are presented. Furthermore, key contributions of this study including theoretical contributions and managerial implications are summarised. Finally, the thesis structure is outlined.

Chapter two literature review was designed to undertake three tasks. First, a comprehensive review of literature on KGMs, supply chain resilience, AFSC risks, and KPIs for AFSC has been conducted. Second, based on the literature review results to generate research gaps. Third, formulate the KRRP conceptual framework as a guidance for future works.

In chapter three, the research methodology including research philosophy, data collection methods, and data analysis methods is discussed. Furthermore, the research design was carefully formulated as a guidance for data collection and analysis. Research ethics is also discussed in this section.

In chapter four, qualitative data collection, analysis and findings is discussed. Initially, the sampling techniques and the semi-structured interviews for data collection process, as well as the thematic analysis for data analysis process are presented. Then, relationships among different constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs) were built based on empirical findings. Finally, the refined KRRP framework (1) was developed based on empirical findings.

The main task for chapter five is to prioritise AFSC risk factors and AFSC resilience capability factors, respectively. Thus, TISM method for building interrelationships is introduced firstly followed by the fuzzy MICMAC analysis to categorise different resilience capability factors and risk factors into different groups, respectively. The data related to the TISM and fuzzy MICMAC analysis is collected through structured interviews.

Chapter six, evaluating empirical research findings: the factors, relationships, and key factors identified in phase one and phase two of empirical study were evaluated to check their applicability in other countries. In this phase, structured interviews were used to collect data.

In chapter seven, discussion. The evolution of different constructs such as KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs across different phases from conceptual phase to empirical phase one, empirical phase two, and finally to the evaluation phase is discussed. This chapter also examines whether the findings conformed or contradicted the literature.

Conclusions of the thesis including conclusions across all phases of the research, theoretical contributions and managerial implications are drawn in the last chapter. Furthermore, limitations and recommendations for future research are highlighted in this chapter.

1.6 Summary

This chapter briefly presents the research background and research motivation and highlights the reason for conducting the research in the field of agri-food industry. One research aim, nine research objectives, and three research questions were proposed based on the research topic. Key theoretical contributions and management implications were also highlighted. Finally, a carefully formulated thesis structure including eight chapters was presented.

Chapter two: Literature review

2.1 Introduction

This chapter attempts to review existing literature related to KGMs, AFSC risks, supply chain resilience, and AFSC performance, as well as to identify research gaps that open avenues for future research.

This chapter includes five sections, which are all critical for this research. First, review existing literature related to KGMs, focusing on trust-based KGM, reciprocity-based KGM, market-based KGM, and contract-based KGM. Furthermore, related definitions, concepts, factors for building each KGM, and empirical research on KGMs was reviewed. Second, review existing literature on AFSC risks, including risk definitions, risk categorisations, and risk analysis. Third, review existing literature of supply chain resilience, including definitions and capabilities for building supply chain resilience. As this study focuses on the agri-food industry, empirical research on AFSC resilience was reviewed. Fourth, explore KPIs that can be used for evaluating the performance of AFSCs. Finally, summarise research gaps based on the literature review results and build a conceptual framework as a guidance for empirical study.

2.2 Knowledge governance mechanisms

Knowledge is a vital resource for firms to survive and achieve sustainability and profitability in the dynamic and volatile business environment (Connell et al. 2001; Zailaniet al. 2012; Lim et al. 2017). A KBV construes that knowledge, as a valuable primary resource, has the ability to create perdurable value for firms and help them to achieve competitive advantages (Felin and Hesterly. 2007; Mejri et al. 2018). Knowledge is one of the most important resources for individuals, businesses, governments, nations and society at large, and is complex by nature (Liu. 2020). For example, knowledge as an intangible asset, or tacit knowledge, poses great pressure for researchers to create, store, share, use, learn, and improve (Evans et al. 2015). Thus, managing knowledge effectively is deemed to be critical for firms to achieve sustainable competitive advantages. Many scholars proposed different concepts and measures to manage knowledge, including organisational learning (OL), KM, knowledge governance (KG), and learning organisation (LO) (Ali. 2012; Cao and Xiang. 2012; Oh. 2019). All these four concepts of OL, KM, KG and LO deal with existing knowledge and potential for creating knowledge within an organisation. However, they consider knowledge processes from different perspectives and have different focuses in terms of their approach to knowledge (Pemsel et al. 2014). Table 2.1 demonstrates the difference among the OL, KM, KG, and LO.

Table 2.1 The difference among OL, KM, KG and LO

Terms	Definitions	Characteristics				
		Individual	Team	Organisation	Process	Technology
OL	"Learning what worked and what did not work from the past and transferring this experiential learned knowledge effectively to present-day and future knowledge workers" (Dalkir. 2017, p.266).	√	√			
	"The capacity or processes within an organization to maintain or improve performance based on experience" (Nevis et al. 1995, p. 15).	√	√		√	
	"The set of actions (knowledge acquisition, information distribution, information interpretation, and organisational memory) within the organisation that intentionally and unintentionally influence positive organizational change" (Templeton et al. 2002, p. 184).	√	√		√	√
KM	"KM enables individuals, teams and entire organisations as well as networks, regions and nations to collectively and systematically create, share and apply knowledge to achieve their strategic and operational objectives. KM contributes to increase the efficiency and effectiveness of operations on the one hand and to change the quality of competition (innovation) on the other by developing a learning organisation" (North and Kumta. 2018, p.4).	√	√	√	√	√
	"KM as the formalization of and access to experience, knowledge, and expertise that create new capabilities, enable superior performance, encourage innovation, and enhance customer value" (Gloet and Terziovski. 2004, p. 405).	√	√		√	√
	"KM is as a planned, structured approach to manage the creation, sharing, harvesting and leveraging of knowledge as an organisational asset, to enhance a company's ability, speed and effectiveness in delivering products or services for the benefits of clients, in line with its business strategy" (Plessis. 2007, p. 22).	√	√		√	√
LO	"Learning as an entire organisation at all levels to adapt and succeed with the environment that continually changes" (Reese and Sidani. 2018, p. 354).	√	√	√		
	"Facilitating the learning of all its members and consciously transforms itself and its context" (Pedler et al. 1989, p. 2).	√	√	√		
KG	"Organisational structures and mechanisms that can influence the process of using, sharing, integrating, and creating knowledge in preferred directions and toward preferred levels" (Foss et al. 2010, p. 456).			√		
	"KG employs various methods to promote intellectual activity and guide the exchange, transfer and sharing of knowledge in and amongst firms" (Grandori. 1997, p. 34).			√	√	√

From Table 2.1, it shows that OL mainly focus on the process or capacity within an organisation to facilitate the organisational learning process or allow an organisation to learn. Only insights developed by individuals and groups/teams have been extended to the organisational level, a systematic transformation of the organisation's works, practices and values can be happened (Liu. 2020). To achieve OL, it needs to create a learning culture at the organisation level, facilitate individual learning through training and development, enhance information processing and problem solving capacity, facilitate interaction, and strengthen knowledge base (Wang and Ahmed. 2003; Zhan et al. 2020). Five dimensions are considered by scholars to play an important role in facilitating OL: experimentation, risk-taking, interaction with the external environment, dialogue, and participative decision-making (Gatignon et al. 2002; Chiva et al. 2007; Park and Kim. 2018).

KM tends to focus on different dimensions to facilitate the management of knowledge, including individual, technology, process, and business environment. It can be concluded that KM is a complex research area that needs support from different disciplines (e.g., human resource management, information system, computer science, management science, and organisational studies) (Hislop et al. 2018; North and Kumta. 2018). KM includes six key KM processes: knowledge acquisition, knowledge storage, knowledge codification, knowledge sharing, knowledge application, and knowledge creation (Chen and Huang. 2009; Liao et al. 2010; Soto-Acosta et al. 2014; Liu. 2020).

LO mainly concentrates on six imperatives to build a learning organisation. In summary, at the individual level, it creates continuous learning opportunities and facilitates communication among employees; at group level, strengthens team learning; at organisational level and societal level, develops systems to capture learning, empowerment and invest on system connection. Regardless of the level, they all need leadership to support it (Gandolfi and Stone. 2018).

Although KG has some similarity with KM and LO, as they all focus on the organisational level to manage knowledge, KG is more focused on the organisational capabilities to improve knowledge processes through application of suitable mechanisms (Pemsel et al. 2014). Some scholars have considered KG as a new research approach to explaining different KM processes, in comparison with the existing research primarily holds the KBV (Cao and Xiang. 2012). KG assumes that governance mechanisms can guide and influence KM processes. Problems, methods and significance of KG are the foundation of KG research (see Table 2.2).

Table 2.2 Research problems, methods and significance of KG

Research problems (what)	"Knowledge governance chooses governance structure and coordinates mechanisms to influence the transfer, sharing, integration, use and creation of knowledge. Typical research problems include: What is the effect of different types of incentive measures for knowledge sharing, integration and creation? In and between firms, which kind of governance mechanism is available for promoting knowledge sharing, integration, and creation? What are the risks in the process of knowledge governance? How do we avoid these risks by appropriating governance mechanisms?" (Foss and Michailova. 2009, p. 8)
Research methods (how)	"Knowledge governance approaches problem solving through the relationship of knowledge governance mechanisms and knowledge management process. For example, it embodies some hypotheses on individual incentives, preferences, expectations and cognitive styles. Scholars trace the causal processes from organisational levels to individual levels and their interacting functions. In addition, they explore various micro-processes (at the individual level) that lead to knowledge use, sharing and creation" (Foss and Michailova. 2009, pp. 9-10).
Research significance (why)	"Knowledge governance provides more comprehensive understanding of the factors of individual levels of influence on knowledge management processes, such as ability, decision-making, behaviors, belief, expectations, interest, imagination and preference". "Knowledge governance can help us understand how factors at the level of an individual correspond to those at organisational levels. This is essential for studying macro-level problems. Knowledge governance integrates a fresh perspective to understand the problems between knowledge and collective efforts of the organisation" (Foss and Michailova. 2009, pp. 272-285).

Source: Foss and Michailova (2009, pp. 8-10, pp. 272-285)

KG is a relatively new concept, which refers to the application of formal or informal rules that coordinate, guide and regulate knowledge processes, including knowledge creation, knowledge sharing, as well as access to and use of knowledge (van Kerkoff. 2014; Clark et al. 2016). It includes four aspects - governance environment, governance mechanisms, implementation, and governance goal. Governance mechanisms are identified critically because it coordinates the behaviour of organisational members, facilitate knowledge communications, and decrease conflicts and misunderstandings during KM process (Yang. 2011; Fang et al. 2013). It is increasingly accepted among academics and practitioners that KGMs have become a useful organisational strategy for value creation and sustainable competitive advantage (Lyles and Salk. 2007). Maximising the firm's knowledge related effectiveness, renewing knowledge constantly, and improving firm's innovation performance can be achieved by applying appropriate KGMs (Latilla et al. 2018). Hoetker and Mellewigt (2009, p. 1027) argued that "KGMs are the underlying and concrete management and control activities, which describe in detail how the required behaviour of the partner will become motivated, influenced, and established, or more generally, in which ways the desirable or predetermined gains are to be fulfilled". For example, Grandori (1997) examined organisation mechanisms of KG in and among firms. Their research results indicate that organisation mechanisms are effective in promoting intellectual activities such as knowledge exchange, share, and transfer.

Michailova and Foss (2009) and Foss et al. (2010) hold a similar view after examining KGMs from the perspective of the application of formal and informal mechanisms. Formal KGM includes organisation structure, salary, job design and leadership, whereas informal KGM reflects organisational culture, social networks, fairness, management style, and management support (Foss et al. 2010). Many scholars (Cao and Xiang. 2012; Wang et al. 2018) have suggested that formal KGMs represent an effective way to motivate employees to expend effort on searching, creating, sharing and transferring knowledge. Performance evaluations, incentives and other reward systems, promotions, training, bonuses, and performance-based pay all can be seen as measures of formal KGMs (Wang and Noe. 2010). Informal KGMs are the primary means for establishing interpersonal relationships, which can help people to share knowledge (Yamao et al. 2009). Social norms, teamwork, and trust can be seen as measures of informal KGMs (Quigley et al. 2007).

2.2.1 Trust-based knowledge governance mechanism

Besides categorising KGMs into formal and informal, KGMs can also be divided into four groups, which are trust-based, reciprocity-based, market-based, and contract-based KGMs (Fang et al. 2013). Trust refers to the "confidence in the ability of others, yielding ascriptions of capability and reliability" (Cook and Wall. 1980, p. 40). It plays a significant role in controlling and coordinating inter-firm relations such as fostering open communication and flexibility, reducing transaction cost, facilitating knowledge exchange and transfer, enabling partner commitment, and facilitating cooperation (Inkpen and Tsang. 2005; Kautonen. 2006; Li et al. 2010; Jiang et al. 2013). Furthermore, trust increases transparency of inter-firm learning and minimise the transaction cost over the long-run (Lane et al. 2001; Shahzad et al. 2020). However, a lack of trust between/among partners may result in inefficient and ineffective performance (Kwon and Suh. 2004).

A trust-based KGM is a way of fostering trust between partners for facilitating knowledge transfer (Nooteboom. 2000). It can be seen as a key factor in forming collaborative inter-organisational relationships, reducing costs and risks involved in collaboration, facilitating supply chain learning, and further increasing overall supply chain performance (Bunduchi. 2013). Key antecedents for building trust such as existing relationship, third party referrals, accurate and open communication, previous positive collaborations, reasonable behaviour, and geographical proximity, all have been approved effectively in facilitating inter-organisational knowledge transfer in various supply chains (Bstieler. 2006; Bonte, 2008; Rutten et al. 2016). It is interesting to note that almost all researchers (Khalfan et al. 2007; Wang et al. 2014; Dubey et al. 2019; Wang et al. 2019) have investigated key antecedents for building trust from general supply chain perspective, green supply chain perspective, construction supply chain perspective, manufacturing supply chain perspective, and humanitarian supply chain perspective (see Table 2.3). There is a significant lack of studies to investigate trust-based KGM from the perspective of AFSC.

Table 2.3 Key antecedents for building trust-based KGM

Key antecedents	Research context	Author(s)
Existing relationship, third party referrals	General supply chain	Smith Ring et al. (1994); Das and Teng (2001); Bstieler (2006); Bonte (2008)
Partner's asset specificity, information sharing, perceived satisfaction, partner's reputation	General supply chain	Kwon and Suh (2004)
Experience, problem-solving, reasonable behaviour, shared goals and reciprocity	Construction supply chain	Khalfan et al. (2007)
Communications, shared value, participation, learning capacity	Green supply chains	Cheng et al. (2008)
Existence of legal document, risk sharing, incentive alignment, responsibilities alignment, share of the firm in total value added	Retail distribution supply chain	Ghosh and Fedorowicz (2008)
Government support, interpersonal relationships	General supply chain	Cai et al. (2010)
Information availability, information quality	General supply chain	Chen et al. (2011)
Managerial ties	Manufacturing supply chain	Wang et al. (2014)
Accurate and open communications, geographical proximity	General supply chain	Rutten et al. (2016)
Organisational culture, big data analytics	Humanitarian supply chain	Dubey et al. (2019)
Data security, blockchain technology	General supply chain	Wang et al. (2019)

After investigating the relationship between trust and knowledge sharing in the context of green supply chains, Cheng et al. (2008) proposed that shared values, active participation, communication and learning opportunity are positively related to building trust, whereas opportunistic behaviour and power are negatively related to build trust. Furthermore, their research results also indicate that the more a factor contributes to trust positively, the more the factor contributes to knowledge sharing. Ghosh and Fedorowicz (2008) reinforced that trust as a governance mechanism has significant positive effects in sharing information among supply chain partners. Information sharing among business partners will lower the degree of behavioural uncertainty and indirectly will improve the trust level among supply chain partners (Kwon and Suh. 2004). Besides fostering trust from individual, organisation and policy perspectives, some researchers discussed how to improve trust from data security perspectives such as applying blockchain technology and big data analytics (Dubey et al. 2019; Wang et al. 2019).

2.2.2 Reciprocity-based knowledge governance mechanism

Reciprocity has been defined by Polanyi (1957, p. 210) as "the giving and receiving according to need", which is a key mechanism to maintain the stability of supply chain and exchange relationships. Kjorstad (2017) reinforced the "norm of reciprocity" as an essential mechanism to ensure stabilising of social systems. Their research suggests that a norm of reciprocity makes two minimal demands: (1) people should help those who have helped them; and (2) people should not injure those who have helped them. The norm of reciprocity plays a key role in various business contexts and relationships as it exerts its influence on different business partners to return good deeds that they have received from others, and thus it can act as an insurance of future supports when needed (Tangpong and Pesek. 2007).

In a supply chain KM context, when there is a strong norm of reciprocity in the collective, knowledge contributors are more willing to share their knowledge with others (Wasko and Faraj. 2005; Yan and Jian. 2017). Thus, the reciprocity-based KGM has been suggested by Fang et al. (2013) as a way to help build reciprocal relationships between members for facilitating knowledge transfer. It has been indicated that reciprocity-based KGM will affect one's knowledge sharing attitudes first, before it results in more active knowledge sharing activities (Bock et al. 2005). Relationships based on reciprocity may promote the transfer/share of distinctive knowledge and resources because stable relationships between involved parties have been built (Inkpen and Tsang. 2005; Tsai and Kang. 2019). When individuals have faith that their knowledge contribution will be rewarded through reciprocations and ensuring ongoing contribution (Wasko and Faraj. 2005), they are motivated to share tacit knowledge (Hau et al. 2013). Ganguly et al. (2019) observed that knowledge reciprocity has positive effects in facilitating tacit knowledge sharing and improving the innovation capability of an organisation. Furthermore, knowledge reciprocity also helps to temper opportunism, facilitate cooperation, and further reduce the transaction costs of supply chain members (Ganguly et al. 2019).

2.2.3 Market-based knowledge governance mechanism

Knowledge is increasingly recognised by marketing management as a valuable resource that can be managed to enhance the firm's competitive advantage and financial performance (Sharma and Bansal. 2020). Acquiring knowledge from markets and sharing it between different departments of a firm has been recognised as a key measure to increase the core capability of a firm (Kim and Shim. 2018). Market knowledge acquisition not only helps firms to expand their knowledge base, but also helps them to generate new ideas and detect future trends through integrating knowledge from potential markets (Laursen and Salter. 2006; Li et al. 2017). Thus, market-based KGM has emerged as a key capability for helping firms to acquire knowledge from markets. In the market-based KGM, prices afford high-powered incentives that encourage members to explore and exploit knowledge, and then apply the acquired knowledge to their products to satisfy further the market requirements (Nickerson and Zenger. 2004). In these conditions, knowledge is transferred and exchanged at a market price based on the negotiation between supply and demand. This type of KGM is more suitable for acquiring tangible aspects of knowledge, such as technology or patents (Millar and Choi. 2010; Xie et al. 2018).

2.2.4 Contract-based knowledge governance mechanism

Contracts are always used to specify promises, roles, processes, and obligations of contracting parties through detailed, explicit, and legally written contracts (Vandaele et al. 2007). Specifically, detailing rewards and incentives for achievements, punishments for noncompliance, and, most importantly, outcomes or outputs need to be delivered (Poppo and Zenger. 2002). Well-specified contracts provide formal rules and procedures for contracting parties to maintain the relationship, also provide guidelines for them to solve conflict in future situations (Charterina et al. 2018). Thus, opportunistic behaviours of business partners can be restrained, as partners find it risky and costly to pursue short-term interests or to violate contract terms (Blomqvist et al. 2005). However, some researchers (e.g., Luo. 2002; Wang et al. 2011) argued that over-detailed contracts might hamper information sharing, increase costs for compliance, pose threats for building a trust relationship, and set of obstacles for tacit knowledge transfer, as too detailed contract clauses on what is and is not allowed. Too-detailed contracts or too-little detailed ones, both have negative effects on the relationships of business partners. Besides, contracts' functions such as (1) coordination function for specifying behaviours of contracting parties; (2) safeguarding function for protecting parties against potential opportunism and financial and operational uncertainties (Kern and Willcocks. 2000); (3) adaption function for adjustments resulting from market changes (Schepker et al. 2014); and (4) learning function for partner-specific learning and joint improvements (Mayer and Argyres. 2004), these functions have their unique advantages, therefore, have been applied in the field of KM.

Contract-based KGM is a form of control and coordination for building social bonds between partners for facilitating knowledge transfer (Fang et al. 2013). It is useful in regulating knowledge sharing/transfer through the process of formal contract documentation. For example, contract-based KGM has been used in the outsourcing activities for controlling whether and what knowledge should be shared (Samuel et al. 2011). Furthermore, contract-based KGM has positive effects in preventing knowledge leakage in the context of strategic alliances (Jiang et al. 2013). For improving the innovation performance of firms, trust and contract are essential after investigating manufacturing industry (Wang et al. 2011). Contract-based KGM has been approved effective in transferring knowledge among business partners, but the research result conducted by Zhang and Zhou (2013) states a sharp contrast with previous findings. Their research results indicate that contract-based KGM has no effect on knowledge transfer in China as the weak enforceability of the legal system in China makes contracts a less reliable mechanism.

In Table 2.4, different papers on KGMs are selected and summarised based on the following two criteria:

- First, only papers published in international peer-reviewed journals can be included in the table for analysis, to ensure a certain level of quality (Touboulic and Walker. 2015);
- Second, out of the papers selected in the previous stage, only those papers in which the abstract, introduction, and conclusions that focus on the KGMs that can be included in the table for analysis, to ensure that all the papers selected are concentrating on the KGMs.

Table 2.4 summarises the content and characteristics of each paper. In consistent with Seuring and Muller (2008), five research methodologies were used to distinguish papers: theoretical and conceptual papers, case studies/interviews, surveys, modelling papers, and literature reviews. Furthermore, the selected papers are listed in chronological order to show how KGMs evolved over time (Mangiaracina et al. 2015). Based on the summary of studies on KGMs, several research gaps related to the KGMs are summarised as follows:

- First, based on the author's knowledge, little research has been conducted to explore which factors are effective for building KGMs. Existing research on KGMs mainly focuses on KGMs implementation (Fang et al. 2013; Tan et al. 2018; Yang et al. 2019) and KGMs categorisation. Thus, there is a clear need to explore antecedents for building different KGMs.
- Second, the application of KGMs have been applied in different industries, including home appliance industry, high-tech industry, manufacturing industry, and IT industry (Liu et al. 2017; Kim et al. 2018; Zhao et al. 2018; Singh et al. 2019) (see Table 2.4).

However, there is a lack of literature investigating the application of KGMs in the agri-food industry. Thus, the research results indicate a clear need to investigate KGMs in the agri-food industry.

Table 2.4 Empirical studies on KGMs

Author(s) (year)	Topic focus	Methodology adopted	Theoretical/ empirical	Qualitative/ Quantitative/Mix-methods approach	Research context
Peltokorpi and Tsuyuki (2006)	KGMs used for promoting KM processes	Case study	Empirical	Quantitative	Project-based organizations
Antonelli and Calderini (2008)	Knowledge compositeness of the flow of patents delivered to the main European automobile companies and the evolution of their technological and product market shares	Modelling	Empirical	Quantitative	Automotive industry in Europe
Bocquet and Mothe (2010)	Knowledge governance within clusters	Modelling	Empirical	Qualitative	Small firms
Bosch-Sijtsema and Postma (2010)	Explore governance factors affecting knowledge transfer	Case study	Empirical	Qualitative	International projects
Olander et al. (2010)	Relational and contractual KGMs	Case study	Empirical	Qualitative	Research and development firms
Gooderham et al. (2011)	Market-based, hierarchical and social KGMs for facilitating knowledge transfer	Modelling	Empirical	Quantitative	Multinational corporations
Cao and Xiang (2012)	Formal and informal KGMs for facilitating knowledge sharing	Modelling	Empirical	Quantitative	Chinese strategic emerging firms
Husted et al. (2012)	Commitment –based and transaction-based KGMs	Modelling	Empirical	Quantitative	Public/State organizations and business firms
Cao and Xiang (2013)	Analyse the knowledge governance on knowledge sharing	Modelling	Empirical	Quantitative	Chinese strategic emerging firms
Huang et al. (2013)	Formal and informal KGMs	Modelling	Empirical	Quantitative	Multinational companies
Liu et al. (2017)	Transactional and relational KGMs	Modelling	Empirical	Quantitative	Home appliance industry
van Kerkoff and Pilbeam (2017)	KG for facilitating understanding socio-cultural dimensions of environmental decision-making	Case study	Empirical	Qualitative	Not mentioned
Kim et al. (2018)	The relationship between KGMs and sustainability	Modelling	Empirical	Quantitative	Manufacturing firms
Pemsel et al. (2018)	KGMs to foster capability development	Case study	Empirical	Qualitative	Project-based organization
Tan et al. (2018)	The implementation of KGMs	Modelling	Empirical	Quantitative	Small and medium enterprises (SMEs)
Zhao et al. (2018)	KG on innovation performance	Modelling	Empirical	Quantitative	High-tech industries
Davila et al. (2019)	The use of KGMs and their effect on innovation performance in Brazilian firms	Survey and modelling	Empirical	Mix-methods approach	Not mentioned
Singh et al. (2019)	Formal and informal KGMs	Modelling	Empirical	Quantitative	Large-sized IT organizations
Yang et al. (2019)	Contract-based and trust-based KGMs	Modelling	Empirical	Quantitative	SMEs

2.3 Supply chain risks and related concepts

Risks exist in all types of supply chains. Even if supply chains operate effectively, risks are still prevalent (Rao and Goldsby. 2009; Quang and Hara. 2018). Risks are prevalent because of several reasons. First, many firms focus solely on improving their financial performance and product quality, thus, neglect the management of risks. A series of lean strategies (e.g., JIT and supply base reduction) have been applied to eliminate waste and reduce cost across the 1990s (Tang and Tomlin. 2008; Danese et al. 2018). There is no doubt that these strategies can help to increase the company's financial performance, but also pose challenges to their supply chains as the number of partners decreases (Christopher et al. 2011; Kamalahmadi and Parast. 2016). Second, supply chains are becoming more complex and longer in the era of globalisation, which caused supply chains to be vulnerable to disruptions as they are slow to respond to supply chain risks (Mangla et al. 2015). Third, the global business environment is becoming turbulent because of increased competition, changes in customer expectations, and rapid technological innovation (Acquaah et al. 2011; Liu. 2013; Fan and Stevenson. 2018). Thus, it is necessary for us to have a deep understanding of supply chain risks and its related concepts.

In this section, a comprehensive understanding of supply chain risks and its related concepts was conducted through a literature review. First, the definitions of supply chain risks were provided. Second, SCRM and its related concepts were reviewed. Finally, risk factors existing in the AFSC and related risk categorisation were reviewed, as this study focusing on the AFSC.

2.3.1 Supply chain risk definition and perceptions

In an era, full of uncertainty and turbulence, supply chain risk identification, categorisation, assessment, and mitigation are being considered as increasingly important, but only a limited number of scholars have explicitly defined supply chain risks. Supply chain risk has been defined by March and Shapira (1987, p.1404) as "the variation in the distribution of possible supply chain outcomes, their likelihoods, and their subjective values". This definition focuses on two characteristics of supply chain risks, which are supply chain outcomes and the likelihood of occurrence. Juttner et al. (2003, p.200) defined supply chain risk as "any risks for the information, material and product flows from the original supplier to the delivery of the final product for the end user". Their definition highlights that supply chain risks may hide in different supply chain business activities, such as risk from information, product, and material flows. The definition proposed by Bogataj and Bobataj (2007) assumes that any activities that influence the decrease of value added to supply chains can be seen as supply chain risks. Likewise, Ho et al. (2015) defined supply chain risk as adversely unexpected events that influence any part of a supply chain. Different supply chain risk definitions are summarised in Table 2.5.

Table 2.5 Definitions of supply chain risk (Note: keywords are highlighted)

Author(s)	**Definition of supply chain risk**	**Characteristics**
March and Shapira (1987, p.1404)	"The variation in the distribution of possible supply chain **outcomes**, their **likelihoods**, and their subjective values."	Impact and likelihood of occurrence
Juttner et al. (2003, p.200)	"Any risks for the **information, material and product flows** from original supplier to the delivery of the final product for the final user."	Risks from information, material and product flows
Wagner and Bode (2006, p.303)	"The negative deviation from the expected value of a certain performance measure, resulting in **negative consequences** for the focal firm."	Negatives consequences for the focal firm
Bogataj and Bobataj (2007, p.291)	"The potential variation of outcomes that **influence the decrease of value added** at any activity cell in a chain."	Influence the decrease of value added
Ellis et al. (2010, p.36)	"An individual's perception of the total potential loss associated with the disruption of **supply** of a particular purchased item from a particular supplier."	Supply risk only
Ho et al. (2015)	"The likelihood and impact of **unexpected macro and/or micro level events or conditions** that **adversely influence** any part of a supply chain leading to operational, tactical, or strategic level failures or irregularities."	Unexpected adversely events, influence any part of a supply chain
Heckmann et al. (2015, p.130)	"Supply chain risk is the **potential loss** for a supply chain in terms of its target values of efficiency and effectiveness evoked by uncertain developments of supply chain characteristics whose changes were caused by the occurrence of triggering-events."	Uncertain developments of supply chain characteristics, efficiency, effectiveness

Although these definitions have their unique characteristics that focus on the different domains of supply chains, such as risks from information, material, and product flows (Juttner et al. 2003), negative consequences for the focal firm of a supply chain (Wagner and Bode. 2006), they focus either on a specific function or a part of a supply chain, and do not take the supply chain performance into consideration. Given this, Heckmann et al. (2015, p.130) proposed a supply chain risk definition with consideration of the impacts of risks on supply chain performance: "supply chain risk is the potential loss for a supply chain in terms of its target values of efficiency and effectiveness evoked by uncertain developments of supply chain characteristics whose changes were caused by the occurrence of triggering-events".

Supply chain risk is often used interchangeably with the term of "supply chain uncertainty" (Hult et al. 2010). Risk is associated with the negative consequence that arises from an event or activity (Ho et al. 2015), whereas uncertainty may have both positive and negative outcomes. It has been argued that the term "supply chain uncertainty" is a broader concept that refers to uncertainties (including risks) that may occur at any point of a supply chain (Simangunsong et al. 2012). For example, demand uncertainty may help farmers in AFSC to gain profits because of demand increasing, or cause farmers bankrupt due to a lack of demand from customers. However, supply risk refers to failure to supply goods to customers (Kumar et al. 2010).

2.3.2 Supply chain risk management

SCRM is becoming a hot topic that attracted researchers and practitioners to investigate, especially in the modern era wherein firms operate in uncertain business environments (Manuj and Mentzer. 2008; Baryannis et al. 2019). SCRM has been defined by several researchers, as summarised in Table 2.6. The results indicate that almost all the definitions on SCRM have emphasised that to collaborate and coordinate between/among supply chain partners is necessary to reduce supply chain risks (Norrman and Jasson. 2004; Juttner. 2005; Tang. 2006; Goh et al. 2007; Ho et al. 2015; Fan and Stevenson. 2018). Therefore, it is not surprising that these definitions may have limitations because they solely focus on the specific element to define SCRM. Considering SCRM is a complex process that may involve different activities, a comprehensive definition on SCRM is required that includes SCRM process, tools and techniques that required for tackling risks, coordination and collaboration, and SCRM outcomes (Ho et al. 2015). Thus, Fan and Stevenson (2018, p. 215) defined SCRM as "The identification, assessment, treatment, and monitoring of supply chain risks, with the aid of the internal implementation tools, techniques and strategies and of external coordination and collaboration with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantage".

Table 2.6 Definitions of SCRM (Note: keywords are highlighted)

Author(s)	Definitions of SCRM
Juttner (2005, p.124)	"The identification and management of risks for the supply chain, through a **coordinated approach** amongst supply chain members, to reduce supply chain vulnerability as a whole".
Norrman and Jasson (2004. P.436)	"To **collaborat**e 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".
Tang (2006, p. 453)	"The management of supply chain risks through **coordination or collaboration** among supply chain partners so as to ensure profitability and continuity".
Goh et al. (2007, p.164)	"The identification and management of risks within the supply network and externally through **a coordinated approach** amongst supply chain members to reduce supply chain vulnerability as a whole".
Thun and Hoenig (2011, p. 243)	"Characterised by a cross-company orientation aiming at the **identification** and reduction of risks not only at the company level, but rather focusing on the entire supply chain".
Ho et al. (2015, p. 2036)	"An inter-organisational collaborative endeavour utilising **quantitative and qualitative risk management methodologies** to **identify, evaluate, mitigate and monitor** unexpected macro and micro level events or conditions, which might adversely impact any part of a supply chain".
Fan and Stevenson (2018, p. 215)	"The **identification, assessment, treatment, and monitoring** of supply chain risks, with the aid of the internal implementation of tools, techniques and strategies and of external **coordination and collaboration** with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantage".

SCRM includes four processes: risk identification, risk assessment/evaluation, risk mitigation/treatment, and risk monitoring (Ho et al. 2015; Fan and Stevenson. 2018). Risk identification is the first step of SCRM, which means identifying the risks that exist in supply chains. Risk identification is critical for SCRM because only the risks be identified that risk management plan can be triggered (Neiger et al. 2009). To identify supply chain risks, the priority is to classify risks into different categories (Aqlan and Lam. 2015). Potential risks in supply chains can be categorised according to different perspectives (Rao and Goldsby. 2009; Rangel et al. 2015) such as low/high probability risks, high/low consequence risks, and internal/external risks (Kleindorfer and Saad. 2005; Kumar et al. 2010; Ho et al. 2015). Besides, some studies have divided risks into three categories – internal, network-related, and external risks (Lin and Zhou. 2011), as well as material flow risk, financial flow risk, and information flow risk (Tang and Musa. 2011). Further categorisation of risks is provided by Mason-Jones and Towill (1998) and Christopher and Peck (2004). Risks are classified into five types: (1) internal to the focal firm, which are process and control risks; external to the focal firm, but internal to the supply chain network, which are demand and supply risk; and (3) external to the supply chain network, which are environmental risks.

Risk assessment/evaluation is associated with evaluating the likelihoods and consequences of prospective risks (Knemeyer et al. 2009). It is a necessary step to perform SCRM as the identified risk factors and related risk categories need to be properly evaluated and assessed, further suitable management actions can be adopted (Hallikas et al. 2004). The current research typically focuses on four dimensions of supply chain risk assessment: supply chain risk prioritisation, supply chain risk interrelationships, supply chain risk assessment strategies, and the assessment of the relationship between supply chain risks and strategies (Ho et al. 2015). While focusing on the assessment of particular risk types has its advantages, the interrelationship among different supply chain risks is certainly an important issue that needs to be investigated (Zhao et al. 2020). Traditional risk management strategies may fail without considering the interconnections among different risks, as some risks may exacerbate when the mitigation strategies of other risks are implemented (Aqlan and Lam. 2015). Investigating interrelationships among different supply chain risks leads to a better management of the supply chain, as supply chain managers need to consider all the risks and their relationships as a whole to deploy risk mitigation strategies (Diabat et al. 2012; Ho et al. 2015; Zhao et al. 2020).

Risk mitigation means to reduce risks to an acceptable level (Fan and Stevenson. 2018). A significant amount of work has been conducted by academia and practitioners in the area of risk mitigation/treatment (Tang and Tomlin. 2008; Diabat et al. 2012; Aqlan and Lam. 2015), as controlling and mitigating the negative effects of supply chain risks is the priority. Through applying strategies to eliminate the impacts of risk events (risk avoidance), transfer risks (risk transfer), and share some or all risks with other supply chain members (risk sharing), supply chain risks can be minimized or eliminated. Risk mitigation strategies have been identified as effective to tackle supply chain risks. Some of the strategies are increasing flexibility, building collaborative relationships with supply chain members, sharing information, properly managing suppliers, adopting co-opetition, implementing corporate social responsibility (CSR) activities, and building SCRM culture (Christopher and Lee. 2004; Bakshi and Kleindorfer. 2009; Dowty and Wallace. 2010; Talluri et al. 2013; Dong and Cooper. 2016).

Finally, supply chains risks need to be continuously monitored, reviewed, and updated, thus, appropriate supply chain risk mitigation strategies that can be applied to respond to the constantly changing risks (Zsidisin. 2003; Tsang et al. 2018). Although risk monitoring plays an important role in helping supply chains to operate smoothly and efficiently in the volatile business environment, it has received limited attention (Blackhurst et al. 2008; Hoffmann et al. 2013). The literature review results conducted by Fan and Stevenson (2018) indicates that only 2.8% of papers paid attention to risk monitoring among the selected 354 papers.

Furthermore, various quantitative and qualitative research methods are applied to assess, control and mitigate the negative effects of supply chain risks, including mathematical programming (Laeequddin et al. 2009), quantitative survey analysis (Wagner and Bode. 2006), integrative structural modelling (ISM) (Diabat et al. 2012), analytic hierarchy process (AHP) (Guan et al. 2011), and case analysis (Leat and Revoredo-Giha. 2013). Table 2.7 summarises some of the most widely used research methods in the SCRM research.

Table 2.7 Typical research methods for SCRM

Author(s) (year)	**Topic focus**	**Methodology adopted**	**Theoretical/ empirical**	**Qualitative/ Quantitative/Mix-methods approach**
Ritchie and Brindley (2007)	Risk mitigation	Case study	Empirical	Qualitative
Wagner and Bode (2008)	Risk identification and analysis	Modelling	Empirical	Quantitative
Laeequddin et al. (2009)	Risk assessment	Modelling	Theoretical	Quantitative
Pujawan and Geraldin (2009)	Risk assessment and mitigation	Modelling	Theoretical	Quantitative
Dani and Deep (2010)	Risk mitigation	Case study	Theoretical	Qualitative
Dowty and Wallace (2010)	Contingency planning	Case study	Empirical	Qualitative
Christopher et al. (2011)	Risk analysis and mitigation	Case study	Empirical	Qualitative
Guan et al. (2011)	Risk identification	Modelling	Theoretical	Quantitative
Zhang et al. (2011)	Contingency planning	Modelling	Theoretical	Quantitative
Diabat et al. (2012)	Risk assessment	Case study and modelling	Empirical	Mix-methods approach
Baghalian, Rezapour, and Farahani (2013)	Risk analysis	Modelling	Theoretical	Quantitative
Leat and Revoredo-Giha (2013)	Risk identification and contingency planning	Case study	Empirical	Qualitative
Ren et al. (2015)	Risk assessment	Modelling	Theoretical	Quantitative
Septiani et al. (2016)	Risk identification, assessment, mitigation	Conceptual	Theoretical	Qualitative
Behzadi et al. (2018)	Risk mitigation	Conceptual	Theoretical	Qualitative
Esteso et al. (2018)	Risk mitigation	Conceptual	Theoretical	Qualitative
Moazzam et al. (2018)	Risk assessment	Case study	Empirical	Qualitative
Zhou et al. (2019)	Risk mitigation	Case study	Empirical	Qualitative

Source: Zhao et al. (2020, p. 4853)

Although all these methods have their advantages in analysing supply chain risks, each one has its own limitations. For example, AHP cannot effectively evaluate risk and uncertainty because it presumes the relative importance of risks (Chan and Kumar. 2007), while ISM provides answers to what and how questions but is unable to answer why in theory building (Jena et al. 2017). However, it is interesting to note that although TISM has an advantage over ISM in answering the why question, and has been applied in different areas such as cloud computing (Amma et al. 2014), construction (Sandbhor and Botre. 2014), flexible manufacturing systems (Jain and Raj. 2015), and smartphone manufacturing ecosystems (Jena et al. 2016). To the author's best knowledge, far too little attention has been paid to how to use TISM to identify the interrelationships among different AFSC risks. Qualitative methods are mainly used for identifying or categorising risks and constructing SCRM ideas (Cavinato. 2004), whereas quantitative methods are used for risk assessment (Sodhi. 2005).

2.3.3 Risk factors in AFSC and related risk categorisation

Generally, there are risks hidden in all business activities (Pfohl et al. 2011). AFSCs face more challenges due to their unique characteristics – perishability, seasonality, and long production throughput time. Furthermore, globalisation, along with rapid urbanisation, diet diversification, and evolving regulatory and legislative interventions, command the increase of better quality, rich nutrition, and low pesticide usage in agri-food products (Tsolakis et al. 2014). There is no doubt that customer demands on higher quality products, makes AFSC are more vulnerable to AFSC risks. Thus, AFSCs' managers need to coordinate management activities efficiently and effectively to maintain quality and other performance standards (Moazzam et al. 2018). However, this is a difficult task as risks may arise from diverse factors. For example, defective and risky products maybe recalled because of contamination, with such recalls proving costly and detrimental to firms' reputation and service quality (Marucheck et al. 2011). Fresh vegetables maybe wasted due to imperfect shape and imbalance in offer and demand. For example, in Argentina, imperfect shape vegetables (e.g., tomato, eggplant, and prepper) would be laid in the land till perishability because farmers could not sell these imperfect vegetables. However, the situation is totally different in the Southern France. Imperfect vegetables were all donated to the charities or sold to the secondary market with a relatively lower price because farmers in the Southern France could not stand their vegetables be wasted.

Simultaneously, risks may emerge in different AFSC stages before the consumption of the final products such as production, storage, processing, and distribution (Nakandala et al. 2017; Zhou et al. 2019), with significant and adverse effects on the supply chain performance (Blackhurst et al. 2005; Yang and Yang. 2010; Macdonald et al. 2018). The production process is associated with biological production, which is affected by weather variability, pests and diseases, seasonal factors, and price variability (Weintraub and Romero. 2006). In the processing stage, there are special risks associated with food quality and safety (Esteso et al. 2018). For example, contamination is the most serious of food safety-related risks that may occur in the production and processing stages, and may involve incidents that could constitute a public health emergency of domestic or international concern (Dani and Deep. 2010). Typical food contamination includes biological contamination, physical contamination, chemical contamination, and cross-contamination (Nerin et al. 2016). In the distribution stage, the agricultural market is particularly volatile and heterogeneous, and extremely sensitive to economic and financial fluctuations (Borodin et al. 2016). Further, the seasonality, supply spikes and perishability attributes of agri-food products may cause substantial loss of product value if not properly handled in the packaging, storage, and transportation processes (Behzadi et al. 2018).

Therefore, it is crucial to develop a typology with a structured and detailed collection of risks for definitive risk analysis and management. Three steps are followed to categorise the risks (Sodhi et al. 2012; Zhao et al. 2020). First, a broad view on SCRM to build a generic understanding of the risk categories and match various risk factors with appropriate categories was built. Second, this study focuses on AFSCs and new categories to evaluate which risk factors should be incorporated or removed and why. Third, pilot interviews were conducted with experts to refine the results further. Thus, the identified AFSC risks fall into nine categories: supply, demand, biological and environmental, political and macroeconomic, weather-related, logistical and infrastructure, policy and regulatory, financial, and management and operational risks (see Table 2.8).

Table 2.8 AFSC risks identified from literature

Risk types	Risk factors	References
Supply risks	(1) supplier bankruptcy; (2) volatility in fertiliser cost; (3) delay in securing financial support; (4) poor planning; (5) yield uncertainty; (6) supplier quality problem; (7) capacity fluctuations/shortages in the supply market;	Anton et al. (2011); Leat and Revoredo-Giha. (2013); Nyamah et al. (2017); Behzadi et al. (2018);
Demand risks	(1) insufficient information from customers; (2) volatile of customer demand; (3) market price volatility; (4) changes in food safety requirements;	Dani and Deep. (2010); Nyamah et al. (2017); Behzadi et al. (2018);
Biological and environmental related risks	(1) pests and diseases risk; (2) contamination related to poor sanitation and illnesses; (3) contamination affecting food safety; (4) contamination and degradation of production and processing processes;	Nyamah et al. (2017); Leat and Revoredo-Giha. (2013);
Political and macroeconomic related risks	(1) political instability, war, civil unrest or other socio-political crises; (2) interruption of trade due to disputes with other countries; (3) nationalisation/confiscation of assets, especially belonging to foreign investors; (4) changes in the political environment due to introduction of new laws or stipulations;	Nyamah et al. (2017); Yeboah et al. (2014);
Weather-related risks	(1) periodic deficit/excess rainfall; (2) extreme drought; (3) Flooding; (4) extreme wind; (5) cold weather; (6) hailstorms;	Nyamah et al. (2017); Leat and Revoredo-Giha. (2013);
Logistical and infrastructure related risks	(1) poor infrastructure and services; (2) volatility in fuel price; (3) unreliable transport; (4) changes in transportation; (5) lack of infrastructure and service units; (6) poor performance of logistics service providers; (7) lack of effective system integration; (8) labour disputes;	Nyamah et al. (2017); Yeboah et al. (2014);
Policy and regulatory risks	(1) stricter food quality and safety standards; (2) animal welfare legislation negatively affecting the competiveness; (3) potential restrictions on waste disposal; (4) weak institutional capacity to implement regulatory mandates;	Nyamah et al. (2017); Jaffee et al. (2010);
Financial risks	(1) uncertain trade, market, land and tax policies; (2) Inadequate financial support; (3) delay in payment and even possible non-payment; (4) change in exchange rate; (5) insufficient credit;	Anton et al. (2011); Bachev (2017); Nyamah et al. (2017);
Management and operational risks	(1) poor management decisions on asset allocation; (2) use of expired seeds; (3) poor quality control; (4) poor decision making in use of inputs; (5) farm and firm equipment breakdowns; (6) inability to adapt to changes in cash and labour flows (7) forecast and planning errors;	Yeboah et al. (2014); Anton et al. (2011); Nyamah et al. (2017);

Source: Zhao et al. (2020, p. 4861)

2.4 Supply chain resilience

It is increasingly accepted that the global business environment is becoming more turbulent (Hamel and Valikangas. 2003). Globalisation of both procurement and distribution, along with fierce competition, leave firms within a supply chain being exposed to a higher internal and external risks (Hendrick and Singhal. 2005; Ali et al. 2017). In addition, increased outsourcing and a higher level of interdependencies among firms in supply chains, led to fewer buffer stocks and a decreased flexibility in the face of fast-changing business environment (Mason-Jones et al. 2000; Revilla and Saenz. 2017). Exogenous disruptions that originate outside the supply chain and is beyond the managerial control (Hult et al. 2010). For example, natural disasters, terrorist attacks, and industrial accidents have major ecological and economic consequences that can deteriorate firms' financial, market and operational performance (Wagner and Bode. 2008; Crum et al. 2011; Linnenluecke. 2017). Endogenous disruptions that originate inside of supply chain and can be mitigated by managerial response. For example, misapplication of policies/standards can be avoided through strengthening training and development. According to the research of Singhal and Hendrick (2002) and Pickett (2006), when disruption is announced, the average shareholder return immediately drops 7.5% and the total loss grows to an average of 18.5% after four months of disruption. To become more successful in dealing with vulnerabilities, uncertainties, and risks in supply chains, the idea of supply chain resilience has been gaining attention in recent years (Kamalahmadi and Parast. 2016; Ali et al. 2017; Pettit et al. 2019).

2.4.1 Definitions of supply chain resilience

Resilience is a multidisciplinary and multifaceted concept and has been discussed in several disciplines such as ecology (Meyer. 2016), psychology (Schwarz. 2018), economy (Bag et al. 2019), metallurgy (Coulson et al. 2017), engineering (Woods. 2015), and management (Williams et al. 2017). The term resilience has been popularised since Holling published the seminal work named "Resilience and Stability of Ecological Systems" in 1973. In his work, three characteristics of resilience were emphasised: a measure of systems persistence, the ability to absorb disturbances, and the capability to maintain the same relationships between systems entities after a disturbance. However, Fiksel (2003) argued that resilient systems should have four major characteristics, namely, diversity, efficiency, adaptability, and cohesion. In the engineering science, resilience has been defined as "the tendency of a material to return to its original shape after the removal of a stress that has produced elastic strain" (Merriam-Webster. 2007, p.1340). After conducting a comprehensive literature review on the concept of resilience and comparing resilience definitions in various fields such as ecological systems, social-ecological systems, psychology, and disaster management, Bhamra et al. (2011) stated that resilience fundamentally represented the capability and ability of an element to return to a normal state or a better state after a disruption.

In the context of supply chain, the concept of resilience gained the needed attention after two publications were published, namely, *Building the resilient supply chain* (Christopher and Peck. 2004), and *The resilient enterprise: overcoming vulnerability for competitive advantage* (Sheffi. 2005). Christopher and Peck (2004, p.2) defined supply chain resilience as "the ability of a system to return to its original state or move to a new, more desirable state after being disturbed". The concept refers to a supply chain's capacity to survive and recover from unexpected and inevitable supply chain disruptions, but supply chains can evolve to a better configuration through learning from disruptions (Pettit et al. 2010). Sheffi (2005) also highlighted the importance of supply chain resilience through analysing many cases of supply chain disruptions. Most of the examples listed in his work focus on learning from disruptions and shift to a stronger position. This means that potential success is hidden in the disruptions and can be elicited through coordinating resources scientifically.

Supply chain resilience can be seen as a competitive advantage, if supply chains can survive, recover and evolve efficiently and effectively from supply chain disruptions than its competitors (Hamel and Valikangas. 2003; Macdonald et al. 2018). However, these two early works considered the definition of supply chain resilience from engineering and ecological perspective, respectively, as the limitations that they do not provide a clear understanding of "resilient" in the context of supply chain (Pettit et al. 2019). Furthermore, researchers have investigated supply chain resilience from different perspectives, which caused the problem of a lack of consensus on the definition of supply chain resilience (Spiegler et al. 2012; Mensah and Merkurvey. 2014; Tukamuhabwa et al. 2015). For example, some stated that resilience is a proactive capability, which should be prepared for supply chain disruptions. While others perceived that resilience is a reactive capability, which should be used after a disruption (Kamalahmadi and Parast. 2016). Table 2.9 presents a comprehensive list of supply chain resilience definitions proposed in the literature.

Table 2.9 Various definitions of supply chain resilience (Note: keywords are highlighted)

Author(s) year(s)	**Definitions of supply chain resilience**
Christopher and Peck (2004, p. 2)	"The ability of the system to return to its **original state** or move to a new **more desirable state** after being disturbed".
Closs and McGarrell (2004, p. 10)	"Supply chain resilience is the supply chain's ability **withstand** and **recove**r from an incident. A resilient supply chain is **proactive** – anticipating and establishing planned steps to **prevent** and **respond** to incidents. Such supply chain quickly rebuild or re-establish **alternative means** of operations when the subject of an incident".
Datta (2007, p. 56)	"Supply chain resilience is not only the ability to **maintain control** over performance variability in the face of disturbance but also a property of being adaptive and capable of **sustained response** to sudden and significant shifts in the environment in the form of uncertain demands".
Longo and Oren (2008, p. 528)	"Resilience is a critical property that, in a context of supply chain management, allows the supply chain to **react to** inter/external risks and vulnerabilities, **quickly recovering** an equilibrium state capable of guaranteeing high performance and efficiency levels".
Ponomarov and Holcomb (2009, p. 131)	"The adaptive capability of the supply chain to **prepare for** unexpected events, **respond to** disruption and **recover from** them by maintaining continuity of operations at the desired level of connectedness and control over structurers and function".
Ponis and Koronis (2012, p. 921)	"The ability to **proactively plan** and design the supply chain network for anticipating unexpected disruptive events, **respond adaptively** to disruptions while maintaining control over structure and function an transcending to a post-event robust state of operations, if possible, more favourable than the one prior to the event, thus gaining competitive advantage".
Carvalho et al. (2012, p. 358)	"Supply chain resilience is concerned with the system's ability to return to its **original state** or to a new, **more desirable** one after experiencing a disturbance, and avoiding the occurrence of failure modes".
Roberta Pereira et al. (2014, p. 637)	"The capacity of supply chain to **respond quickly** to unexpected events so as to **restore operations** to the previous performance level or even to a new or better one".
Hohenstein et al. (2015, p. 108)	"Supply chain resilience is the supply chain's ability to **be prepared for** unexpected risk events, **responding and recovering quickly** to potential disruptions to return to its original situation or grow by moving to a new, **more desirable state** in order to increase customer service, market share and financial performance".
Tukamuhabwa et al. (2015, p. 8)	"The adaptive capability of a supply chain to **prepare for and/or respond to** disruptions, to make **a timely and cost-effective recovery**, and therefore progress to a post-disruption state of operations-ideally, **a better state** than prior to disruption".
Yang and Xu (2015, p. 141)	"The ability of a system to return to its original state or move to a new and **more desirable state** after being disturbed, or to adapt to existing resources and skills to new situations and operating conditions, in order to survive despite withstanding a severe and enduring impact".
Kamalahmadi and Parast (2016, p. 121)	"The **adaptive capability** of a supply chain to reduce the probability of facing sudden disturbances, **resist** the spread of disturbances by **maintaining control** over structures and functions, and **recover and respond** by immediate and effective reactive plans to transcend the disturbance and restore the supply chain to robust state of operations".

A review of the definitions shows that most of the definitions considered that building resilient supply chain has a positive effect in helping supply chains become better after a disruption (Christopher and Peck. 2004; Ponomarov and Holcomb. 2009; Carvalho et al. 2012; Ponis and

Koronis. 2012; Roberta Pereira et al. 2014; Hohenstein et al. 2015; Tukamuhabwa et al. 2015; Yang and Xu. 2015). It is clear that most of the definitions of supply chain resilience relate to the ability of the supply chain to withstand changes of steady-state and move to the original or a better state after a disruption (Ribeiro and Barbosa-Povoa. 2018). As Blackhurst et al. (2011) stated, a supply chain that was still able to operate under disruptions and unforeseen events was characterised as resilient.

Based on the author's knowledge, a majority of definitions on supply chain resilience tend to include more elements present than earlier definitions (refer to Table 2.10, p. 65). For example, the important role of proactive planning in preventing and responding to incidents for achieving supply chain resilience has been clarified by Closs and McGarrell (2004). Datta (2007) considered maintaining control over performance, adaptive capability, sustained response, and uncertain demands in his definition. Longo and Oren (2008) included elements such as internal/external risks, recovering capability, and high performance and efficiency levels towards a resilient supply chain. For a further improvement, Ponis and Koronis (2012) discussed the elements of adaptively responding to disruptions, maintaining control over structure, and transcending to a post-event robust state of operations. Carvalho et al. (2012) introduced the new element failure modes into his definition. Hohenstein et al. (2015) stated that resilience consisted of four critical and complementary elements, namely, preparing for unexpected risk events, responding and recovering quickly from potential disruptions, and growing to a more desirable state. Kamalahmadi and Parast (2016) discussed the probability of facing sudden disturbances, maintaining control over structure and functions, and effective reactive plans in their definition of supply chain resilience. Besides, they divided supply chain resilience into four phases, namely, anticipation phase, resistance phase, recovery phase, and response phase. Anticipation phase refers to how to formulate proactive plans in case of unexpected and inevitable disruptions. Resistance phase concerns how to maintain control over structure and functions during the disruptions. The aim for the resistance phase is to resist and deactivate the perturbation before it expands. Finally, rapid and effective reactive plans are expected to be implemented in the recovery and response phase in order to restore the firm's position to a higher level. While there are conceptual differences in how supply chain resilience is defined, the majority of literatures keeps consistency in the formative elements of supply chain resilience, namely, proactively planning, adaptively responding, and recovering from disruptions, and maintaining control over structures (Ponomarov and Holcomb. 2009; Tukamuhabwa et al. 2015; Kamalahmadi and Parast. 2016). In addition, almost all the concepts on supply chain resilience indicate that resilience is a generalised capability to prepare in advance without knowing what situation or event will happen in the future (Linnenluecke. 2017). Table 2.10 shows the characteristics of existing definitions of supply chain resilience.

Table 2.10 Key characteristics of existing definitions on supply chain resilience

Author(s) year(s)	Key characteristics											
	Original state	Desirable state	Preparation	Resistance	Response	Recovery	Adaptability	Connectedness/ Control	Robustness	Failure modes	Time	Cost effective
Christopher and Peck (2004)	√	√					√					
Closs and McGarrell (2004)			√	√	√	√						
Datta (2007)					√		√	√				
Longo and Oren (2008)					√	√						
Ponomarov and Holcomb (2009)			√		√		√	√				
Ponis and Koronis (2012)		√	√		√			√				
Carvalho et al. (2012)	√	√								√		
Roberta Pereira et al. (2014)	√	√			√							
Hohenstein et al. (2015)	√	√	√		√	√						
Tukamuhabwa et al. (2015)	√	√	√		√						√	√
Yang and Xu (2015)	√	√		√			√					
Kamalahmadi and Mellat Parast (2016)				√	√	√			√			

2.4.2 Capabilities for building supply chain resilience

There are several studies that propose that resilience capabilities should be integrated into the designing of supply chains (Sheffi. 2005; Tang and Tomlin. 2008; Namdar et al. 2018). Various authors use different terms to represent resilience capabilities, including resilience antecedents (Ponomarov and Holcomb. 2009; Scholten et al. 2014), resilience principles (Christopher and Peck. 2004; Kamalahmadi and Parast. 2016), resilience strategies (Tukamuhabwa et al. 2015), and resilience competencies (Wieland and Wallenburg. 2013). For consistency, and in line with Sheffi (2005) and Tang and Tomlin (2008), the term "capabilities" is used from now onwards. Figure 2.1 illustrates the relationship between supply chain resilience principles and supply chain resilience capabilities. Supply chain resilience capabilities are the critical enables for building supply chain resilience principles, whereas supply chain resilience capability factors are the detailed managerial practices that can be used for building supply chain resilience capabilities.

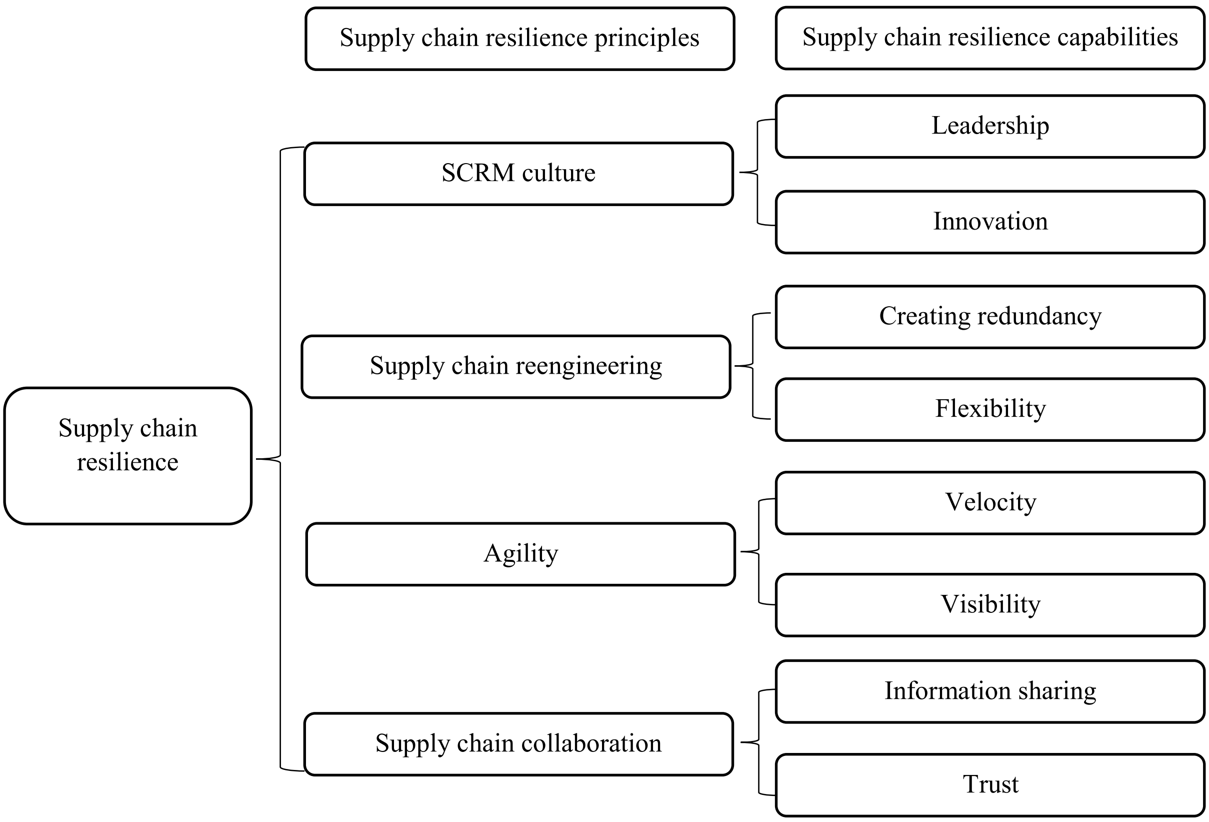


Figure 2.1 Supply chain resilience principles and capabilities (Source: Kamalahmadi and Parast. 2016, p. 122)

Supply chain resilience capabilities have been witnessed to have positive effects in reducing vulnerabilities, preventing or reducing the occurrences of supply chain disruptions (Craighead et al. 2007; Sabahi and Parast. 2020). It will lead to a firm's sustainable competitive advantage if successfully integrating resilience capabilities into their daily operations (Ponomarov and Holcomb. 2009; Jain et al. 2017). Christopher and Peck (2004) identified four principles for building supply chain resilience, namely, supply chain reengineering, supply chain collaboration, agility, and SCRM culture. Characteristics such as velocity, visibility, redundancy, flexibility, trust, information sharing, leadership, and innovation were treated as resilience capabilities, as shown in Table 2.11.

Table 2.11 Summary of supply chain resilience capabilities

Supply chain resilience capabilities	Corresponding author(s)
Knowledge management – "Knowledge and understanding of supply chain structures - both physical and informational and its ability to learn from changes" (Scholten et al. 2014, p. 212).	Choi and Hong (2002); Ponomarov and Holcomb. (2009); Scholten et al. (2014); Pereira and Silva (2015)
Agility – "The ability to respond quickly to unpredictable changes in demand and/or supply" (Wieland and Wallenburg. 2013, p. 302). ----- **Velocity** – "The pace of flexible adaptions that can determine the recovery speed of the supply chain from a disruption" (Christopher and Peck. 2004, p. 10). ----- **Visibility** – "The identify, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events" (Francis, 2008, p. 182).	Longo and Oren (2008); Francis. (2008); Zsidisin and Wagner (2010); Blackhurst et al. (2011); Juttner and Maklan (2011); Carvalho et al. (2012); Ponis and Koronis (2012); Pettit et al. (2013); Wieland and Wallenburg (2013); Tukamuhabwa et al. (2015)
Supply chain reengineering – "The conceptualisation, design implementation, operation and reengineering of the supply chain" (Christopher and Peck. 2004, p. 7). -----**Creating redundancy** – "The strategic and selective use of spare capacity and inventory that can be used to cope with disruptions, e.g. spare stocks, multiple suppliers and extra facilities" (Juttner and Maklan. 2011, p. 247). ----- **Flexibility** – "The ability to take different positions to better respond to abnormal situations and rapidly adapt to significant changes in the supply chain" (Lee. 2004, p. 2).	Naim et al. (2000); Lee (2004); Sheffi (2005); Sheffi and Rice. (2005); Tang (2006); Tomlin (2006); Craighead et al. (2007); Sodhi and Lee (2007); Tang and Tomlin (2008); Knemeyer et al. (2009); Zsidisin and Wagner. (2010); Yang and Yang (2010); Colicchia et al. (2010); Bode et al. (2011); Pettit et al. (2013)
Supply chain collaboration – "The level of joined decision making and working together at a tactical, operational or strategic level between two or more supply chain member (horizontal or vertical). Scalable through the magnitude of relationship strength, quality and closeness" (Barratt. 2004, p. 31). ----- **Trust** – "Trust facilitates cooperation and collaboration both within the organization and across partners in the supply chain" (Kamalahmadi and Parast. 2016, p. 124). ----- **Information sharing** – "The application of information technology enhances connectivity and supports other resilience capabilities" (Pettit et al. 2013, p. 48).	Barratt. (2004); Sinha et al. (2004); Faisal et al. (2007); Kong and Li (2008); Ponomarov (2009); Erol et al. (2010); Juttner and Maklan (2011); Pettit et al. (2013);
Supply chain risk management culture – "Ensuring that all organisational members embrace supply chain risk management, and this may involve top management support and firm integration" (Christopher and Peck. 2004, p. 11). ----- **Leadership** – "Top management's support has a positive effect in generating supply chain wide strategies and changing incentive alignment" (Kamalahmadi and Parast. 2016, p. 126). ----- **Innovation** – "The motivation and capability to seek and invent new business ideas" (Golgeci and Ponomarov. 2013, p. 605).	Christopher and Peck (2004); Christopher (2005); Faisal et al. (2007); Santos-Vijande and Alvarez-Gonzalez (2007); Blackhurst et al. (2011); Demmer et al. (2011); Golgeci and Ponomarov (2013); Tukamuhabwa et al. (2015)

Some researchers (e.g., Tang and Tomlin. 2008; Carvalho et al. 2012) argued that flexibility could be seen as a part of agility, while others (e.g., Christopher and Peck. 2004; Kamalahmadi and Parast. 2016) viewed flexibility belonging to supply chain reengineering. In line with Christopher and Peck (2004) and Kamalahmadi and Parast (2016), and considering that the concept of flexibility may be involved in the design, implementation, operation, and reengineering of supply chain, thus, it is proposed flexibility as a dimension of supply chain reengineering. In addition, some researchers (e.g., Juttner and Maklan. 2011; Carvalho et al. 2012) discussed redundancy as a dimension of flexibility, others (e.g., Lee. 2007; Knemeyer et al. 2009; Scholten et al. 2014) argued that redundancy and flexibility should be treated as different terms. Rice and Caniato (2003), Tang and Tomlin (2008), and Carvalho et al. (2011) suggested that flexibility was more beneficial when sources of risks were extended to supply chains because it was concerned with investments in infrastructure and resources before they actually were needed. Whereas redundancy is more beneficial when sources of risks are outside the control of supply chain participants, as it helps to keep the capacity of supply chains to respond to disruptions. Consistent with the aforementioned arguments, flexibility and redundancy should be considered as different resilience capabilities.

Scholten et al. (2014) considered the four capabilities proposed by Christopher and Peck (2014) along with KM, were necessary for developing supply chain resilience. After examined the supply chain resilience capabilities in the financial crisis, Juttner and Maklan (2011) proposed that KM seemed to enhance the supply chain resilience by improving the flexibility, visibility, velocity and collaboration capabilities of the supply chain. Therefore, KM is considered as a new capability for building supply chain resilience.

Table 2.11 reveals four key capabilities for building supply chain resilience that are discussed by various researchers, namely, flexibility, redundancy, supply chain collaboration, and visibility. This is consistent with the literature review results conducted by Hohenstein et al. (2015), Tukamuhabwa et al. (2015), and Kamalahmadi and Parast (2016). Their research results indicate that there is a large number of studies dealing with flexibility, redundancy, supply chain collaboration, and visibility. Therefore, these capabilities can be seen as key capabilities for building supply chain resilience, which are discussed in the following sub-sections before building the conceptual framework.

2.4.2.1 Increasing flexibility

Flexibility has been defined by Fayezi et al. (2016, p. 2) as "an operational ability that assists organisations in changing efficiently internally and/or across their key partners in response to internal and external uncertainties via effective integration of supply chain relationships". Flexibility ensures that changes, uncertainties, and unpredictable events caused by the risks can be absorbed by the supply chain through effective coordination process and the appropriate response (Lin et al. 2006; Manuj and Mentzer. 2008; Skipper and Hanna. 2009; Rojo et al. 2018). It allows companies to realign resources quicker than its competitors, thus, a higher chance for the company to escape from the negative influences of the external environment can be achieved (Ponomarov and Holcomb. 2009; Gunasekaran et al. 2015).

Based on the recent literature review on supply chain flexibility (Stevenson and Spring. 2007; Tiwari et al. 2015), supply chain flexibility has been analysed from different dimensions, including manufacturing flexibility, building/refining conceptual model of supply chain flexibility, measuring supply chain flexibility, quantify and timing flexibility in supply contracts, empirical analysis of supply chain flexibility, as well as flexibility considerations in supply chain design and simulation. Thus, supply chain flexibility can be achieved through building sourcing flexibility, product development flexibility, manufacturing flexibility, logistics flexibility, and information technology flexibility (Swafford et al. 2006). Having a flexible supply base, flexible supply contracts, flexible labour arrangements, flexible products, flexible transportation systems, and flexible pricing are examples of the ways that flexibility can help to enhance supply chain resilience (Colicchia et al. 2010; Merschmann and Thonemann. 2011; Willis et al. 2016; Han et al. 2017; Delic and Eyers. 2020). Table 2.12 shows different flexibility measures adopted in supply chains. Juttner and Maklan (2011) highlighted that sourcing flexibility could be considered as a key enabler for supply chain resilience because of its benefits in cost reduction and lead-time reduction. The access to a wider supply base means companies to inject in supply chains additional production lines and quickly shift volumes and production in case of disruption (Sheffi. 2006; Tang. 2006; Tomlin. 2006; Pavlov et al. 2019). Conversely, the lack of sourcing flexibility or the rely on a single supplier may be a risky option due to hampering the normal flow of product manufacturing and delivery on some occasions. However, Christopher and Peck (2004) and Sheffi and Rice (2005) argued that having a single supplier might be a good choice to improve product quality and production process because a closer relationship could be achieved through investing in supplier relationship.

Table 2.12 Different types of flexibility at the supply chain level

Business area	Flexibility dimensions	Author(s)
Product development	Product development flexibility, new product design flexibility, product modification flexibility	Zhang et al. (2002); Stevenson and Spring (2007)
Procurement	Procurement flexibility, sourcing flexibility, supply flexibility, purchasing flexibility	Sanchez and Perez Perez (2005); Yi et al. (2011)
Manufacturing	Manufacturing flexibility, volume flexibility, mix flexibility, operations flexibility, process flexibility, expansion flexibility	Nair (2005); Stevenson and Spring (2007)
Logistics	Logistics flexibility, inbound logistics flexibility, routing flexibility, material handling flexibility, physical distribution flexibility, delivery flexibility, storage flexibility	Nair (2005); Soon and Udin (2011)
Marketing	Marketing flexibility, launch flexibility, responsiveness flexibility	Lummus et al. (2003); Sanchez and Perez Perez (2005)
Organisation	Network flexibility, organizational flexibility, labour flexibility, worker flexibility, inter-organizational relationship flexibility	Stevenson and Spring (2007); Yi et al. (2011)
(Financial) information	Information systems flexibility, Spanning flexibility	Nair (2005); Zhang et al. (2006)

2.4.2.2 Creating redundancy

Sheffi and Rice (2005) stated that redundancy was an important enabler for building supply chain resilience, as it was a good solution for emergencies. Redundancy represents a spare capacity by keeping resources in reserve to mitigate or limit the negative effects of supply chain disruptions (Blackhurst et al. 2005; Sheffi and Rice. 2005; Tan et al. 2019). It must be built in advance (Manuj and Mentzer. 2008; Pettit et al. 2010; Maghsoudi et al. 2018). Thus, supply chains can respond to sudden changes/disruptions through backup suppliers and slack resources in production or transport capacity (Craighead et al. 2007; Zsidisin and Wagner. 2010; Bode et al. 2011; Kamalahmadi and Parast. 2017). There are several approaches mentioned in the literature on how to build redundancy in a supply chain:

- Holding safety and emergency stock of materials and finished goods in some key facilities in case of supply chain disruption occurs (Chopra and Meindl. 2015);
- Redundant plants were suggested to be used to maintain the production process even if one of the plants was destroyed during the supply chain disruption (Tomlin. 2006);
- Back-up facilities have been mentioned by Tomlin (2006) and Chopra and Meindl (2015), which play a key role in maintaining the production process during supply chain disruptions;
- It is suggested to increase suppliers' redundancy in their operations (Sawik. 2013).

To ensure quick recovery from a supply chain disruption, Tang and Tomlin (2006) suggested that multiple transportation modes, multiple carriers or providers, multiple routes, as well as multiple distribution channels must be considered by supply chain managers in case of a disruption. However, Stecke and Kumar (2009) argued that investments in creating redundancy should be limited as extra inventories imply cost and obsolescence. After conducting a systematic literature review on AFSC resilience, Stone and Rahimifard (2018) emphasised that redundancy could be viewed as a key supply chain-wide resilience capacity.

2.4.2.3 Supply chain collaboration

As supply chains are extending across the globe, supply chain risk becomes a network-level phenomenon that needs to be addressed from the network perspective (Christopher and Peck. 2004; Kamalahmadi and Parast. 2016). Thus, a high level of collaboration, cooperation, and partnership is suggested to be built among supply chain members (Matopoulos et al. 2007; Panahifar et al. 2018). Supply chain collaboration can be seen as a business process whereby partners collaborative work together to achieve common goals and gain mutual benefit (Stank et al. 2001; Chen et al. 2017). It has been defined by various researchers (e.g., Min et al. 2005; Matopoulos et al. 2007; Whipple and Russell. 2007; Scholten and Schilder. 2015), most of them agree that supply chain collaboration has three major characteristics: working collaboratively, building a culture of sharing, and establishing a partner relationship. "Two or more independent firms work jointly to plan and execute supply chain operations can achieve greater success than acting in isolation" (Simatupang and Sridharan. 2002, p. 19). Five benefits could be achieved through applying supply chain collaboration practices, namely, increase efficiency, effectiveness, profitability of involved independent supply chain firms, reinforce, and expand their collaborative relationships (Min et al. 2005). Matopoulos et al. (2007) consolidated that implementing supply chain collaboration practices could help achieve two macro-level benefits, including general cost reductions and general revenue growth. These two benefits have been reinforced by Sahay (2003) at their work.

Joint decision-making, joint problem solving, cooperative contracts, and establishing long-term relationships with partners, all have been proven effective in building supply chain collaboration (Stank et al. 2001; Bakshi and Kleindorfer. 2009; Salam. 2017). Furthermore, building linkages or partnership among independent supply chain members involve sharing information, resource, and risk; these can help them to accomplish mutual objectives (Golicic et al. 2003). Scholten et al. (2014) construed that sharing information and knowledge across the chain was the fundamental principle of supply chain collaboration. Free exchange of real-time information and data with upstream suppliers and downstream consumers has positive effects on customer service (Christopher and Peck. 2004; Faisal et al. 2006). Besides, the time for anticipating, responding and recovering from disruption will be reduced if the right type of information and knowledge is available in time (Scholten and Schilder. 2015). Various supply chain collaboration practices were summarised in Table 2.13.

Table 2.13 Summary of supply chain collaboration practices

Supply chain collaboration practices	**Definition**	**Author(s)**
Information sharing	"The extent to which a firm shares a variety of relevant, accurate, complete and confidential ideas, plans, and procedures with its supply chain partners in a timely manner" (Pettit et al. 2013, p. 48).	Christopher and Peck (2004); Cao et al. (2010); Mandal (2012)
Goal congruence	"The extent to which supply chain partners perceive their own objectives are satisfied by accomplishing the supply chain objectives" (Cao et al. 2010, p. 6617).	Simatupang and Sridharan (2005); Cao et al. (2010)
Trust	"A positive belief, attitude, or expectation of one party concerning the likelihood that the action or outcomes of another will be satisfactory" (Kamalahmadi and Parast. 2016, p. 124).	Siha et al. (2004); Faisal et al. (2007); Ponomarov (2009); Hudnurkar et al. (2014)
Decision synchronization/ Joint decision-making	"The process where supply chain partners orchestrate decisions in supply chain planning and operations that optimise supply chain benefits" (Cao et al. 2010, p. 6617).	Spekman et al. (1997); Stank et al. (2001); Bakshi and Kleindorfer. (2009); Cao et al. (2010)
Collaborative communication/ Regular meetings	"The contact and message transmission process among supply chain partners in terms of frequency, direction, mode, and influence strategy" (Hudnurkar et al. 2014, p. 192).	Fynes et al. (2005); Cao et al. (2010); Hudnurkar et al. (2014)
Co-operation	"Co-operation refers to situations in which firms work together to achieve mutual goals" (Fynes et al. 2005, p. 342).	Fynes et al. (2005); Liu and Wang (2011)
Resource-sharing	"The process of leveraging capabilities, resources and assets as well as investing in capabilities, resources and assets with supply chain partners" (Cao et al. 2010, p. 6617).	Lambert et al. (1999); Cao et al. (2010)
Joint knowledge creation	"The extent to which supply chain partners develop a better understanding of and response to the market and competitive environment by learning and working together" (Cao et al. 2010, p. 6618).	Slater and Narver (1995); Kaufman et al. (2000); Cao et al. (2010)
Commitment	"Commitment refers to the willingness of trading partners to exert effort on behalf of the relationship and suggest a future orientation in which firms attempt to build a relationship that can be sustained in the face of unanticipated problems" (Fynes et al. 2005, p. 342).	Walter (2003); Fynes et al. (2005)
Long-term relationship	"Build a long-term relationship to achieve desired goals" (Fynes et al. 2005, p. 342).	Fynes et al. (2005);

2.4.2.4 Building visibility

Visibility has been defined by Francis (2008, p. 182) as "the identity, location and status of entities transiting the supply chain, captured in timely message about events, along with the planned and actual dates/times of these events". It is a capability to monitor the entities and any events happened across the supply chain, for example, entities and events regarding end-to-end orders, inventory level, transportation, and distribution (Sheffi. 2001; Smith. 2004; Wei and Wang. 2010; Somapa et al. 2018). Visibility helps supply chain managers to see from one end of the pipeline to the other end (Christopher and Peck. 2004). Thus, it helps supply chain managers to make decisions, avoid over-reactions, unnecessary interventions, and ineffective decisions in a risk event situation (Christopher and Lee. 2004). As Chiang et al. (2012) stated, with the increase of visibility in supply chains, more reliable decisions could be made by supply chain managers. After conducting an empirical study to explore the role of procurement in helping to achieve supply chain resilience, Pereira et al. (2014) stated that visibility should be built and improved in procurement activities, as it not only helped managers to recognise disruptions occurring at upstream supply chain, but also helped managers to manage purchasing schedules through monitoring inventories, demand, and supply conditions.

2.4.3 Overview of empirical research on supply chain resilience

The increasing frequency and impact of unexpected adverse events (e.g., Tohoku earthquake, Tsunami, and Covid-19 epidemic) have led researchers and practitioners to re-consider resilience approaches from the whole supply chain perspective (Sa et al. 2019). Recent literature review articles on supply chain resilience, including Kamalahmadi and Parast (2016), Ali et al. (2017), Stone and Rahimifard (2018), Hosseini et al. (2019), all observed a growing body of literature on supply chain resilience and its importance in maintaining business continuity and competitiveness. Furthermore, their findings indicate that more empirical research need to be conducted. Thus, they have appealed that more rigorous empirical research should be conducted to test and ascertain the value of supply chain resilience. Table 2.14 summarises the research on supply chain resilience. To ensure a certain quality, only international peer-reviewed journal articles are included in the table for analysis.

Table 2.14, it summarises some important points related to supply chain resilience.

- First, based on the author's knowledge, most of the studies have been conducted in the manufacturing industry (Datta et al. 2007; Wieland and Wallenburg. 2013; Dubey et al. 2019; Tan et al. 2019; Li and Zobel. 2020). Although agri-food industry plays an important role in the world's economy as a key source of food supply, however, there is a significant lack of empirical studies that identify capabilities and related resilience capability factors for building supply chain resilience. A recent literature review article on AFSC resilience (Stone and Rahimifard. 2018) also demonstrates a clear demand for empirical studies on AFSC resilience.
- Second, almost all the studies listed in the Table 2.14 were using a single method approach, such as case study, graph theory, and structural equation modelling (SEM) (Juttner and Maklan. 2011; Brusset et al. 2017; Dubey et al. 2019; Polyviou et al. 2020). There is only one study which have explored supply chain resilience using two research methods (Datta et al. 2007), which indicates a lack of empirical studies that explore supply chain resilience using a multi-method or mix-method approach. Shaw et al. (2020) believe that adopting a multi-method or a mix-method approach in research provides researchers with an opportunity to investigate research issues from different angles and further helps to achieve a clearer and more holistic picture of the issues being investigated. Thus, adopting a multi-method or a mix-method approach is necessary for the research in supply chain resilience.
- Third, existing work on supply chain resilience has mainly focused on identifying antecedents for building supply chain resilience (Scholten et al. 2014; Urciuoli et al.

2014), building relationships between supply chain risks and supply chain resilience (Brusset et al. 2017), evaluating and improving supply chain resilience (Datta et al. 2007; Pettit et al. 2010; Scholten and Schilder. 2015; Sa et al. 2019) and measuring supply chain resilience (Soni et al. 2014; Tan et al. 2019). Although a number of studies have investigated resilience capability factors for building supply chain resilience, few studies have taken the interactions of different resilience capability factors into consideration (Tendall et al. 2015; Zhao et al. 2018). Resilience capability factors are the detailed managerial practices that can be used for building supply chain resilience capabilities. Thus, more research is required to explore the interrelationships among different resilience capability factors (Zhao et al. 2018).

Table 2.14 Empirical studies on supply chain resilience

Author(s) year	Topic focus	Industry focus	Methodology adopted	Qualitative/ Quantitative/Mix-method approach
Blackhurst et al. (2005)	Supply chain resilience building and disruption mitigation	Multi-industry	Case study	Qualitative
Datta et al. (2007)	Production/distribution systems to improve resilience	Manufacturing industry	Case study and modelling	Mix-methods approach
Juttner and Maklan (2011)	Supply chain resilience in global financial crisis	Chemical industry, electronic industry, and wood industry	Longitudinal case study	Qualitative
Carvalho et al. (2012)	Supply chain redesign	Automotive industry	Modelling	Quantitative
Golgeci and Ponomarov (2013)	Supply chain resilience building and disruption mitigation	Manufacturing industry	Modelling	Quantitative
Leat and Revoredo-Giha (2013)	Resilience building of whole supply chain	Agri-food industry	Case study	Qualitative
Wieland and Wallenburg (2013)	The effects of relational competencies on supply chain resilience	Manufacturing industry	Modelling	Quantitative
Scholten et al. (2014)	Antecedents for building supply chain resilience	Voluntary organisations active in disaster	Multiple case study	Qualitative
Soni et al. (2014)	Supply chain resilience measurement	Not specified	Modelling	Quantitative
Urciuoli et al. (2014)	Antecedents for building supply chain resilience	Oil and gas industry	Multiple case study	Qualitative
Scholten and Schilder (2015)	The role of collaboration for building supply chain resilience	Agri-food industry	Case study	Qualitative
Brusset et al. (2017)	Relationships between supply chain capabilities, risks and resilience	Not specified	Modelling	Quantitative
Ivanov (2018)	Resilient supply chain structure design	Electronic industry	Modelling	Quantitative
Namdar et al. (2018)	Resilient supply chain design	Not specified	Modelling	Quantitative
Dubey et al. (2019)	Antecedents of resilient supply chains	Manufacturing industry	Modelling	Quantitative
Sa et al. (2019)	Resilience building of supply chain nodes	Agri-food industry	Multiple case study	Qualitative
Tan et al. (2019)	Supply chain resilience measurement	Manufacturing industry	Modelling	Quantitative
Li and Zobel (2020)	Supply chain network resilience and ripple effect	Manufacturing industry	Modelling	Quantitative
Polyviou et al. (2020)	Resilience building of supply chain nodes	Manufacturing industry	Multiple case study	Qualitative

2.5 Supply chain performance management

In the era of globalisation, outsourcing, JIT, total quality management (TQM), lean production, and enterprise resource planning (ERP) have been used by managers to achieve cost optimisation and high efficiency (Gunasekaran et al. 2004). As supply chain partners are constantly increasing, this results in supply chains becoming longer and more complex. For better managing suppliers and resources in a supply chain, SCM has been implemented. SCM has been defined by Mentzer et al. (2001, p. 48) as "the systematic, strategic coordination of the traditional business functions and the tactic across these business functions within a particular company and across businesses within a supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole". SCM seeks to improve the long-term performance of supply chains through coordinating activities among stakeholders and effective use of resources and capabilities of partners (Ketchen and Giunipero. 2004; Ketchen and Hult. 2007). To achieve an efficient and effective supply chain, measuring and managing the performance of the supply chain is crucial (Abidi et al. 2014). This may involve the development of an appropriate performance measurement system (PMS) that can be used by different stakeholders and supply chain processes.

This section presents a literature review of supply chain performance management. The rest of this section is organised as follows. First, different PMSs that can be used for measuring supply chain performance is analysed. Second, KPIs for AFSC is reviewed.

2.5.1 Supply chain performance management systems

In order to be able to assess the performance of supply chains, an adequate PMS is essential. Maestrini et al. (2017, p.301) defined supply chain PMS as "set of metrics used to quantify the efficiency and effectiveness of supply chain processes and relationships, spanning multiple organisational functions and multiple firms and enabling supply chain orchestration". It has two broad roles in managing supply chain performance. The first is to ensure that organisations have clear objectives and explicit strategies to achieve objectives. The second is to measure performance against these objectives to provide feedback on whether the goals are being achieved (Martinez et al. 2010). Clearly, measuring the performance of supply chains will help organisations to identify where problems exist and what improvements need to be done (Gunasekaran and Kobu. 2007). The extant literature provides numerous supply chain PMSs, as shown in Table 2.15.

Table 2.15 Different supply chain PMSs

Author(s) (year)	Performance metrics	The supply chain types
Fitzgerald et al. (1991)	Financial, competitiveness, quality of service, flexibility, resource utilization, innovation	Service supply chain
Kaplan and Norton (1992)	Financial, environment, customer, internal business, innovation and learning	Environmental supply chain
Gunasekaran et al. (2001)	Supplier, delivery, customer service, inventory, logistics cost	General supply chain
Gunasekaran et al. (2004)	Plan, source, make/assemble, deliver	General supply chain
Wong and Wong (2007)	Revenue, on-time delivery rate, internal manufacturing capacity, cycle time, cost	General supply chain
Olugu et al. (2011)	Greening cost, customer perspective, level of process management, product characteristics, management commitment, supplier commitment, traditional supply chain cost, responsiveness, quality, flexibility	Automobile green supply chain
Cho et al. (2012)	Responsiveness, flexibility, reliability, tangibles, assurance, empathy, profitability cost, asset, resource utilization	Service supply chain
Olugu and Wong (2012)	Greening cost, management commitment, level of process management, product characteristics, supplier commitment, customer perspective, quality, responsiveness, flexibility, traditional supply chain cost, recycling efficiency, recycling cost, management commitment, material features, customer involvement	Automotive supply chain
Jothimani and Sarmah (2014)	Reliability, responsiveness, flexibility, cost measures, asset management efficiency	Third party logistics supply chain
Sellitto et al. (2015)	Source, make deliver, return	Footwear supply chain
Tian and Sarkis (2020)	Locally available renewable resources, locally available non-renewable resources, imported resources, purchased renewable resources, purchased non-renewable resources, exported resources, labour, services, gross domestic product	Green supply chain

Table 2.15, it concludes that researchers have developed different PMSs for evaluating the performance of different supply chains (e.g., service supply chain, green supply chain, automobile supply chain, and footwear supply chain). However, researchers have rarely investigated PMSs for AFSC. For example, Gunasekaran et al. (2001) suggested that assessing

supply chain performance from three different levels: strategic, tactical, and operational levels. Hence, supplier, delivery, customer service, inventory, and logistics cost were included in their supply chain PMS. To evaluate supply chain collaborative performance, a framework that included five connecting features of collaboration was proposed: collaborative performance system, information sharing, decision synchronisation, incentive alignment, and integrated supply chain processes (Simatupang and Sridharan. 2005). For measuring supply chain performance, Agarwal et al. (2006) developed a framework that included market sensitiveness, process integration, information driver, and flexibility.

Based on a recent literature review on supply chain PMSs, Maestrini et al. (2017) identified four supply chain PMSs that were frequently cited in the literature, which were supply chain balanced scorecard (BSC) developed by Kaplan and Norton (1992), supply chain operations reference model (SCOR) developed by Supply Chain Council in 1996, resource output flexibility model developed by Beamon (1999), as well as process-based supply chain PMS (Lambert and Pohlen. 2001). Most of these PMSs entail both financial and non-financial metrics as well as both quantitative and qualitative metrics. For example, Beamon (1999) proposed three types of performance measures - resources, output, and flexibility - as necessary components for supply chain PMS. The SCOR links performance metrics, supply chain processes, best practices, and people into a unified structure, which has been widely applied for supply chain optimisation and evaluation (Sangari et al. 2015). Five supply chain performance attributes are considered in the SCOR model; these are reliability, responsiveness, agility, costs, and assets management. In the BSC model, Kaplan and Norton (1992) categorised performance measures into four groups - finance, customer, internal business process, learning and growth - in which SCM goals, end-customer benefit, financial benefit and SCM improvement are discussed. Finally, a series of quantitative and qualitative performance measures (e.g., order fulfilment, demand management, demand forecasting) are deployed in the process-based model to assess the efficiency and effectiveness of each supply chain.

2.5.2 Key performance indicators for AFSC

An AFSC consists of different levels - namely, input supplier, farmer, cooperative, food processor, distributor/wholesaler, retailer, and consumer - and it is a complex system responsible for the circulation of agri-food products from the initial stage of production to the final stage of consumption (Zhao et al. 2019). Due to the high complexity of the AFSC's network and the extreme difficulty in monitoring every node in the AFSC, food safety issues (e.g., food contamination and animal disease) are frequently reported and spread (Wang et al. 2012). Subsequently, many organisations are forced to focus on improving the overall AFSC performance rather than only focussing on their internal operations (Najmi and Makui. 2012). Therefore, there is no doubt that measuring AFSC performance has received significant attention from academia and the agri-food industry to improve understanding, strengthen the collaboration between AFSC partners, and increase whole AFSC integration (Dey and Cheffi. 2013; Jakhar and Barua. 2014; McAdam et al. 2017; Ukko et al. 2020).

Supply chain PMSs may be used for measuring the AFSC performance, but performance metrics should reflect more on the quality aspects of AFSC products (Aramyan et al. 2007). For example, seven performance indicators of food quality including sensory properties, food safety, food nutrition, packaging, production system, production handling, transportation, and environmental aspects, were added to the SCOR model when measuring performance of the milk supply chain in Pakistan (Moazzam et al. 2012). Aramyan et al. (2007) suggested efficiency, flexibility, responsiveness, product quality, and process quality to be used for evaluating the performance of the tomato supply chain. However, Dinu (2016) argued that only efficiency needed to be considered in measuring the performance of AFSC because of the perishability and short shelf-life of agri-food products. Thus, Dinu's model proposed four performance indicators, which were time loading, days on stock, days out of stock, and cost-saving. Chae (2009) holds a similar view that only a small list of performance indicators is critical for AFSC performance. Hence, four categories of performance indicators (e.g., sales and marketing, production, purchasing, and operation strategy) were used to assess AFSC performance.

Considering the above arguments on supply chain PMSs, it is proposed to use efficiency, flexibility, responsiveness, product quality, and process quality to assess AFSC performance due to the following reasons. First, agri-food products have unique characteristics such as perishability, short-shelf life, easily contaminated and high dependency on climatic conditions, and requirement of air-conditioned transportation and storage (Zhao et al. 2020). Therefore, performance measures should reflect the quality aspects of the product and process. Second, only a limited number of performance measures (e.g., profit, return on investment, lead time, and customer satisfaction) (Aramyan et al. 2007; Elrod et al. 2013; Kataike et al. 2019) are critical for the agri-food company's operation management, customer service and financial viability. Besides, these performance measures should be easily monitored and managed (Chae. 2009). Third, financial and non-financial indicators should be included to measure AFSC performance (Aramyan et al. 2007), as most of the classical supply chain PMSs did.

2.6 Discussion of the research gaps

Based on the above literature review on KGMs, AFSC risks, supply chain resilience, and supply chain performance management, a number of research gaps have been identified, which open avenues for further research:

1) While previous research on KGMs has been conducted in a variety of industries, including the high technology industry, the electronic manufacturing industry, the rail infrastructure industry, the automotive industry, and the home appliance industry (Liu et al. 2007; Antonelli and Calderini. 2008; Kim et al. 2008; Singh et al. 2019; Yang et

al. 2019) (refer to Table 2.4), KGMs exploration and examination is still in its infancy, with scholarly and practitioner interests but minimal insights into the implementation of KGMs on the agri-food industry. Aforementioned industries were selected over the agri-food industry, as they are knowledge-intensive, where knowledge creation, sharing, and transferring are more frequent than in other industries (Marra et al. 2012; Jen et al. 2020). Recent literature review articles on supply chain KM (Cerchione and Esposito. 2016; Martins et al. 2019), showed that most of the papers published in journals were in the subject of computer science, engineering, material sciences, environmental sciences, and business, management and accounting, while few of existing papers were published in the agricultural and biological science. Further, as KGMs are likely to have benefits in enhancing knowledge transfer/sharing between/among organisations, examinations of KGMs in the agri-food industry will be necessary to ensure the optimisation of AFSCs' performance (Zhao et al. 2020).

2) Most of the existing work on SCRM has mainly focused on the risk identification, assessment, mitigation, and monitoring (Rangel et al. 2015; Fan and Stevenson. 2018; Moazzam et al. 2018; Zhou et al. 2019; Bier et al. 2020). Based on the author's knowledge, studies defining the correlations among different AFSC risks remain limited (Ho et al. 2015; Nakandala et al. 2017; Behzadi et al. 2018). However, there are some attempts. For example, Chaudhuri et al. (2016) used fuzzy ISM approach to build interrelationships among different risks identified from food processing companies. Chaudhuri and Govindan (2017) used DEMATEL based approach to build interrelationships among different risks identified from third party logistics providers. These attempts both focused on the parts of AFSCs, rather than built interrelationships among different AFSC risks identified from the whole AFSC perspective. More research is required to explore the interrelationships among various AFSC risks

identified from the whole AFSC perspective, since the hidden effects of one risk related to other risks may cause substantial damage to other parts of AFSCs (Chopra and Sodhi. 2004; Zhao et al. 2020).

3) Based on the recent literature review on AFSC resilience (Stone and Rahimifard. 2018), existing work on AFSC resilience mainly focuses on the most commonly cited core capabilities for building AFSC resilience, such as flexibility, redundancy, supply chain collaboration, and visibility (Christopher and Peck. 2004; Jain et al. 2017; Kumar and Singh. 2021). More empirical studies are suggested on the agri-food industry to identify other core resilience capabilities to achieve AFSC resilience (Kamalahmadi and Parast. 2016; Falkowski. 2017).
4) Existing research on KGMs mainly focuses on KGMs exploration, KGMs categorisation, KGMs implementation for facilitating knowledge transfer/sharing, the relationship between KGMs and firm innovation performance, and the relationship between KGMs and firm's sustainability (Fang et al. 2013; Tan et al. 2018; Yang et al. 2019) (Refer to Table 2.4). KGMs as key mechanisms to facilitate knowledge sharing/transfer and have capabilities for helping organisations to survive in this increasingly volatile business environment (Batista et al. 2019). However, previous studies, which examined the role of KGMs for creating competitive advantage from an organisation perspective, neglected the influence of KGMs on resilience and on performance from an AFSC perspective. Recent literature review on supply chain KM (Perez-Salazar et al. 2019) also highlighted that, a lack of empirical research to explore the influence of KGMs on AFSC resilience and on AFSC performance. It is evident that the impact of KGMs on AFSC resilience and on AFSC performance demands more research.

5) Finally, most of the existing literature uses a single method, adopting either a qualitative or a quantitative approach. For example, the aforementioned studies (Ritchie and Brindley 2007; Dani and Deep 2010; Christopher et al. 2011; Moazzam et al. 2018; Zhou et al. 2019) largely applied quantitative methods for risk mitigation and assessment. They focused on either examining the implications of risk factors or summarising risk mitigation methods. Only two studies (Diabat et al. 2012; Micheli et al. 2014) adopted a case study approach and ISM to investigate the impact of one risk on another from an agri-food company perspective rather than from the whole AFSC perspective. Combining these two qualitative methods poses some limitations to identifying the causes in theory building because the causality between different risks cannot be explained. Furthermore, from 2003 to 2013, the number of studies using quantitative methods was almost four times higher than the number of those applying qualitative methods in the SCRM field (Ho et al. 2015). Thus, there is a need to explore the integration of multiple qualitative approaches to tackle the complexity of AFSC risks (Zhao et al. 2020).

2.7 Conceptual framework proposed based on the literature review

The KRRP conceptual framework has been built based on the literature review, as shown in Figure 2.2. There are four clusters in the conceptual framework: KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. In the era of knowledge economy, performance improvement and risk reduction cannot happen without the great contribution of knowledge (Tchamyou. 2017). Thus, this study assumes that KGMs have an impact on AFSC performance and on AFSC resilience capabilities, respectively, as AFSC partners need to develop knowledge capabilities that can help them to survive from risks and improve their performance. Impact means effect or influence, it is unclear the effect or influence is positive or negative. AFSC resilience capabilities are used for reducing the AFSC risks, while AFSC KPIs are developed to control and measure AFSC risks. Thus, a conceptual framework has been formulated for AFSC practitioners to increase KM capabilities, build AFSC resilience capabilities, reduce AFSC risks, and improve AFSC performance.

As shown in Figure 2.2, four constructs have been included in the conceptual framework: KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. Normally, KGMs are divided into formal and informal (Beugelsdijk. 2008; Wang. 2009; Cao and Xiang. 2012). However, the categorisation of KGMs into formal and informal is too broad; therefore, it has difficulty in identifying more factors that help to build KGMs. Thus, KGMs have been divided into four groups (e.g., trust-based, reciprocity-based, market-based, and contract-based KGM) following Fang et al's (2013) research.

In the cluster of AFSC resilience capabilities, four capabilities (e.g., flexibility, redundancy, supply chain collaboration, and visibility) have been included in the conceptual framework because of several reasons. First, flexibility is crucial for modern supply chains to solve rising uncertainty and competitiveness in the market and to adjust the changing demands and environments of business (Blome et al. 2014). Therefore, flexibility has been included in the conceptual framework. Second, redundancy is included in the conceptual framework, as lean is a prevalent concept that has been implemented in different industries in the last 30 years for reducing cost and waste (Danese et al. 2018). However, lean strategy poses challenges for different industries in the uncertain business environment. Third, supply chain collaboration should be included in the conceptual framework as supply chains are becoming longer and more complex. More collaboration activities between AFSC members are required in the volatile business environment (Min et al. 2005; Cao and Zhang. 2011; Herczeg et al. 2018; Uvet et al. 2020). Fourth, visibility becomes crucial with the development of digitisation of agri-food industry. To achieve a resilient AFSC, building visibility plays an extremely important role because visibility helps to achieve quick response in the volatile business environment. Finally, these four resilience capabilities are frequently mentioned by different researchers (Tomlin. 2006; Kamalahmadi and Parast. 2016; Sa et al. 2019) because of their critical roles in building supply chain resilience.

In the cluster of AFSC risks, AFSC risks are categorised into nine groups based on the characteristics of agri-food products (e.g., perishability and easily affected by weather): supply risks, demand risks, biological and environmental risks, political and macroeconomic risks, weather-related risks, logistical and infrastructure risks, policy and regulatory risks, financial risks, and management and operational risks. Supply risk is that of a breakdown in material and service supplies, information and monetary flows between an enterprise and its suppliers, while demand risk refers to a breakdown in the flow of product, information or revenues between an enterprise and its customers (Leat and Revoredo-Giha. 2013). Biological and environmental risks are mostly associated with yield and quality reduction that disrupt the flows of foods and services of AFSCs (Jaffee et al. 2010). Political and macroeconomic risks refer to political uncertainty and fluctuations of economic activity and prices (Barry. 2004). Weather-related risks are associated with extreme weather conditions (e.g., high humidity, excess rain, and wind damage) that disrupt the flows of foods and services of AFSCs. Logistical and infrastructure risk is included as AFSCs are easily affected by the availability and timing of goods and services, energy, and information provided by the logistics and infrastructures. Agri-food products are consumed by consumers, any policies with regard to food safety, food security, and food quality may pose challenges to the whole AFSCs. Thus, policy and regulatory risks are included in the conceptual framework. Financial risks are related to a firm's capital that is obtained and financed (Leat and Revoredo-Giha. 2013). Finally, management and operational risks are associated with poor management decisions that may disrupt the flows of goods and services of AFSCs.

Finally, in the cluster of AFSC KPIs, the performance of AFSC are evaluated by efficiency, flexibility, responsiveness, product quality, and process quality.

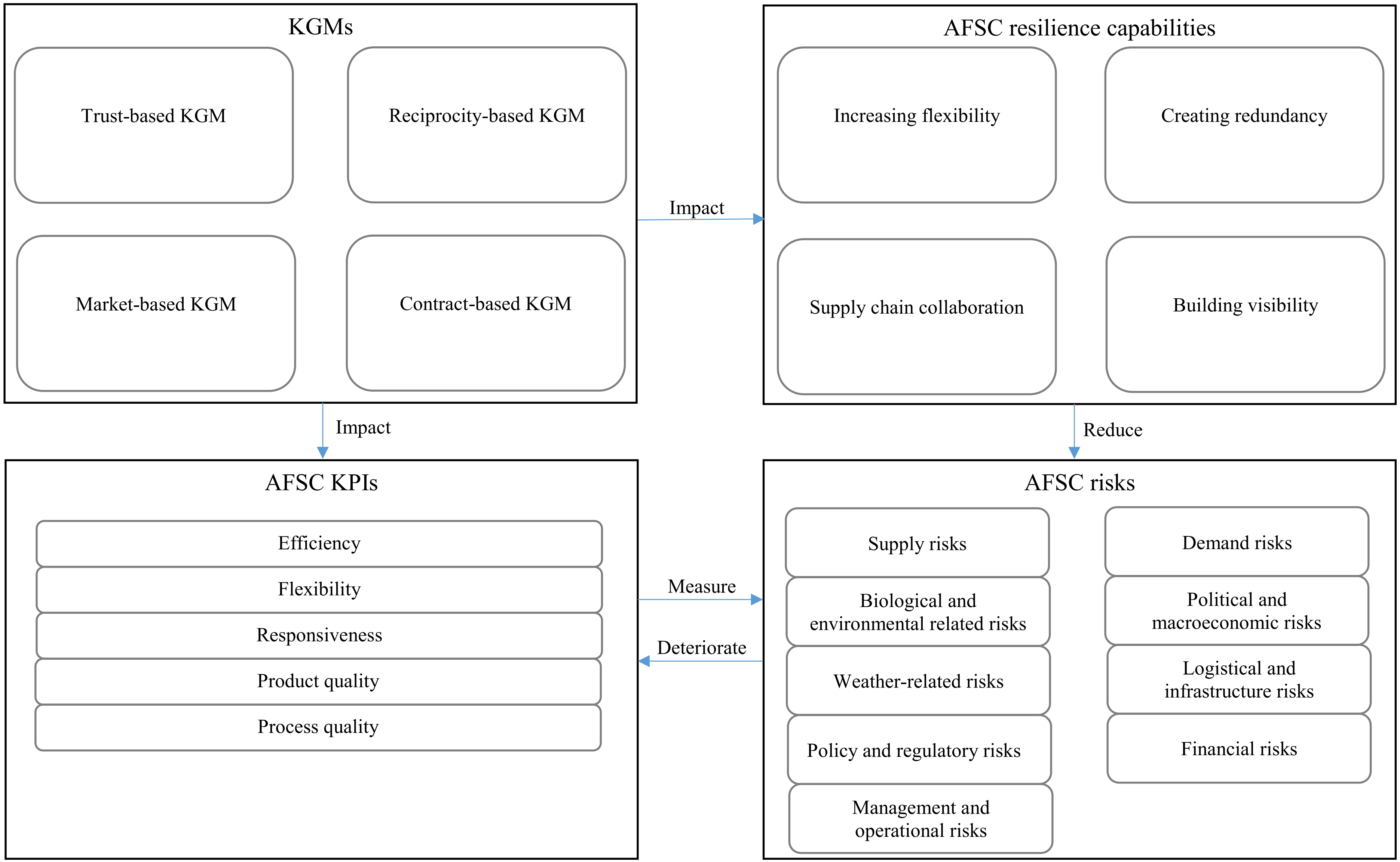


Figure 2.2 KRRP conceptual framework

2.8 Summary

This chapter presents a literature review of KGMs, supply chain resilience, supply chain risks, and supply chain performance management. Based on the literature review results, five research gaps are proposed and a conceptual framework has been built. The chapter lays a solid theoretical foundation for exploring the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks.

Firstly, the definitions of KG and its related concepts were reviewed (e.g., learning organisation, organisational learning, and KM); as a result, the difference between KG and its related concepts is clarified. Afterwards, related research that used KGMs is analysed to have a comprehensive understanding in terms of research methods, research context, and topic focus. Finally, trust-based, reciprocity-based, market-based, and contract-based KGMs and their related elements are reviewed.

Then, a review on supply chain risks and related concepts has been conducted, including supply chain risk definitions, SCRM, risk factors in the AFSCs and related risk factors' categorisation. It is important to note that risk factors in AFSC have been extensively reviewed, as the focus of this study is agri-food industry.

Afterwards, supply chain resilience and its related concepts are discussed. Through a detailed analysis of different definitions of supply chain resilience, a deep understanding of supply chain resilience has been built. Afterwards, different resilience capabilities for building supply chain resilience have been reviewed, including flexibility, redundancy, supply chain collaboration, and visibility. Finally, an overview of empirical research on supply chain resilience is provided, which helps me to identify the research gaps.

Finally, the definition of supply chain performance management, different PMSs, and KPIs used for evaluating AFSC performance have been reviewed. Based on the literature review results, five research gaps that related to different constructs (e.g., KGMs, AFSC resilience, AFSC risks, and AFSC performance), the relationships among different constructs, and the methodology used have been proposed, which open avenues for future research. Furthermore, a conceptual framework that includes KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs has been built as a foundation for the empirical research.

The next chapter discusses and justifies the research methodology used in this research, including research philosophy, research approach, methodology choice, research strategy, and research methods. Furthermore, an overall research deign will be illustrated to lay a solid plan for the research from the methodological perspective.

Chapter three: Research methodology

3.1 Introduction

This chapter presents the research methodology used in this study. The research methodology is carefully designed to provide a clear guide to obtain empirical data to fulfil the aim and objectives of the study. It outlines the research philosophy, approach, methodological choice, strategy, design, time horizon, and methods chosen for this study along with the justifications behind choosing them. The research "onion" is shown in Figure 3.1. The detailed explanations of data collection and data analysis methods will be highlighted and explained in Chapters four and five, respectively.

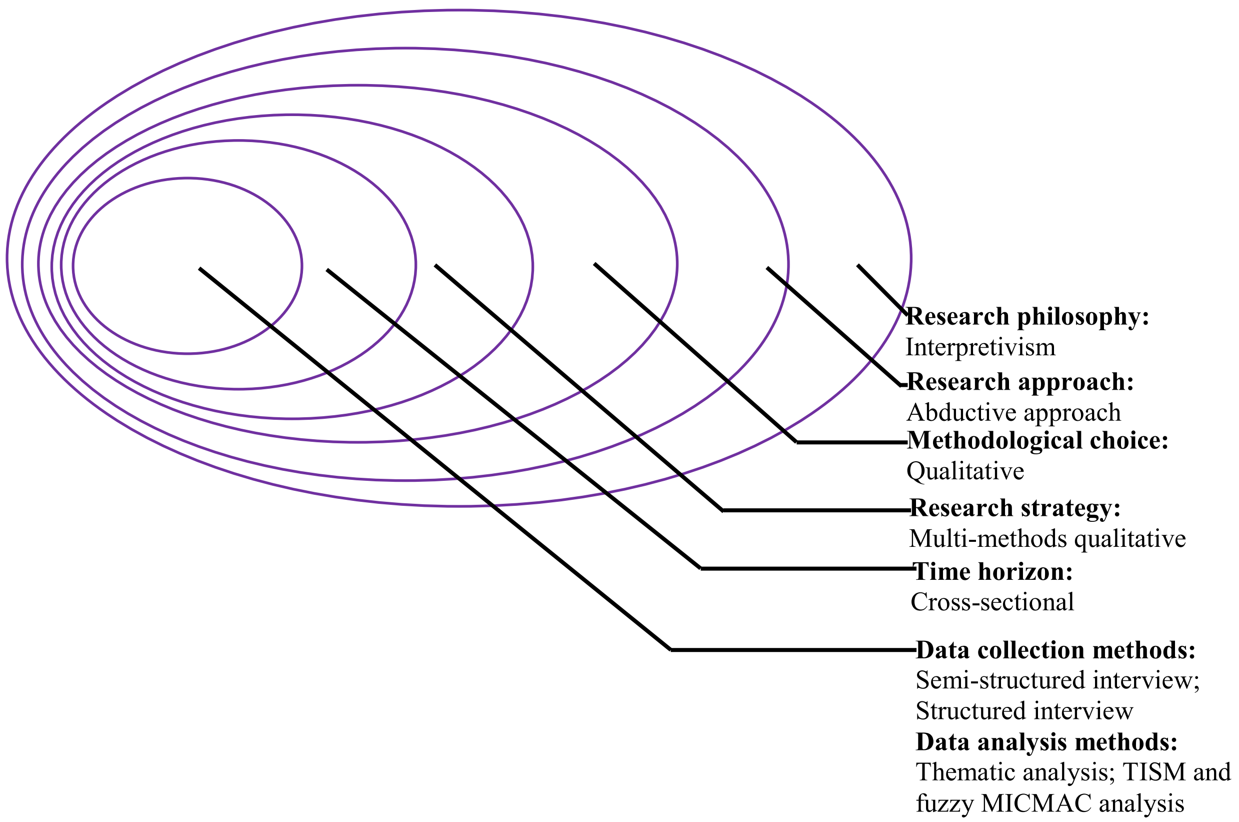


Figure 3.1 The research "onion"

3.2 Research philosophy

Research philosophy is a broad term that relates to the development of knowledge and the nature of that knowledge (Saunders et al. 2019), which can be seen as a tool to allow researchers to generate ideas/assumptions in the context of research with appropriate methods in a suitable time. Furthermore, it discusses the ways in which researchers view the nature of the world. In other words, it provides the theoretical foundation of the research, which involves the choice of research strategy, formulation of the research questions, data collection, processing, and analysis (Zukauskas et al. 2018). The most important research philosophy issue is to reflect upon philosophical choices and defend them with respect to the alternatives that could have adopted, rather than to check how far the research is philosophically informed (Saunders et al. 2019).

According to Saunders et al. (2019), there are five types of research philosophies: positivism, interpretivism, pragmatism, critical realism, and postmodernism. Positivism research philosophy claims that the social world can be understood in an objective way (Zukauskas et al. 2018). Thus, a highly structured methodology used for yielding pure data and facts that are not influenced by human interpretation or bias is the main characteristic of positivism research philosophy. Interpretivism research philosophy holds an opposite position. It emphasises that the social world can be interpreted in a subjective manner by communicating with experienced people in the social world. Creating a new, rich and deep understanding of the social phenomena is the ultimate aim for interpretivism researchers. As for the pragmatism research philosophy, it asserts that the social world can be interpreted through different methods, but best meet the requirements of scientific research aim. Moreover, pragmatism is concerned with action and change and the interplay between knowledge and action. This makes it appropriate as a basis for research approaches intervening into the world and not merely observing the world (Goldkuhl. 2012). The research philosophy of critical realism concerns “explaining what we see and experience, in terms of the underlying structures of reality that shape the observable events” (Saunders et al. 2019, p. 138). Finally, postmodernism focuses on the role of language and the role of power relations, it seeks to expose and question the power of relations that support dominant realities (Calas and Smircich. 1997).

The aforementioned research philosophies can be seen through the eyes of ontology, epistemology, axiology, and typical methods. Each researcher is guided by their own research philosophies to develop knowledge in a particular field. This means that different researchers can have different ideas/assumptions about the nature of truth, knowledge, and its acquisition (Cohen et al. 2007). This section concentrates on interpretivism philosophy, since other research philosophies are out of the scope of this study. Interpretivism is highly appropriate for business and management research such as organisational behaviour, marketing and human resource management, as rich insights can be obtained (Saunders et al. 2019). A brief comparison of research philosophies, with respect to ontology, epistemology, axiology and typical methods is provided in Table 3.1.

Table 3.1 Comparison of five research philosophies

	Positivism	Critical realism	Interpretivism	Pragmatism	Postmodernism
Ontology (nature of reality or being	Real, external, independent One true reality (universalism) Granular (things) Ordered	Stratified/layered (the empirical, the actual and the real) External, independent Intransient Objectives structures Causal mechanisms	Complex, rich Socially constructed through culture and language Multiple meanings, interpretations, realities Flux of process, experiences, practices	Complex, rich external "Reality" is the practical consequences of ideas Flux of processes, experiences and practices	Nominal Complex, rich Socially constructed through relations Some meanings, interpretations, realities are dominated and silenced by others Flux process, experiences, practices
Epistemology (what constitutes acceptable knowledge	Scientific method Observable and measurable facts Law-like generalisations Numbers Causal explanation and predication as contribution	Epistemological relativism Knowledge historically situated and transient Facts are social constructions Historical causal explanations as contribution	Theories and concepts too simplistic Focus on narratives, stories, perceptions and interpretations New understanding and worldviews as contribution	Practical meaning of knowledge in specific contexts "True" theories and knowledge are those that enable successful action Focus on problems, practices and relevance Problem solving and informed future practice as contribution	What counts as "truth" and "knowledge" is decided by dominant ideologies Focus on absences, silences and oppressed/repressed meanings, interpretations and voices Exposure of power relations and challenges of dominant views as contribution
Axiology (role of values in research	Value-free research Researcher is detached, neutral and independent of what is researched Researcher maintains objectives stance	Value-laden research Researcher acknowledges bias by world views, cultural experience and upbringing Researcher tries to minimise bias and errors Researcher is as objective as possible	Value-bound research Researchers are part of what is researched, subjective Researcher interpretations key to contribution Researcher reflexive	Value driven research Research initiated and sustained by researchers' doubts and beliefs Researcher reflexive	Following research problem and research question Range of methods: mixed, multiple, qualitative, quantitative, action research Emphasis on practical solutions and outcomes
Typical methods	Typically deductive, highly structured, large samples, measurement, typically quantitative methods of analysis, but a range of data can be analysed	Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency Range of methods and data types fit subject matter	Typically inductive Small samples, in-depth investigations, qualitative methods of analysis, but a range of data can be interpreted	Mixed or multiple method designs, quantitative and qualitative	Typically deconstructive –reading texts and realities against themselves In-depth investigations of anomalies, silences and absences Range of data types, typically qualitative methods of analysis

Source: Saunders et al. (2019, p. 119)

The interpretivism research philosophy focuses on how to work with the subjective meanings already there in the social world; that is to acknowledge their existence, to reconstruct them, to understand them, to avoid distorting them, to use them as building-blocks in theorising (Goldkuhl. 2012). Thus, interpretivism is appropriate for researchers to gain a deeper understanding of the phenomenon and its complexity in its unique context (Creswell. 2014). It seeks to understand a particular context through accepting the multiple viewpoints of different individuals from different groups (Cao and Le. 2015). Thus, a comprehensive understanding of a particular context can be reached via probing participants' thoughts, values, prejudices, perceptions, views, feelings and perspectives (Wellington and Szczerbinski. 2007; Morehouse. 2011). Some researchers (e.g., Mack. 2010; Chowdhury. 2014) argued that interpretive research tended to be more subjective rather than objective. This will cause many biases because research outcomes are unavoidable to be affected by the participants' own interpretation and their own belief system. However, as emphasised by Saunders et al. (2019), a single phenomenon could be interpreted from different angles rather than a truth that could be determined by a process of measurement. Thus, fruitful and insightful information can be discovered. Saunders et al. (2019) also argued that the philosophy of interpretivism superbly suited business and management research. The justification to support the philosophy of interpretivism rather than other philosophies more suitable for this research is listed below.

- ❖ The research context of this study is AFSC. As Dani (2015) stated, that AFSC was not a linear chain of entities, but a very complicated web of interconnected entities (e.g., input suppliers, farmers, processors, wholesalers, distributors, and retailers) working collaboratively to make food available for consumers. Considering that the research philosophy of interpretivism is more suitable than other philosophies to investigate complex business and management realities, it is suggested to be applied in this research.

- ❖ The aim of this research is to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks. Thus, communicating with different AFSC participants to explore factors related to KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs is necessary. The main characteristic of interpretivism is to help researchers to accept different viewpoints from different perspectives of different people. Therefore, it is suggested to be applied in this research.

Through discussion of five research philosophies, interpretivism was selected because of its two characteristics: (1) it can help researchers to obtain different viewpoints; and (2) it is suitable for exploring complex business and management research. Next, research approaches will be critically discussed.

3.3 Research approach

Research approaches are the plans and the procedures for research across different stages from broad assumptions to detailed methods of data collection, analysis, and interpretation (Creswell. 2014). There are three main research approaches, namely, the deductive approach, inductive approach, and abductive approach. The abductive approach is the combination of deductive and inductive approaches. The comparison of deductive, inductive, and abductive approaches is listed in Table 3.2.

Table 3.2 Major differences among deductive, inductive, and abductive approach

	Deduction	Induction	Abduction
Logic	In a deductive inference, when the premises are true, the conclusion must also be true	In an inductive inference, known premises are used to generate untested conclusions	In an abductive inference, known premises are used to generate testable conclusions
Generalisability	Generalising from the general to the specific	Generalising from the specific to the general	Generalising from the interactions between the specific and the general
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory The collection of quantitative data	Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework The collection of qualitative data	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth
Wealth of literature	Abundance of sources	Scarcity of sources	Not specified
Theory	Theory falsification or verification	Theory generation and building	Theory generation or modification; incorporating existing theory where appropriate or modify existing theory

Source: adapted from Saunders et al. (2019)

A deductive approach involves the development of a theory that is subjected to a rigorous test (Saunders et al. 2019). There are three advantages to using a deductive approach: (1) can explain causal relationships or links between concepts and variables; (2) can measure concepts quantitatively; and (3) can generalise research findings to a certain extent. As for an inductive approach, it involves "the search for pattern from observation and the development of explanations – theories – for those patterns through series of hypotheses" (Bernard. 2011, p. 7). Generally, this approach can help to build a theory through identifying patterns and relationships in the collected data (Saunders et al. 2019). The main difference between the inductive approach and the deductive approach is that the inductive approach aims at building a theory, while the deductive approach focuses on testing or evaluating a theory (Arlbjorn and Halldorsson. 2002). The deductive and inductive research processes are shown in Figure 3.2.

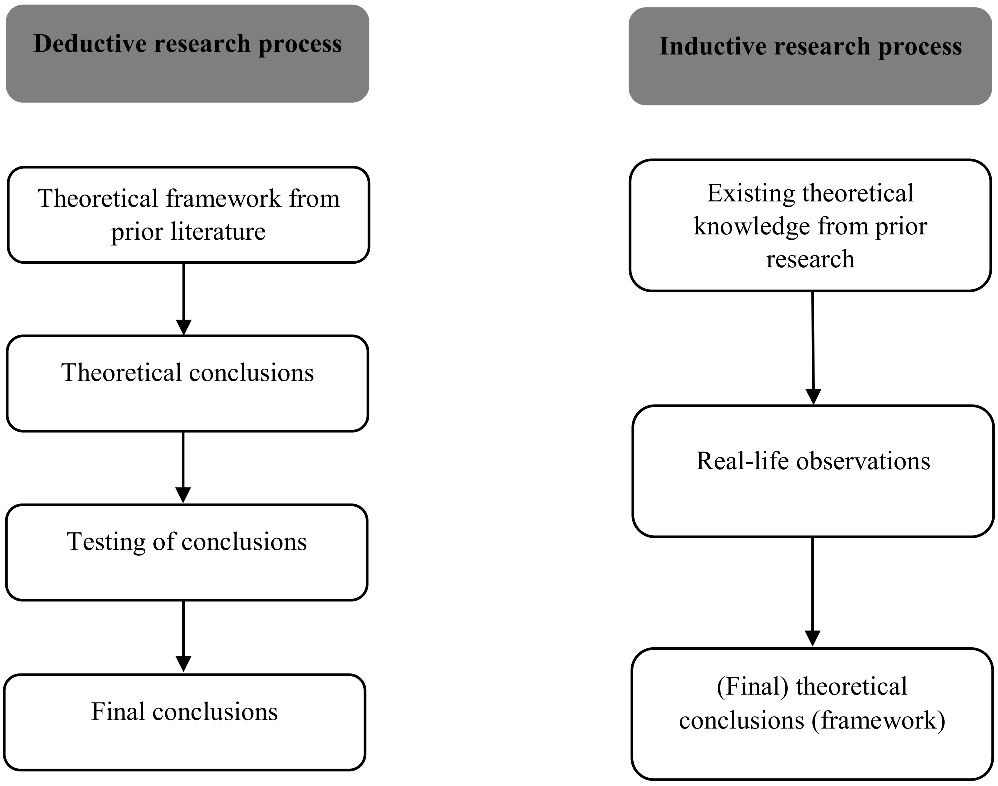


Figure 3.2 Inductive and deductive research processes (Source: Kovacs and Spens. 2005, p. 137)

Two practical criteria suggested by Creswell (2014) for evaluating whether the research will be deductive or inductive are provided as follows. First, the nature of the research topic. If there is a wealth of literature that can help researchers to develop a theoretical framework, it will be suggested to use a deductive approach. Otherwise, an inductive approach will be suggested. Second, the available time for conducting research. Deductive research can be quicker to complete, whereas inductive research can be much more protracted. Considering the aforementioned discussions on deductive and inductive approach, it is better to use the combination of inductive and deductive approach (abductive approach) in this research. The abductive approach stems from the insight that most great advances in science neither followed the pattern of pure deduction nor of pure induction (Taylor et al. 2002). The aim of conducting abductive approach is to gain a deep understanding of the new phenomenon and to suggest a new theory. It emphasises on theory matching – searching for appropriate theories to an empirical finding (Dubois and Gadde. 2002). In comparison with the inductive/deductive research focusing on generalisations or specific manifestations only, the abductive research concentrates on the particularities of specific situations that deviate from general structure of such kind of situations (Danermark. 2001). The abductive research process is shown in Figure 3.3. Saunders et al. (2019) asserted that it was often advantageous to do with abductive approach. Thus, deductive approach was used in the theoretical phase to develop a conceptual framework as a guidance for the empirical study, as there is a large amount of literature on KGMs, supply chain resilience, AFSC risks, and KPIs for AFSC. Then, an inductive approach would be adopted in the empirical phase to allow new themes and relationships generated from the collected data, as there is rare literature that describes the relationships among KGMs, AFSC resilience, AFSC risks, and KPIs for AFSC.

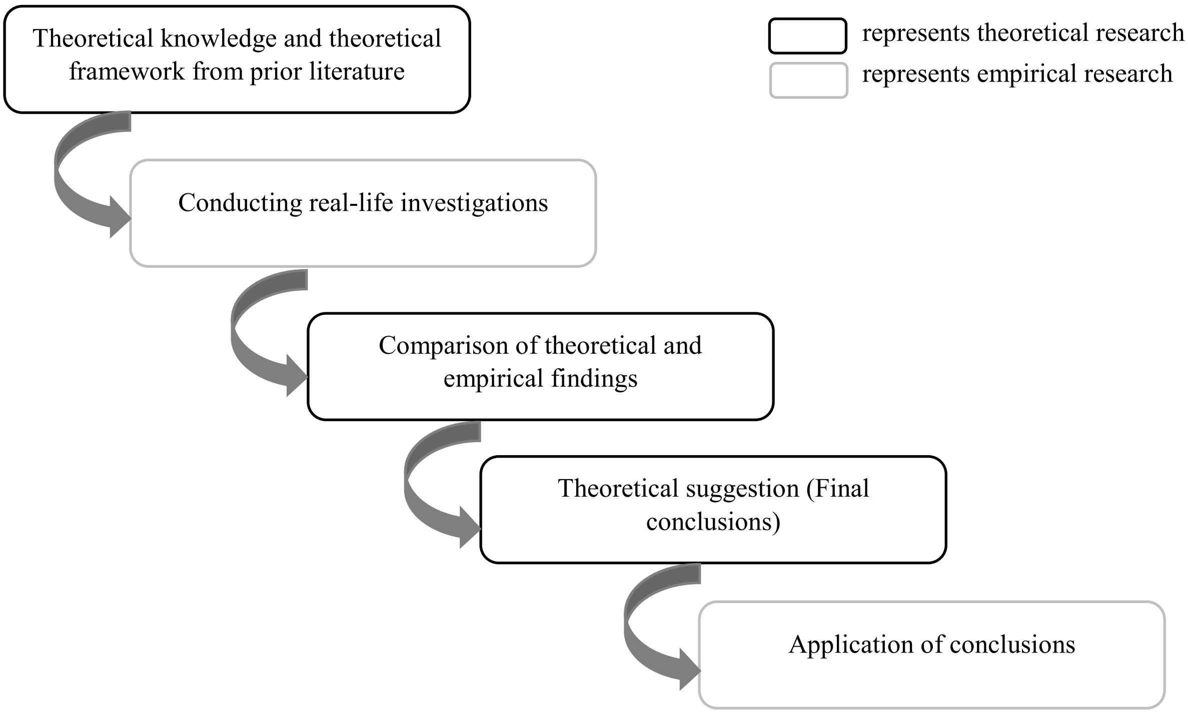


Figure 3.3 The abductive research process

3.4 Methodological choice and research strategy

This section outlines the methodological choice for this research, and then illustrates what research strategy has been adopted along with the justifications behind choosing them. Finally, it illustrates the time horizon strategy for this research.

There are three main methodological choices, namely, qualitative research, quantitative research, and mixed methods research. The major differences between qualitative, quantitative, and mixed methods research is shown in Table 3.3.

Table 3.3 Major differences among quantitative, qualitative, and mixed methods research

	Research philosophy	Research approach	Characteristics	Research strategies
Qualitative research	Generally associated with interpretivism	Usually associated with inductive approach	Studies participants' meanings and the relationships between them	Usually associated with action research, case study research, ethnography, grounded theory and narrative research
Quantitative research	Generally associated with positivism	Usually associated with deductive approach	Usually examine relationships between variables numerically	Usually associated with experimental and survey research strategy
Mixed methods research	Generally associated with critical realism and pragmatism	May use deductive, inductive, and abductive approach	Not specified	Mixed research strategies

Qualitative research has been proved as an effective strategy to study participants' meanings and the relationship between them through using a variety of data collection techniques and analytical procedures (Saunders et al. 2019). As stated by Aspers and Corte (2019), qualitative research could produce a detailed description and interpretation of participants' feelings, opinions, and experiences in terms of a specific context. Furthermore, qualitative research enables the researchers to investigate the participants' inner experience, and to figure out how meanings are shaped through and in culture (Corbin and Strauss. 2008). In addition, compared with quantitative research, qualitative research design is highly flexible because it can be constructed and reconstructed to a greater extent (Maxwell. 2012). Furthermore, as interpretivism is suggested to be used in this study, researchers believe that there is a tight connection between interpretivism and qualitative approaches (Silverman. 2000; Willis. 2007). Thus, qualitative research, rather than quantitative, is adopted in this research to obtain the experienced AFSC practitioners' opinions on the KGMs, AFSC resilience capabilities, AFSC risks, and KPIs for AFSC, as well as to understand the relationships among these constructs, since such opinions are difficult to capture using quantitative research.

Multi-methods approach involves the application of two or more sources of data or research methods to the investigation of a research question or to different but highly linked research questions (Beach and Derek. 2020). It has several advantages. First, multi-methods approach helps to achieve a breadth and depth understanding through using a range of qualitative/quantitative research methods. Thus, it helps researchers to gain a comprehensive understanding towards research questions and increase the robustness of their understanding (Mingers. 2001). This study attempts to build a theory through using a range of qualitative research methods by answering three research questions such as "what are the KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs that exist in the AFSCs", "what is the model that can be used to describe the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks", and "what are the key AFSC risk factors and key resilience capability factors". Second, multi-methods approach helps to discover new factors that open avenues for future research (Hoyles et al. 2005). Third, multi-methods approach enables researchers to ask a broader set of questions (e.g., what, how, and why). Therefore, it can help researchers to expand the scope of the study and enrich their understandings (Plewis and Mason. 2005). Based on the above discussions, this study adopts multi-method qualitative research strategy to obtain answers to the research questions and meet the research objectives.

There are two time horizon strategies, namely, cross-sectional and longitudinal studies. Cross-sectional studies involve the study of a particular phenomenon at a specific time, whereas longitudinal studies mainly focus on the change and development regards a specific phenomenon (Saunders et al. 2019). Thus, this research adopts cross-sectional strategy.

3.5 Overall research design

Research design is a systematic process to choose different methods and techniques to combine them in a logical and reasonable manner in order to answer research questions efficiently and effectively (Saunders et al. 2019). As illustrated in Figure 3.4, there are six phases of overall research design, namely, theoretical phase, empirical phase one (identifying constructs and building relationships among constructs), empirical phase two (prioritisation of risk factors and resilience capability factors), evaluation phase (evaluate empirical research findings), and conclusion phase. The justification for using two empirical phases in this study because of two reasons. First, previous PhD theses on KM (Uchitha. 2015) and supply chain resilience (Karim. 2017), both used two empirical phases in their PhD project. Second, two empirical phases have been designed in this study as it fulfils the requirements of the research aim and research objectives.

The theoretical phase consists of four parts, namely, formulation of research questions and objectives, comprehensive literature review, generation of research gaps, and development of a conceptual framework. It aims at building a solid theoretical foundation to support this research. Thus, the theoretical phase starts with the introduction to the research context, research justification, research aim, research objectives, and research questions. Then, a comprehensive literature review on KGMs, supply chain resilience, AFSC risks, and KPIs for AFSC is conducted to build a deep understanding of the topic and its related constructs. Consequently, research gaps have been identified and the KRRP conceptual framework has been built.

In the empirical phase one (identifying constructs and building relationships among constructs), interview template was designed and pilot-tests were conducted. Semi-structured interview has been selected to acquire data from experienced AFSC practitioners on KGMs, AFSC resilience capabilities, AFSC risks, and KPIs for AFSC. Then, thematic analysis was used to generate themes from the collected data. Afterwards, TISM was used to build relationships among different constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. Based on the research results of empirical phase one, the refined KRRP framework (1) has been built.

In the empirical phase two (prioritisation of risk factors and resilience capability factors), structured interviews was used to collect data. TISM was used to identify interrelationships among different risk factors and among different resilience capability factors, respectively. Then, fuzzy MICMAC analysis was used to classify different risk factors and different resilience capability factors into different categories, respectively. Finally, a refined KRRP framework (2) was built.

In the evaluation phase (evaluate empirical research findings), a structured interview was used to collect data in Chile, in order to evaluate the empirical research results obtained in the empirical phase one and two. Thus, KGMs, AFSC resilience capability factors, AFSC risk factors, AFSC KPIs, interrelationships between/among AFSC resilience capability factors, interrelationships between/among AFSC risk factors, as well as key risk factors and key resilience capability factors would be evaluated. The evaluation phase can be seen as a complement for empirical phases, because it provides evaluation for the research results of this study based on the opinions of the experienced AFSC practitioners.

In the conclusion phase, a comparison of the research results of this study with that in literature is conducted. Conclusions across different stages are drawn. Finally, limitations and future research directions were proposed.

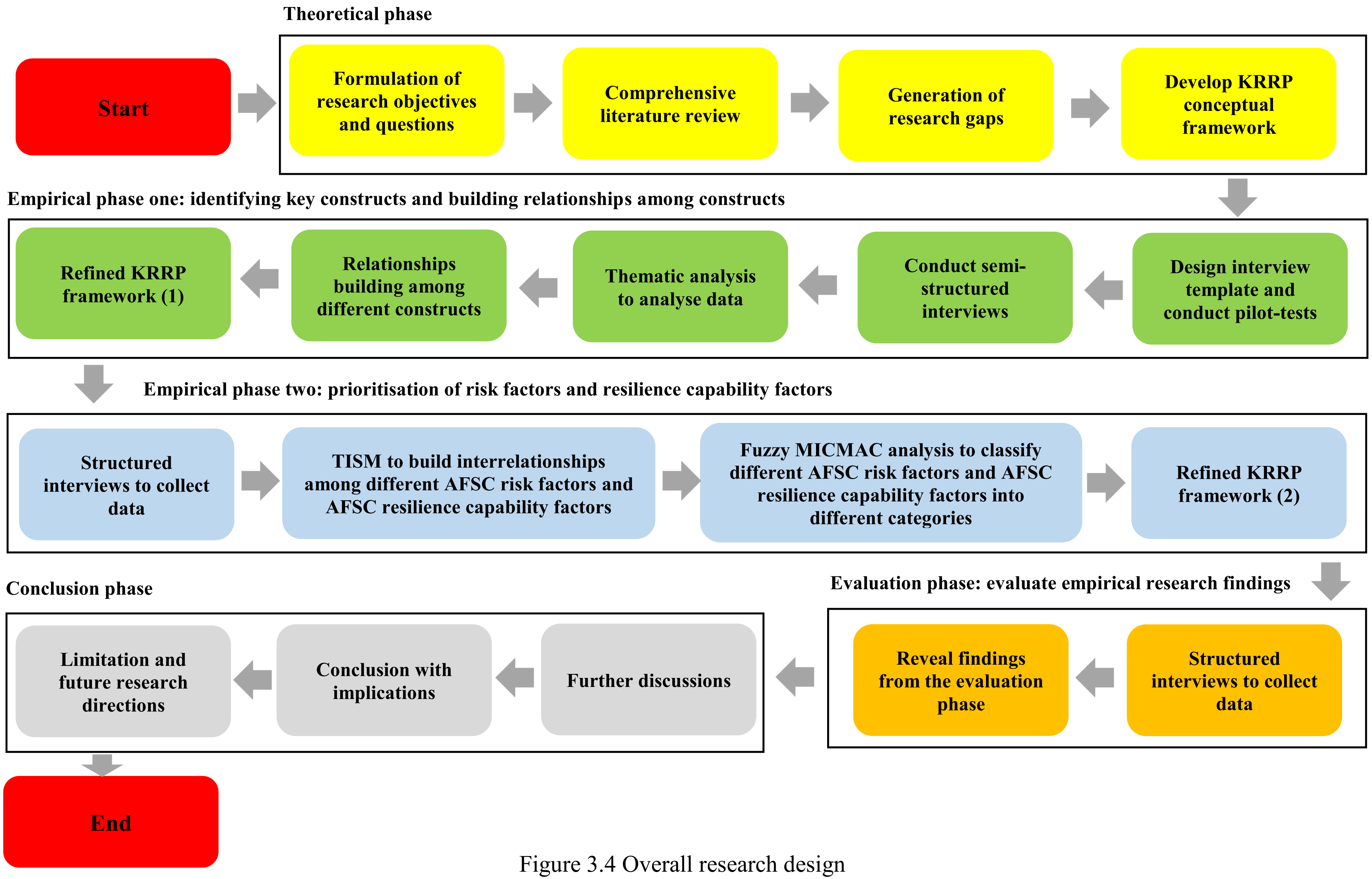


Figure 3.4 Overall research design

3.6 Research methods

This section presents the research methods adopted in this research, as well as the justification for using each method. Research methods comprise several methods used for data collection and data analysis to investigate a certain issue (Charmaz. 2014). Careful selection of data collection and data analysis methods is vital for conducting rigorous scientific research (Tashakkori and Teddie. 2008). Figure 3.5 illustrates the research mthods adopted in this study.

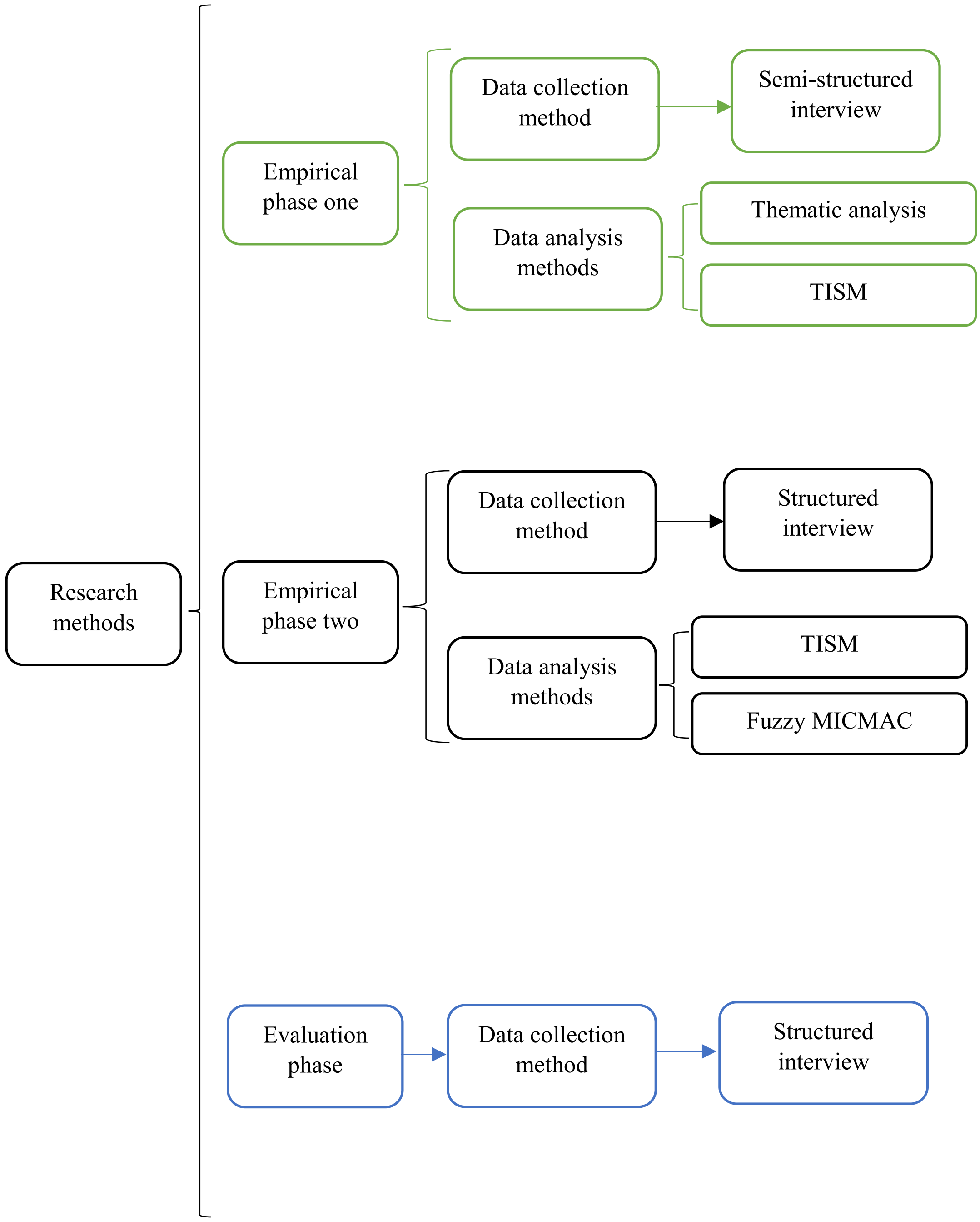


Figure 3.5 Research methods adopted

3.6.1 Research methods adopted for identifying themes and building relationships among knowledge governance mechanisms, AFSC resilience, AFSC risks, and AFSC key performance indicators

The research methods adopted in the empirical phase one, including one data collection method (semi-structured interview) and two data analysis methods (thematic analysis and TISM). Semi-structured interviews were used for collecting data from experienced AFSC practitioners and thematic analysis was used for generating different themes that related to KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. TISM was use for building relationships among different constructs. A multiple data analysis methods was adopted in the empirical phase one, as it can help to unpack different possible meanings from a single dataset (Clarke et al. 2015), as well as to balance the strengths and limitations of individual methods against each other (Frost et al. 2011).

An interview is an effective research method for researchers to gather valid and reliable data that are relevant to the research questions and objectives (Saunders et al. 2019). It may be categorised into three different categories based on their level of formality and structure, namely, structured interviews, semi-structured interviews, and in-depth interviews. Semi-structured interviews rather than structured and in-depth interviews were selected in the empirical phase one because of two primary considerations. First, the nature of data collection questions. Semi-structured interviews are suitable for answering questions where the questions are either complex or open-ended, and where the order and logic of questioning may need to be varied (Dicicco-Bloom and Crabtree. 2006; Saunders et al. 2019). Second, the purpose of the research. Semi-structured interviews are appropriate for understanding the relationships between variables. There are three advantages of using semi-structured interviews to collect data. First, it allows for in-depth investigation and clarification of interesting and relevant issues raised by the interviewees (Kallio et al. 2016). Second, it can help to elicit valuable and complete information when interviewees are provided with sufficient opportunities to speak freely (Bailey. 2008). Third, it provides opportunities for interviewer and interviewees to discuss sensitive issues (Mclntosh and Morse. 2015). As stated by Sekaran and Bougie (2013), the main advantages of using semi-structured interviews is that researchers can adapt the questions based on the reality, clarify doubts, and ensure that the questions and answers are properly understood by the interviewer and interviewee respectively through repeating or rephrasing the questions. Although semi-structured interviews have different advantages that makes it as the most appropriate data collection method for the empirical phase one, its limitations also need to be mentioned to ensure optimisation its benefits. There are several limitations of semi-structured interviews, including extremely time-consuming, interviewee sensitive, interviewer should completely master this research technique, and bias may generate during the data collection process (Adams. 2015; Mclntosh and Morse. 2015). Semi-structured interview was used in the empirical phase one to collect data from experienced AFSC practitioners.

Then, thematic analysis was used to analyse the data collected through semi-structured interviews. Thematic analysis is a systematic approach to analyse qualitative data, being “a method for identifying, analysing and reporting patterns (themes) within data” (Braun and Clarke. 2006, p. 79). Its key characteristic is the systematic process of coding, examining meaning and generation of a description of the social reality through the creation of theme (Vaismoradi et al. 2016). Thematic analysis differs from other qualitative analysis methods (e.g., content analysis, narrative analysis, and discourse analysis) as it can provide a purely qualitative, detailed and nuanced account of data through searching and identifying common threads across an entire interview or a set of interview (DeSantis and Noel Ugarriza. 2000; Braun and Clarke. 2006). The justification for using thematic analysis is based on three key fundamentals. First, thematic analysis is a simpler technique in comparison with content analysis, narrative analysis, and discourse analysis. It is easier to use when summarising key features of a large data set. Second, thematic analysis results are easily understood by public, especially by the people who have low educational level. Considering that most AFSC practitioners do not receive a higher education (UNESCO. 2017), it would be better to use thematic analysis when AFSC practitioners were asked to verify the thematic analysis results. Third, a high level of flexibility and tangibility can be achieved when using thematic analysis to analyse qualitative data (Braun and Clarke. 2006). Table 3.4 provides a list of comparison of thematic analysis with a list of qualitative data analysis approaches. However, thematic analysis has its drawbacks that may affect the data analysis result. For example, thematic analysis is a highly flexible research technique, this flexibility can lead to inconsistency and mismatch between the generated themes and the research data (refer to Table 3.4) (Holloway and Todres. 2003; Braun and Clarke. 2006). Thematic analysis was selected in the empirical phase one to generate themes.

Afterwards, TISM was selected to build relationships among different constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs). TISM is a qualitative modelling technique that evolved from interpretive structural modelling (ISM) that is used to transform unclear and poorly articulated mental models into visible, well-defined models used for many interpretations (Sushil. 2012). Compared with ISM, the biggest advantage of TISM is that it provides interpretation for both links and nodes in the hierarchical structural model, hence facilitates in answering "what", "why" and "how" in theory building (Jena et al. 2017). As stated by Sushil (2012), interpretation of each link and node with deep knowledge supported by a group of experts would not only be useful in making the hierarchical model fully interpretive, but would also contribute in creating a knowledge base of the interpretive logic of all the relations. Other methods such as DEMATEL (Decision making trial and evaluation laboratory), graph theory, ANP (Analytic network process), SEM (Structural equation modelling) all have the ability to build relationships between different constructs, but they all have their drawbacks that cannot be applied in this study. For example, DEMATEL is limited in dealing with problems of uncertainties and bias of associated with human judgement (Si et al. 2018). Graph theory has limited in deciding the direction of relationships between factors (Deo. 2016). ANP has limited applicability due to its complex procedure, whereas SEM needs a large sample size to apply (Mangla et al. 2018). Thus, TISM was selected in the empirical phase one to build relationships among different constructs.

Table 3.4 Comparison of different qualitative data analysis methods

Qualitative data analysis methods	Definitions	Advantages	Disadvantages
Content analysis	A systematic coding and categorizing approach used for exploring large amounts of textual information unobtrusively to determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication (Gbrich. 2007; Vaismoradi et al. 2013).	(1) Looks directly at communication via texts or transcripts, and hence gets at the central aspect of social interaction; (2) Can allow for both quantitative and qualitative operations; (3) Can provide valuable historical/cultural insights through analysis of texts; (4) Can be used to interpret texts for purposes; (5) Is an unobtrusive means of analysing interactions; (6) Provides insights into complex models of human thought and language use.	(1) Extremely time consuming; (2) Inherently reductive, particularly when dealing with complex texts; (3) Can be difficult to automate or computerize; (4) Tends too often to simply consist of word counts; (5) Is often devoid of theoretical base, or attempts too liberally to draw meaningful inferences about the relationships and impacts implied in a study.
Narrative analysis	An approach taken interview data that is concerned with understanding how and why people talk about their lives as a story or a series of stories (Earthy and Cronin. 2008).	(1) Provide a highly flexible theoretical framework; (2) Can provide an alternate view in comparison with essentialist and constructivist views of self; (3) The results of research can be used pedagogically to offer alternative futures.	(1) Can capture only a limited number of experiences; (2) Narratives tend to focus on “close to home” interpretations of experience and may ignore broader structural influences.
Discourse analysis	Discourse analysis is an analysis of how texts work within the sociocultural practice (Fairclough et al. 2011).	(1) Can be characterised as a way of approaching and thinking about the problem; (2) Can provide a positive social psychological critique of any phenomenon; (3) Enable to reveal the hidden motivation behind a text or behind of research to interpret that text; (4) Gain a comprehensive view of the problem.	(1) Does not provide a tangible answer to problems based on scientific research; (2) Does not provide absolute answers to specific problem; (3) Everything is always open to interpretation and negotiation.
Thematic analysis	Thematic analysis is an approach for extraction of meanings and concepts from data and includes pinpointing, examining, and recording patterns or themes (Braun and Clarke. 2006).	(1) Is a simpler technique compared with other qualitative data analysis methods; (2) High level of flexibility and simplicity and tangibility of analysis phase; (3) Analysis results are easily understood for public who have low education level. (4) Useful for summarizing key features of a large data set; (5) Useful for examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights.	(1) Sometimes a part of the questions for data collection or interview guidance is introduced as a theme; (2) Unprofessional and simplistic view sometimes destroys the value and validity of thematic analysis; (3) Does not allow researchers to make claims about language use; (4) Lack of substantial literature on thematic analysis – may cause novice researchers to feel unsure of how to conduct thematic analysis.

Source: Saunders et al. (2019)

3.6.2 Research methods adopted for prioritising resilience capability factors and risk factors

Research methods adopted in the empirical phase two, including one data collection method (structured interview) and two data analysis methods (TISM and fuzzy MICMAC analysis). First, building interrelationships among different risk factors and among different resilience capability factors, respectively. Thus, structured interview was used to collect data with experienced AFSC practitioners and ask them “Do you think there is a relationship between risk factor A and risk factor B” or “Do you think is there a relationship between resilience capability factor A and resilience capability factor B” and so on. Afterwards, TISM was used to build interrelationships among different AFSC risk factors and among different resilience capability factors, respectively. There are several methods available for building relationships between different variables such as SEM and fsQCA, but both these methods have their limitations, which make them inappropriate for this study. For example, SEM requires a large sample size to be implemented (at least 200) and fsQCA is sensitive to case selection (Vis. 2012). Second, categorising different risk factors and resilience capability factors into different categories, respectively. Thus, fuzzy MICMAC (Cross-impact matrix multiplication applied to classification) analysis was chosen to categorise different factors into different groups. Although there are other methods such as IRP (Interpretive ranking process) and AHP can assist in determining the relative importance of factors, they either fail on the part of consistency in experts’ feedback or have limited applicability for pairwise matrix of more than 9×9 (Zyoud and Fuchs-Hanusch. 2017; Mangla et al. 2018; Bianchini et al. 2019). For example, AHP uses redundant judgements for checking consistency, and this can exponentially increase the number of judgements to be elicited from decision-makers with the alternatives and criteria increasing (Ramanathan. 2004). In order to compare eight alternatives based on one criterion, 28 judgements are needed. If there are n criteria, 28n judgements should be made. This will be a hard work for the decision-makers. Through prioritising different risk factors and different resilience capability factors using a combination of TISM and fuzzy MICMAC analysis, key risk factors and key resilience capability factors can be identified.

3.6.3 Research methods adopted for evaluation phase

The main aim of this phase is to evaluate the research findings obtained in the empirical phase one and two. Thus, structured interview was used to collect data with experienced AFSC practitioners. Structured interview rather than the unstructured interview, semi-structured interview, and survey was adopted, for several reasons. First, a structured interview is suitable for collecting data where there are a number of standardised questions to be answered (Saunders et al. 2019). Currently, 60 appropriate factors are identified as effective for building KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs, and 50 interrelationships built among different AFSC risk factors and AFSC resilience capability factors need to be verified and evaluated. Hence, the situation makes unstructured and semi-structured interviews not applicable to this research phase (Zhao et al. 2020). Second, a higher response rate and a more reliable answer can be acquired in comparison with using surveys to collect data, as the interviewer needs to read out each question and then record the response following a standardised schedule (Saunders et al. 2019). Finally, managers, directors, presidents, and vice-presidents are more likely to agree to be interviewed rather than complete a questionnaire, particularly on a topic relevant to their current work (North et al. 1983). Thus, this study selected a structured interview to verify and evaluate the findings.

3.7 Research ethics

Ethics in business "refers to a code of conduct or expected societal norms of behaviour while conducting research" (Sekaran and Bougie. 2013, p.13). It has important implications for the negotiation of success to people and organisations and the collection of data (Saunders et al. 2019). In order to have successful research, University of Plymouth research ethical procedures have been considered. Six ethics principles including informed consent, openness and honesty, right to withdraw, protection from harm, debriefing, and confidentiality have been obeyed during the data collection and analysis process. Furthermore, it is important to note that the ethical approval application related to "Increase supply chain performance by addressing KG, resilience capabilities, and risks: empirical evidence from the agri-food industry" was approved by the Faculty Research Ethics Committee (FREC) of University of Plymouth on 13 November, 2017 before starting any data collection for this research (Ref: FREC1718.02).

3.8 Summary

A thoroughly analysis of research methodology has been conducted in this chapter to choose appropriate research philosophy, research approach, methodological choice, research strategy, time horizon, data collection, and data analysis methods. This study follows interpretivism research philosophy along with an abductive approach to answer the research questions and fulfil the aim of the research. As for the methodological choice, a qualitative research was suggested. Multi-method approach was adopted as research strategy. In the empirical phase one – identifying key constructs and building relationships among constructs, a semi-structured interview was used to collect data, and thematic analysis and TISM were combined together to analyse data.

In the empirical phase two – prioritising risk factors and resilience capability factors, structured interviews were used as the data collection method, TISM was used to build interrelationships among different AFSC risk factors and among different AFSC resilience capability factors, respectively, as well as fuzzy MICMAC analysis was used to categorise different AFSC risk factors and AFSC resilience capability factors into different categories.

Research results obtained in the empirical phase one and two were verified and evaluated in the evaluation phase. Thus, structured interviews were undertaken with experienced AFSC practitioners to obtain their feedback on empirical findings. Finally, the time horizon of this study is considered as cross-sectional, as this project was conducted at a particular time.

Chapter four: Phase one of the empirical study - Identifying key constructs and building relationships among the constructs

4.1 Introduction

This chapter provides an overview of phase one of the empirical study, specifically, identifying the key constructs and building relationships among the constructs. Constructs are broad concepts or topics for a study. There are four constructs in this study, namely, KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. Furthermore, there are different capabilities that can be used for building different constructs. For example, different AFSC resilience capabilities were identified in this chapter, which were the enablers for building AFSC resilience. AFSC resilience capability factors are the detailed management practices that can be used for building different AFSC resilience capabilities, whereas AFSC risk factors are the detailed risks that can have severe negative effects on the AFSCs.

Furthermore, sampling techniques, data collection and analysis methods, as well as the empirical findings were all discussed in this chapter. In particular, purposive sampling and snowball sampling over other sampling techniques were used for selecting suitable participants that participated in this research, the use of semi-structured interview to conduct interviews with the experienced AFSC practitioners were all described in this chapter. Then, this chapter illustrates how to use thematic analysis to generate themes that relates to KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs, as well as how to use TISM to validate relationships among different constructs as shown in the KRRP conceptual framework (refer to Figure 2.2). Finally, the empirical findings of phase one are presented and explained in detail. As a result, phase one of the empirical study helps to validate the KRRP conceptual framework developed in the literature review chapter.

4.2 Sampling techniques

There are two types of sampling techniques, namely, probability sampling and non-probability sampling (Saunders et al. 2019). An overview of sampling techniques is shown in Figure 4.1.

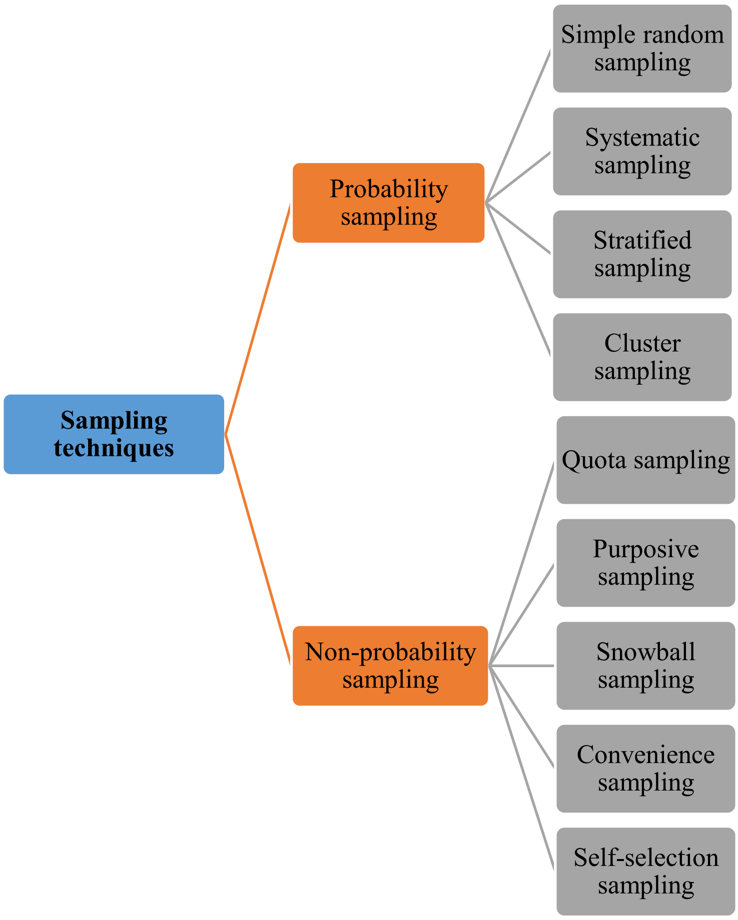


Figure 4.1 Different sampling techniques

Probability sampling is a sampling scheme in which the probability of choosing each individual is usually equal for all cases. This means that the researchers should estimate the characteristics of the population statistically from the sample in advance. Probability sampling includes four sampling strategies, namely, simple random sampling, systematic sampling, stratified sampling, and cluster sampling (Saunders et al. 2019). Brown (1947) stated that probability sampling might provide an accurate result, but might represent the most costly sample in terms of time and energy. For non-probability sampling, the probability for choosing each individual from all cases is not known (Sharma. 2017). Non-probability sampling provides a range of techniques for researchers to select samples based on the researchers' subjective judgment (Saunders et al. 2019). It includes five sampling strategies, namely, quota sampling, purposive sampling, snowball sampling, convenience sampling, and self-selection sampling (Taherdoost. 2016). Compared with the samples in the probability sampling, a sample of participants in the non-probability sampling should have a clear rationale over others (Taherdoost. 2016). Probability sampling is most commonly associated with survey-based research and quantitative research (Miles et al. 2013), whereas non-probability sampling is often associated with qualitative research (Oates. 2006). In consistency with the qualitative approach adopted in this study, non-probability sampling was selected to answer the research questions and gain theoretical insights.

There are various factors that can have an influence on the choice of non-probability sampling techniques, as shown in Table 4.1.

Table 4.1 The impact factors on the choice of non-probability sampling techniques

Sample strategy	Likelihood of sample being representative	Types of research in which is useful	Relative costs	Control over sample contents
Quota	Reasonable to high, although dependent on selection of quota variables	Where costs constrained or data needed very quickly so an alternative to probability sampling needed	Moderately high to reasonable	Relatively high
Purposive	Low, although dependent on researchers' choices: extreme case Heterogeneous Homogeneous Critical case Typical case	Where working with very small samples Focus; unusual or special Focus: key themes Focus: in-depth Focus: importance of case Focus: illustrative	Reasonable	Reasonable
Snowball	Low, but cases will have characteristics desired	Where difficulties in identifying cases	Reasonable	Quite low
Convenience	Very low	Where very little Variation in population	Low	Low
Self-selection	Low, but cases self-selected	Where exploratory research needed	Low	Low

Source: Saunders et al. (2019, p. 224)

For example, the likelihood of sample being representative, types of research in which is useful, relative costs and control over sample contents. Quota sampling is mainly used to ensure that certain groups are adequately represented in the study through the assigning of a quota (Serkaran and Bougie. 2013). Thus, participants are selected based on predetermined characteristics so that the total sample will have the same distribution of characteristics as the wider population (Davis. 2005). However, this arrangement of quota sampling also poses a threat to validity because the researchers are struggling to find suitable participants that meet the criteria rather than the development of a theory. Furthermore, excellent and knowledgeable participants may be ignored because the required number of suitable informants have already been interviewed by the researchers (Morse. 1991).

Purposive sampling is a sampling strategy that enables researchers to select participants based on predetermined criteria. Thus, participants are selected deliberately with the purpose of obtaining information that cannot be obtained otherwise (Maxwell. 2012). The rationale for using the purposive sampling technique is that the researcher assumes that the potential participants may have a deep understanding or unique perspectives on the investigated phenomenon (Mason. 2002). Therefore, their presence in the sample should be guaranteed.

As for the snowball sampling, it is mainly used when it is difficult to identify members to participate in the research (Saunders et al. 2019). Potential members are identified through participants' recommendations. Thus, the sample group appears to grow like a rolling snowball.

Convenience sampling can be seen as the least rigorous sampling technique because it involves selecting participants that are easiest to be obtained (Saunders et al. 2019). Thus, research may result in poor data quality and lacking intellectual credibility (Marshall. 1996).

Self-selection sampling is appropriate when the researchers want to allow potential participants to take part in the research based on their desire. The key component is that the research subjects volunteering to participate in the research rather than being approached by the researcher directly (Sharma. 2017). Therefore, self-selection sampling has advantages in controlling the cost at a relatively low level, but it is difficult to select suitable participants because the participants are self-selected.

Considering the aim of this study is to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks and its exploratory nature, a combination of purposive sampling and snowball sampling is selected. In phase one of the empirical study, purposive sampling was performed firstly to identify suitable participants that were knowledgeable of AFSC and KM. Specific criteria for recruiting suitable participants are (Zhao et al. 2020):

1) The participants should be from the agri-food industry (e.g., agri-chemical providers, seed providers, farmers, processors, wholesalers, distributors, retailers and consumers) and be directly involved in AFSC management.
2) The participants must have more than ten years of working experience in AFSC management, to ensure that the participants have a high level of knowledge and experience and expertise.
3) The selected company must be either a medium-sized (from 50 to 249 employees) or a large-sized company (more than 249 employees) because these companies have rich experience and a deep understanding of managing AFSC. This criterion is used by the European Commission based on the number of persons employed in each enterprise (European Commission. 2005).
4) The company should provide access to its key information, including valuable data about how the management facilitate to apply KGMs, which management practices used for building AFSC resilience capabilities, how the management deal with the risks, which KPIs used for evaluating AFSC performance.

Normally, there are no specific requirements for the sample size because the specific number will depend on the complexity of the research questions, the interview topic, the diversity of the sample, and the nature of the analysis (Saunders et al. 2019). Yin (2003) stated that researchers usually reach a data saturation point after interviewing 8 participants. Francis et al. (2010) suggested at least 10 interviews should be conducted in the initial analysis sample. Based on the above discussion, 19 participants were selected to conduct interviews using a purposive sampling technique.

The data collection process started with a wholesale distribution company in Southern France, which was a focal company in the local AFSC and had good connections with their upstream and downstream partners. Afterwards, snowball sampling was employed to identify additional participants (Zhao et al. 2020). At the end of each semi-structured interviews, each participants were asked to refer to other experienced AFSC practitioners that could participate in this research. Based on the criteria for recruiting participants (see above), some participants were found not suitable for conducting interviews because they did not have enough working experience, which resulted in only three additional participants being identified. After conducting further three interviews, new themes did not emerge, indicating reaching data saturation point; thus, stopping conduct further interviews, which made the total sample size of 22 participants (Zhao et al. 2020).

An overview of all interviewees is shown in Table 4.2, including the interviewees' countries and companies, their positions in their companies, and the role and responsibilities of their companies in the AFSC. Thus, this study includes 22 interviewees from four countries (e.g., France, Spain, Italy, and Argentina). These interviewees are from different companies in the AFSCs, including input suppliers, farmers, cooperatives, food processors, wholesalers, and distributors.

Table 4.2 An overview of the interviewees

Country	Company	Interviewees' position	Role and responsibility in AFSC
Spain	A	Project manager	**Input supplier**: (1) Advising on research and development of agri-food; (2) Transferring the scientific results obtained and maintain relations with the agri-food sector.
	B	Director	**Cooperative**: (1) Fully involved in aspects of food safety and quality, guarantee in all cases compliance with the established legal requirements and thus securing food with the level of safety demanded by both the market and consumers.
	C	Co-owner	**Food processor, wholesaler, and distributor**: (1) Suppliers of major national and international supermarkets;
	D	Director	**Retailer**: (1) Require the participation of professionals in agriculture through implementing agricultural policy; (2) Securing the farmers' interest and promoting their profitability.
France	A	Marketing manager	**Input supplier**: (1) Developing new varieties of vegetables, mainly on cauliflower, artichokes, shallots, onions.
	B	Operation director	**Input supplier**: (1) Specialising in agricultural equipment and management of rural areas through collaborating with professional agricultural organisations and thousands of cooperatives.
	C	Director	**Farmers**: (1) Cultivating plants to generate a weaker consumption of inputs and impacts more in favour of biodiversity, health and environment; (2) Cultivating different plants to improve the business cluster competitiveness.
	D	Director	**Cooperatives**: (1) Formulating agriculture policies of their regions.
	E	Director	**Food processor, wholesaler, and distributor**: (1) Supporting shippers and distributors; (2) Monitoring consumer trends; (3) Developing packaging formats and innovative solutions in response to the network demand.
Italy	A	Director	**Input supplier**: Mainly responsible for providing experimental service for different kinds of vegetables.
	B	Project manager	**Cooperatives**: (1) Providing information and training opportunities for farmers and agri-food companies; (2) Dissemination of good agricultural practices;
	C	Operation manager	**Food processor**: (1) Building direct relationships with local farmers and doing a business in the field of vegetable extracts.
Argentina	A	Co-owner	**Input supplier**: (1) Mainly responsible for selling agri-chemical and various types of seeds to farmers.
	B	Director	**Input supplier**: (1) Mainly responsible for transferring agricultural knowledge to farmers.
	C	Middle management	**Input supplier**: (1) Mainly responsible for helping small farmers to tell them agricultural policies, knowledge, and providing necessary assistance on preventing pests and diseases.
	D	Director	**Input supplier**: (1) Mainly responsible for researching vegetables to promote its production quality and quantity, and develop new pest resistant varieties.
	E	Director	**Input supplier**: (1) Mainly responsible for providing professional advice on marketing.
	F	Owner	**Farmers**: (1) Mainly responsible for producing different kinds of vegetables such as tomatoes, eggplants, cucumbers.
	G	Owner	**Farmers**: (1) Mainly responsible for producing different leaf-vegetables such as lettuce, cabbage, spinach, and celery.
	H	Owner	**Farmers**: (1) Mainly responsible for producing and exporting organic vegetables such as spring onion, green pepper, crown daisy, tomato, and eggplant.
	I	Director	**Cooperative**: (1) Disseminating good agricultural practices and providing quality certificates to farmers; (2) Providing training courses for farmers, especially for smallholders.
	J	Director	**Wholesaler, distributor, and retailer**: (1) A platform for farmers to sell their products in this market, 20% of vegetables and fruits production in Argentina are sold there.

Source: Zhao et al. (2020, p.4857)

4.3 Empirical data collection with semi-structured interviews

Prior to conducting interviews, an interview guide was developed and questions focused on obtaining the participants' opinion on how to facilitate KGMs, what risks exist in the AFSC, what resilience capabilities are used for tackling risks, and what KPIs are used for evaluating AFSC performance. Furthermore, there was freedom for participants to express ideas with respect to the context being discussed, and the interview guide was used as guidance to keep the focus of the discussion on the subject. Many probing questions were asked to get participants to clarify their answers where necessary.

The interview guide consists of five sections (see Appendix A) (Turner. 2010; Kallio et al. 2016), as an interview guide includes several topics that you plan on covering in the interview associated with a list of research questions that you want to answer under each topic (Bird. 2016). The phase one of the empirical study aims to explore themes related to KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs, as well as the relationships among these four constructs. Therefore, the interview guide includes five sections, including general information section, KGMs section, AFSC resilience capabilities section, AFSC risk section, and AFSC KPIs section. It starts with general information asking about the interviewee and the company, and then specific questions were asked to know the KGMs. Then, the interview guide has two specific sections to ask about AFSC risks and AFSC resilience capabilities, respectively. Finally, questions were asked about KPIs for AFSC.

After developing an interview guide, the interview guide was initially checked by two full-time professors in the area of SCM and operation management, respectively. Then, pilot interviews were conducted with three experienced AFSC practitioners to confirm the coverage and relevance of the content, as well as to identify the questions that need to be reformulated. The modifications and corrections were minor based on the feedback from the experienced AFSC practitioners. Nevertheless, most of the comments focused on how to make potential participants to understand the interview questions more easily because most of the potential participants in the agri-food industry. Therefore, re-wording questions to avoid any misunderstanding or confusion.

Face-to-face semi-structured interviews were carried out with 22 experienced AFSC experts from the agri-food industry across four countries – Argentina, France, Italy, and Spain from April 2017 to May 2019. The agricultural output of France, Italy, and Spain accounts for 16.7%, 12.1% and 11.7% respectively in 28 countries of the European Union (European Commission. 2018). As for Argentina, the whole agro-industrial transformation sector was estimated to be 32% of GDP (Regunaga and Tejeda Rodriguez. 2015). The critical role of agriculture in these four countries provides a very good opportunity for the researcher to explore the topic: increase supply chain performance by addressing KG, resilience capabilities, and risks: empirical evidence from the agri-food industry.

As these four countries located in the southern and northern hemispheres, it was worthy for the author to visit them to investigate the topic in appropriate times as risks are diverse in different seasons. In summer and autumn, AFSC practitioners in the four countries experience more biological and environmental, weather-related, and logistical and infrastructure risks. However, they experience more supply and demand risks in the winter and autumn seasons (Zhao et al. 2020). The interview with managers, directors and middle management in the agri-food related companies, provided a robust opportunity to explore the topic in depth.

A copy of the interview guide was provided to the interviewees three days before the interview sessions to allow interviewees to have enough time to familiarise with the questions and organise the answers. Each interview lasted from 60 minutes to 90 minutes on average to allow participants to have plenty of time to elaborate on their opinions. The consent form was provided for interviewees at the beginning of the interview to make sure that he/she agreed to take part in the interviews. Simultaneously, audio recording permission was requested. Audio recording is suggested to be used in interviews as it can provide three significant benefits for researchers (Barriball and While. 1994). First, it provides a detailed insight into the performance of both the interviewer and interviewee through replication of the contents of each interview. Second, it helps to validate the accuracy and completeness of the information collected. Finally, it reduces the error of the interviewer in translating the data into a transcript. After each interview, the interviewer emailed the interviewees with transcripts and notes taken during interviews to ensure that interviewees' opinions were understood correctly. Thus, it ensures that no important information was missed, and data validity and reliability can be achieved (Kumar et al. 2019).

4.4 Data analysis process with thematic analysis

The qualitative data collected through semi-structured interviews were analysed by using thematic analysis. Thematic analysis is a technique used to analyse textual data and elucidate themes (Forman and Damschroder. 2008). It consists of six steps, as shown in Figure 4.2: familiarising with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (Zhao et al. 2020).

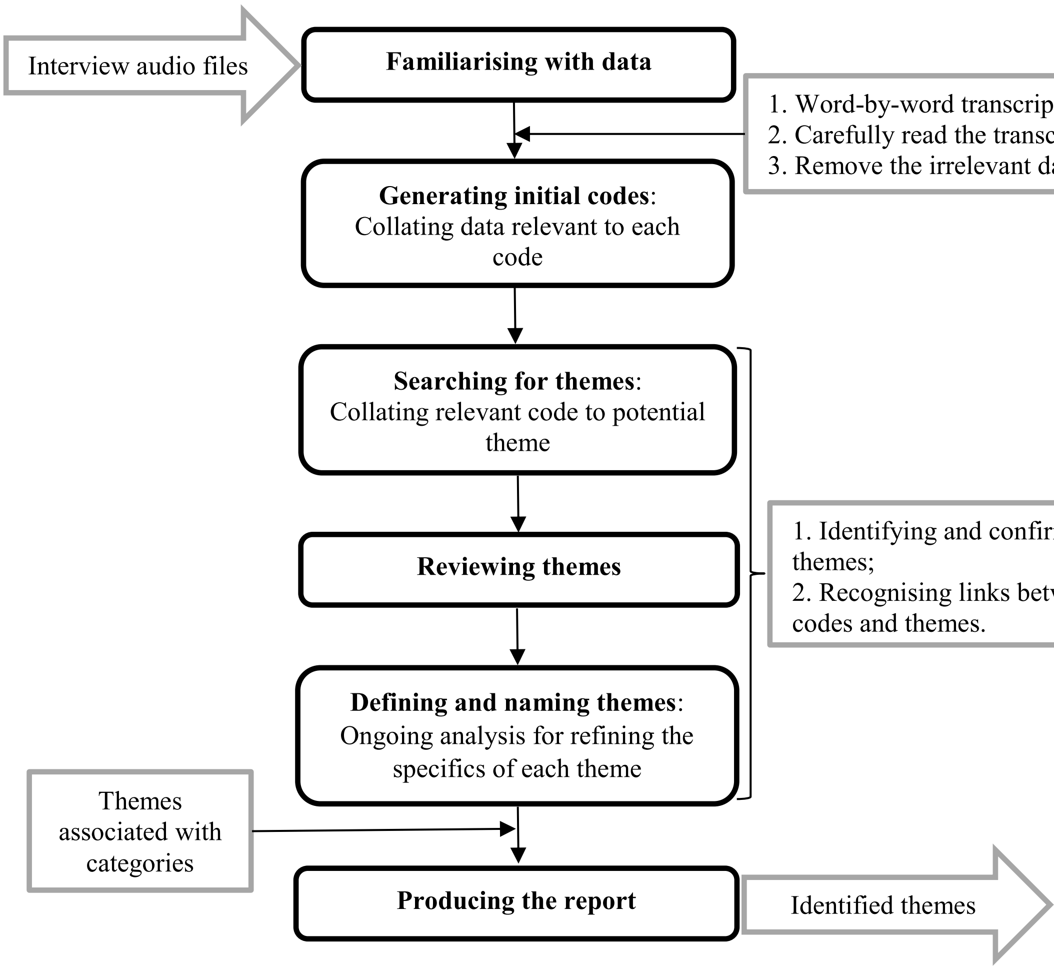


Figure 4.2 Thematic analysis process (Souce: Zhao et al. 2020, p. 4858)

Each interview audio file was transcribed word-by-word to avoid missing any elements from the responses given by the interviewees. Carefully reading the transcript several times to build initial ideas on the whole data set and to ensure that irrelevant data were removed. Afterwards, work systematically on the whole data set and list meaningful and key issues in the data set. This step reduced the amount of raw data that is relevant to KGMs, AFSC resilience capabilities, AFSC risks, and KPIs for AFSC. Through the transformation of raw data into manageable sections, higher-level insights can be achieved (DeCuir-Gunby et al. 2011). The next step involved searching for themes through evaluating the relationships between codes, between themes, and between main themes and sub-themes, and then sorting and organising all relevant codes into potential themes until all possible themes, sub-themes, and related codes were generated. Afterwards, themes were checked for suitability for the extracted codes and the entire data set, generating a thematic map. After reviewing the themes, an ongoing analysis was performed to ensure that there were clear definitions and names for each theme. Finally, vivid and compelling extract examples were selected to produce an analysis report (Zhao et al. 2020).

Throughout the analysis, a number of themes were identified by considering the three stages proposed by King and Horrocks (2010):

- ❖ Descriptive coding (first-order codes): the transcript data from interviews were allocated to suitable descriptive codes that help to answer the research questions.
- ❖ Interpretive coding (second-order themes): the descriptive codes that seemed to have some common meanings were grouped together, with an interpretive code being created to capture them.
- ❖ Defining overarching themes (aggregate dimensions): a number of overarching themes that characterised the key concepts in the analysis were identified.

4.5 Results of thematic analysis

The thematic analysis results are discussed in this section, based on the data collected from 22 experienced AFSC practitioners across four different countries – Argentina, France, Italy, and Spain. In consistency with the KRRP conceptual framework (refer to Figure 2.2), the empirical findings are categorised into four constructs, namely, KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. In the following sections, the thematic analysis results will be discussed to support the inclusion of the variables.

4.5.1 Exploring knowledge governance mechanisms

There are four types of KGMs (e.g., trust-based, reciprocity-based, market-based, and contract-based KGMs) as described in chapter two-literature review and in the KRRP conceptual framework. The empirical findings also revealed that these four types of KGMs are normally used to facilitate knowledge sharing/transfer between different AFSC organisations. Table 4.3 presents an overview of the empirical evidence of different KGMs, linking first-order codes, second-order KGM themes, and the evidence support from each interview. The first-order codes are direct quotes from the interview transcripts (see column one), while the second-order themes are the factors for building KGMs. The third column indicates the presence or absence of evidence obtained within the interviews. A tick (√) represents the presence of weak evidence, three ticks (√√√) mean strong evidence, and no tick means no evidence (i.e. absence of evidence) (see column three). For example, building shared understanding got three ticks from the company A of Spain, which means that there was strong evidence in company A of building shared understanding could help build trust-based KGM. Increasing involvement got one tick from the company I of Argentina, which means that there was weak evidence in company I of increasing involvement could help build reciprocity-based KGM. Finally, the aggregate dimensions reveal the KGM used in AFSC.

Table 4.3 Empirical evidence in discovering KGMs

First-order codes	Second-order themes	Support from cases for KGMs																						Aggregate dimensions
		Spain				France					Italy			Argentina										
		A	B	C	D	A	B	C	D	E	A	B	C	A	B	C	D	E	F	G	H	I	J	
"It is necessary to write a clear definition among all the actors, which is the problem to the research".	**Building shared understanding**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"Did you set some projects for different producers working together? Yes. There has another project trying to make different producers work together".	**Building a project partnership**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"We use education technology to know how to transfer the knowledge in a way that farmers would be able to understand".	**ICT application**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"The producer trusts us because we have been working together with them for a long time, and we try to help them with technical things".	**Long-term relationship**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Trust-based KGM**
"How many times technical people will come here to see the products? Every week".	**Facilitate consistent communications**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"It must be diagnostic weight the problem. Then, we collaborate with each other to develop the research".	**Joint decision-making**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"For example, I give a lot of conferences, visit some farms and conduct personal communications".	**Personal ties**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"Farmers feel that they are members of the community and everybody works together…So farmers feel that they are part of the process".	**Increasing involvement**	√ √			√ √	√	√		√			√ √			√	√		√ √	√		√ √ √	√		

"We need to listen to the opinions from the other actors in this model because this would be the knowledge that you will have to develop".	**Constructive feedback**		√√√	√	√	√	√√	√	√	√√√		√	√√	√√	√√	√√	√	√√	√		√√	√		**Reciprocity-based KGM**
"I am insisting on the idea the farmers playing an active role in telling me the research process. It is not to work against the farmers; it is to work with the farmers. This is a different idea".	**Building an equal relationship**	√	√√	√√	√√	√√√	√	√		√√	√	√√	√	√√√										
"We offer quality certification for farmers if they apply the rules correct. These rules including apply good agriculture practices, using agri-chemicals correctly and not using toxic categories".	**Rewards**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**Market-based KGM**
"There will be new rules to solve these kinds of problems, for example, how to collect empty bottles, where to put empty bottles. It is important to train farmers, to transfer knowledge with them. Thus, they will use a better way to work".	**Legislations and rules application**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"Farmers signed a contract with saying that they will respect the rules of the auction market".	**Sign an contract or agreement**	√	√	√√	√	√	√√√	√	√	√	√	√√	√											**Contract-based KGM**
"If there are fewer middle men, this means the communication between producer and consumer is efficient".	**Fewer intermediaries**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"In this process, it is more about taking responsibility. According to the knowledge experience, we take different responsibility…"	**Role clarity**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	

Source: Zhao et al. (2020)

The findings discovered four types of KGMs that are normally used by AFSC organisations to transfer/share knowledge, namely, trust-based, reciprocity-based, market-based, and contract-based KGM. Trust-based KGM refers to how to build trust between partners for facilitating knowledge sharing/transfer. Seven factors were identified effectively in building trust relationship and gained all support from the 22 companies, namely, building shared understanding, building a project partnership, ICT application, long-term relationship, facilitate consistent communications, joint decision-making, and personal ties. The findings indicate that knowledge sharing/transfer can be significantly improved by increasing the trust relationship among AFSC partners.

Reciprocity-based KGM refers to how to build reciprocal relationships among different AFSC partners. Only three factors were identified in the empirical study, namely, increasing involvement, constructive feedback, and building an equal relationship. Increasing involvement can be seen as a factor in building a reciprocal relationship, as partners can be beneficial from the collective activities such as open days of research institutes and free agricultural conferences. One of the interviewees stated:

"*In the other model…farmers recognise that everybody plays a key role in this process. They feel they are a community and everybody works together…So farmers feel that they are part of the process. Not like in the past researcher imposing them. By recognising the contribution of future actor, farmers feel they are part of the model and they build more trust*".

Constructive feedback can be seen as a new factor because receiving opinions from others can help to create new knowledge. Furthermore, it may help the knowledge to be understood more easily by farmers as most of them do not know professional words and only receive knowledge from their family members. This can be proven by the following statement:

"*We are trying to use different tools to have bidirectional communication between different actors. We need to listen the opinions of other actors in this model because this would be the knowledge that you will need to develop. First of all, learn to listen and have dialogues*."

As shown in Table 4.3, building an equal relationship got evidence only from 12 companies. Most of the cases from Argentina do not support this finding as an unequal relationship existing in their AFSC to hinder knowledge transfer/sharing. One of the interviewee from Argentina stated:

"*Farmers have the feeling that researchers were imposing things*".

However, one of the interviewees from France argued that an unequal relationship between partners could help to facilitate knowledge transfer/sharing, as they needed to follow the requirements of the team leaders. The significant difference between France and Argentina maybe caused by the difference in the structure of the investigated company. The investigated company in Southern France was established by a large number of farmers (2,000 to 3,000 farmers). All the farmers in this company are the co-owners because the farmers were asked to pay a membership fee when they joined this company. Thus, if the company wants to have continuous development, satisfying the requirements of most of the farmers is critical. Conversely, if the farmers want to get more profit from the company, they need to share their knowledge or technology with other farmers to facilitate development. However, the investigated companies in Argentina do not have a special relationship. While there is a large number of farmers joining the different associations in Argentina (e.g., Association of Bolivian farmers), this kind of association is only for socialising rather than for sharing knowledge or technology.

As for the market-based KGM, it refers to incentives that can facilitate inter-organisational members to search for solutions or increase knowledge transfer/sharing. Two factors were mentioned by interviewees that have positive effects for knowledge sharing/transfer, namely, rewards and legislations and rules application. One of the interviewees stated:

"*We offer quality certification for farmers if they apply the rules correctly. These rules include applying agriculture good practices, using agri-chemicals correctly and not using toxic categories*".

Quality certification has an important role in ensuring the quality and safety of agri-food products, which means better quality and less agri-chemical products. The investigated company in Southern France has created its own quality certificate in order to fulfil customer's more strict quality and safety requirements. Thus, more strict quality and safety standards have been implemented in the company regarding the shape, colour, and pesticide of the agri-food products in comparison with other standards such as EU regulation 1308/2013, EU implementing regulation 2017/892, EU implementing regulation 543/2011, and EU delegated regulation 2017/891. Aforementioned regulations have been implemented in the EU with regards to the quality and safety of fruit, vegetables, processed fruit, and processed vegetables. In Argentina, the regional government of La Plata has required the AFSC practitioners to implement good agricultural practices. A certificate will be provided to the qualified farmers if they pass the free training courses offered by the local government. This certificate will improve the farmers' competitiveness in the markets.

Finally, the contract-based KGM concerns building a standard/norm as a way of coordinating for building social bonds between partners for facilitating knowledge sharing/transfer (Fang et al. 2013). Signing a contract or agreement with partners, less intermediaries, and role clarity were proved effectively for facilitating knowledge sharing/transfer. It is interesting to note that signing a contract or agreement in Argentina is not a common phenomenon. As one of interviewees from Argentina stated:

"*We do not use contract here, nobody offers you a contract*".

Therefore, signing a contract or agreement to form partners' behaviour to facilitate knowledge sharing/ transfer is not applicable to Argentina. All the interviewees across the four countries emphasised that less middleman in knowledge sharing/transfer channels and allocating appropriate responsibility for AFSC partners can effectively help to transfer knowledge between partners. The following statement support this argument.

"*If there are fewer middlemen, this means the communication between producer and consumer is efficient*. *In this process, it is more about taking responsibility. According to the knowledge experience, we take different responsibility*…"

4.5.2 Exploring AFSC resilience capabilities

Empirical findings revealed five AFSC resilience capabilities, namely, flexibility, redundancy, supply chain collaboration, visibility, and development and innovation. In comparison with the supply chain resilience capabilities identified in the literature, development and innovation was identified as a new resilience capability for building AFSC resilience. Table 4.4 shows the empirical evidence of AFSC resilience capabilities with the data collected from experienced AFSC practitioners. The first-order codes are direct quotes from interview transcripts (see column one of Table 4.4). Subsequently, the second-order themes represent the factors of building AFSC resilience capabilities (see column two of Table 4.4). The third column represents the presence or absence of evidence obtained within 22 cases across four countries – Argentina, France, Italy and Spain. Three ticks (√√√) mean strong evidence, whereas one tick (√) means weak evidence. For example, leadership got three ticks from company A of Argentina, which means that there was strong evidence in company A of leadership could be a factor for building development and innovation. Finally, the aggregate dimensions represent AFSC resilience capabilities (see column four of Table 4.4).

Table 4.4 Empirical evidence in discovering AFSC resilience capabilities

First-order codes	Second-order themes	Support from cases for AFSC resilience capabilities																					Aggregate dimensions
		Spain				France					Italy			Argentina									
		A	B	C	D	A	B	C	D	E	A	B	C	A	B	C	D	E	F	G	H	I	J	
"There are some training courses, it depends on what needed by producers. Producers may ask or demand from training, so we can organise training courses".	**Training and development**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"Did you set some projects for different producers working together? Yes. There has another project trying to make different producers working together".	**Build a project partnership**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"It is necessary to write the clear definition among all the actors, which is the problem to the research. It must be a common diagnostic weight the problem. Then, we collaborate with each other to develop the research".	**Building shared understanding**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"We always working together because we are familiar with each other and we can talk with each other freely".	**Working team stability**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**Development and innovation**
"Our leader's support is very important for coordinating and collaborating with each other. We could get money to do things if we got their permission".	**Leadership**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"We can make a conference. And we also can go to the farm to tell the producers this new type of fruit and vegetable".	**Information sharing**	√√	√	√	√	√√	√√	√	√√	√	√√	√√√	√									√√	√√	
"Do they make a decision together? Yes".	**Joint decision-making**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**Supply chain collaboration**
"How do you work with farmers? Not through individual assistance, only by confirming groups of producers. Visit the all of the farms and monthly meeting with farmers".	**Regular meetings**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"Producers trust us because we are technicians, we try to help producers…The producer trusts us because we have been working together with them for a long time, and tries to help them with technical things. We have the knowledge".	**Trust**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	

"When the farmers wanted to join the organization, the farmers were required to buy some shares of the organization. If they want to be part of the organization, they should buy some shares. If you want to leave, you can take back your shares".	**Organisational ethos**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"We hire some people on a temporary basis for the harvesting time. 25 % more people".	**Labour contract flexibility**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	
"We do not know customer preference. Thus, we cultivated different types of vegetables to earn money".	**Product differentiation**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**Flexibility**
"Mainly through visual to check the products, and then we sell the products to Central Market. In Central Market, there has an inspector to check the quality of the product in the lab. This is another way to control the quality of products".	**Frequent quality checks**	√	√	√√√	√√√	√	√√	√		√	√√	√		√√√	√	√	√√√	√√	√√√	√	√	√√	√√	
"How many suppliers do you have…More than 100, 110 – 120".	**Multiple suppliers**	√	√			√	√	√	√	√		√		√		√			√	√	√			
"We have insurance in case we have problems of an accident".	**Insurance**	√	√	√	√√	√√	√	√	√	√√	√	√√√		√	√	√	√√	√√	√					**Redundancy**
"At the beginning of the season, we buy a huge amount. With the time pass by, if we need a little more because all the producers buy this seed, we will order a little".	**Reserve raw material stock**	√√	√		√√	√		√	√√√	√	√√	√		√		√√	√						√√	
"It is a competitive advantage if you have traceability technology. Regardless of the quality of the product, you can sell it first, which means you have a quality certificate. Traceability likes a quality certificate".	**Traceability**	√√	√	√	√√	√√	√	√√	√	√√√	√	√					√√		√	√			√	
"In this process, it is more about taking responsibility. According to the knowledge experience, we take different responsibility…"	**Role clarity**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**Visibility**
"We use education technology to know how to transfer the knowledge in a way that farmers would be able to understand".	**ICT application**	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√	

Source: Zhao et al. (2020)

Compared with the four AFSC resilience capabilities identified (e.g., flexibility, redundancy, supply chain collaboration, and visibility) in the literature review, an additional AFSC resilience capability – development and innovation were identified in the empirical study. It includes five factors, namely, training and development, building a project partnership, building shared understanding, working team stability, and leadership.

Working team stability can be seen as a new factor for building development and innovation, and it has been proven significantly for building AFSC resilience (Zhao et al. 2018). Personnel turnover can reduce a company's performance and competitive advantage due to losing portions of the company's memory and knowledge as an individual leaves (Liu. 2020). It is important to note that all the factors identified for building development and innovation gained full support from the 22 cases. For example, building shared understanding is identified as useful for tackling knowledge boundaries (e.g., syntactic boundary, semantic boundary and pragmatic boundary) and further facilitating knowledge sharing/transfer. Proper training and development programmes such as training sessions on good agricultural practices would help farmers to learn new skills. In Rennes (Southern France), an agri-tech conference is held every year to introduce new agri-technologies (e.g., big data, smart sensor, and blockchain) for AFSC practitioners to know the latest trend in the agri-food sector.

However, the investigated cases in Argentina are mostly based on their experience in cultivating vegetables. In other words, they are reluctant to learn new knowledge and cultivate new vegetables. For some agricultural conferences and training sessions, most of AFSC practitioners in Argentina considered these conferences as a place for socialising rather than a place for learning new knowledge. Furthermore, Argentina's eating habits maybe another reason for AFSC practitioners' reluctance to learn new knowledge and to take part in training sessions. For example, one of the interviewees stated:

"In this region of Argentina, we do not have a good culture of how we choose agri-food products. We always try to eat the same thing without taking into account the season. For example, we always want to eat tomatoes in all the seasons".

Another interviewee from Argentina construed the same situation:

"We used to cultivate a lot of peppers in here. It is a special product for us because we do not like to eat pepper. You need to cook it and do something with it. It is not like a tomato that you can eat with any kind of salads. Pepper is a special product to be consumed here. When you want to produce more pepper, you need the market to help you. Market, for example, you need more consumers. So we choose to raise the production of tomatoes instead of continuing rising the production of pepper. We do not like to consume each product here, but each greenhouse is cultivated with tomato. Not anyone like peppers. If you produce more peppers than tomatoes, you may be at risk".

The empirical findings suggest that supply chain collaboration plays an important role in building AFSC resilience. Five resilience capability factors were identified as important for building AFSC resilience, namely, information sharing, joint decision-making, regular meetings, trust, and organisational ethos. It is important to note that joint decision-making, trust, and regularly meetings are considered as the most important factors because these factors gained full support from the 22 interviews. Furthermore, joint decision-making and regular meetings have positive effects in fostering trust because AFSC practitioners always discuss together (Zhao et al. 2018). Information sharing is critical for supply chain collaboration because it helps achieve transparency across the supply chain (Matopoulos et al. 2007). For reducing the bullwhip effect and making collaborative forecasting, information sharing is also necessary (Lee et al. 2000; Aviv. 2007). However, information sharing only gained 14 out of the 22 interviewees' support, most of them are from France, Italy, and Spain. The following statement can support this idea:

"To be honest, many farmers do not care about sharing information. I think if the farmer wants to share information, they will generate a network to share it. Maybe the infrastructure can boost to share information. If the farmer wants, I think they can do it".

Another interesting phenomenon is that of organisational ethos that gained full support from all companies located in France. One of the investigated companies in France has a focal status in their local AFSC; therefore, the organisational ethos could be implemented by other companies in the same AFSC. One of the interviewees from France stated:

"When the farmers wanted to join the organisation, the farmers were required to buy some shares of the organization. If they want to be part of the organisation, they should buy some shares. If you want to leave, you can take back your shares".

It concludes from the aforementioned statements that the focal company's requirements for requiring farmers to buy some shares can help to facilitate supply chain collaboration because all the AFSC practitioners' fates are tied together.

Flexibility was mentioned by interviewees as an important capability for building supply chain resilience. It includes three resilience capability factors, namely, labour contract flexibility, product differentiation, and frequent quality checks. All the investigated companies have implemented flexible labour contracts during harvesting time in order to reduce operation cost. For example, one of the interviewees stated:

"We hire some people on a temporary basis for the harvesting time. 25 % more people".

Furthermore, all the investigated companies have cultivated different agri-food products to meet customers' requirements. For example, 16 types of tomatoes (e.g., cherry tomato, san marzano tomato, roma tomato, jubilee tomato, and celebrity tomato) are cultivated in the same company of France in order to satisfy the customer preference regarding different seasons. In Argentina, different types of vegetables such as eggplant, tomato, lettuce, and rosemary are cultivated to satisfy customers' requirements.

Redundancy is also a prevalent strategy that has been used in different companies. Three resilience capability factors were identified as important such as multiple suppliers, insurance, and reserve raw material stock. It is important to note that reserving raw material stock is always used in developed countries (e.g., France, Italy and Spain) because of good agricultural infrastructure. In Southern France, seven days' stock of broccoli is reserved for the coming peak season. However, high electricity fee and lack of adequate infrastructure in Argentina make reserving raw material stock difficult to be implemented. As one of the interviewees from Argentina stated:

"It is quite a lot of electricity fee – 3000 dollars per month in the summer time. You need to consider the lights and you also need to consider the pumps to get the water".

The last important AFSC resilience capacity identified from the empirical study is visibility. It includes three resilience capability factors, namely, traceability, role clarity, and ICT application. ICT application is considered as an enabler for building visibility because its application facilitates supply chain members to acquire and distribute information (Somapa et al. 2018). Several studies reinforced the effectiveness of ICT application in improving supply chain visibility from an information-sharing perspective (Williams et al. 2013; Brandon-Jones et al. 2015). Role clarity and ICT application gained full support from all 22 investigated companies, whereas traceability only gained support from 15 investigated companies. Traceability can be seen as a competitive advantage, as one of the interviewees stated.

"It is a competitive advantage if you have traceability technology. Regardless of the quality of the product, you can sell it first, which means you have a quality certificate. Traceability likes a quality certificate".

However, traceability technologies are mostly applied in France, Italy, and Spain. As for Argentina, few companies have applied traceability technology because of customers' realisation towards traceability technology. For most customers in Argentina, there is no difference between the agri-food products with traceability technology and without traceability technology. One of the interviewees stated:

"Basically, when we develop products we try to make some difference among the other products. We may use organic products and traceability technology, but there is no difference in the consumer's mind when they see the products. All products look like the same for them. So it is a hard situation to make a difference in your products when all products look like the same for consumers".

Traceability has various potential advantages for AFSC, including minimising the production and distribution of unsafe or poor quality products (Aung and Chang. 2014). However, most Argentina consumers' assumed that the price of non-traceability-covered agri-food products is the same as the products using traceability technology. Applying traceability technology cannot help farmers in Argentina to earn more profits. Thus, this can be seen as the main reason why traceability technology is not prevalent in Argentina.

4.5.3 Exploring AFSC risks

After conducting an empirical study across Argentina, France, Italy, and Spain, 16 risk factors were identified and categorised into eight risk types, including demand risks, supply risks, biological and environmental-related risks, weather-related risks, logistical and infrastructure risks, political and macroeconomic risks, financial risks, and management and operational risks. Although a great number of risk factors were identified in the literature, the empirical findings still revealed some additional risk factors existing in the current AFSC practices. For example, rapid technological development in the logistical and infrastructure risk category, and oral contract or agreement with partners, skill shortage, tax evasion, and the lack of investment in promoting agri-food products in the management and operational risk category (Zhao et al. 2020).

Table 4.5 shows the empirical evidence of different risk types and related risk factors that cause vulnerabilities to the AFSC of Argentina, France, Italy, and Spain. The first-order codes are the direct quotes from the interview transcript (see column one), while the second-order themes are the risk factors that represent the first-order codes (see column two). The third column indicates the presence or absence of evidence obtained from the interview cases. A tick (√) represents the presence of weak evidence, three ticks (√√√) mean strong evidence, whereas no ticks represent no evidence (see column three). For example, market price fluctuations got three ticks from the company A of Spain, which means that there was strong evidence of market price fluctuations could cause vulnerabilities of company A. Finally, the aggregate dimension column represents the main risk types.

Table 4.5 Empirical evidence in discovering AFSC risks

First-order codes	Second-order themes	Support from cases for AFSC risks																						Aggregate dimensions
		Spain				France					Italy			Argentina										
		A	B	C	D	A	B	C	D	E	A	B	C	A	B	C	D	E	F	G	H	I	J	
"Within the market risk … demand and supply can affect the price. Sometimes, there is too much production, which means the price will decrease".	**Market price fluctuations**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Demand risks**
"Another problem is supply and demand. If you provide a large number of products, you may not be able to sell the products. This is the problem of the supply and demand".	**Supply and demand imbalance**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"…Sometimes, we may share some information, but we are reluctant to share information with them".	**Lack of information sharing among partners**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Supply risks**
"There is no agreement/discussion among farmers about how much they need to produce… Another risk is that there are no clear plans for against diseases and pests".	**Poor planning**			√ √								√		√	√	√ √	√ √ √	√	√ √	√ √ √	√ √	√ √	√ √	
"We have all types of risks in here…Biological risk such as pests and diseases' risk…"	**Pest and diseases' risk**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Biological and environmental-related risks**
"During the last ten years, we had very big thunderstorms. Some big thunderstorms destroyed all the mainly greenhouses. Today, I think this is the main risk for us".	**Extreme weather conditions**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Weather-related risks**
"The expenses are mainly the electricity fee because the water is free. We get water from the underground, so it is free. It is quite a lot of electricity fee – 3000 dollars per month in summer…"	**High energy costs**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Logistical and infrastructure risks**
"Obviously, the channels, routes and transportations have been improved over the last year… Therefore, there is an opportunity for producers to sell products to further places".	**Poor agricultural infrastructure**									√			√ √ √	√	√ √ √	√	√ √ √	√	√ √	√	√ √	√ √	√ √	

"As time passes by, there are more innovations. In the past, we needed to do three things with three machines. Now, we only need one machine to do everything".	**Rapid technological development**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"The most important thing is to know is that there were four political and economic changes from 1989 to 2016 which had an impact on the agriculture value chain".	**Political and economic instability**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Political and macro-economic risks**
"…There is a financial and economic risk that some distributors may not pay to us. So if one of them is not paying us, we will be careful when selling agri-food products to them next time".	**Bad debts**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Financial risks**
"Some customers do not even have a bank account or maybe cannot apply for a credit from the bank, so they cannot pay on time".	**Delay in payment**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"…They negotiate with each other on how much each family should pay for renting the land, there is no paperwork of the agreement since they do not need to sign an agreement to say that you are going to pay this and you are going to pay that".	**Oral contract or agreement with partners**	√						√ √			√ √ √	√		√ √	√ √	√ √	√ √	√	√	√	√	√ √ √	√ √	
"…In the past, people who worked in the shops would be knowledgeable and motivated to sell vegetables and fruits. Now, the people who are working there just want to get some income, and they may not be knowledgeable and very motivated to sell products".	**Lack of investment in promoting agri-food products**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Management and operational risks**
"…Not all the farmers pay their labour taxes…because the control system here is not so strict. So this is the problem that you can get a fine - a very huge fine…"	**Tax evasion**			√			√ √			√ √		√		√ √	√	√ √ √	√	√	√ √ √	√ √ √	√	√ √	√	
"The second risk is the skill shortage. The number of skilled workers in this area is decreasing as time passes by, to be left with low-skilled workers".	**Skill shortage**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	

Source: Zhao et al. (2020, pp. 4859-4860)

There are two risk factors in the demand risk category, namely, market price fluctuations and supply and demand imbalance. From Table 4.5, it is easy to identify that the two risk factors gained supports from the 22 interviews. These risk factors could cause unfair competition between farmers, a mismatch between firm projection and the actual, and could threaten the performance of AFSC. In Argentina, the risk of market price fluctuations and supply and demand imbalance are worse than in France, Spain, and Italy, as they lack of data source and electronic information-sharing system. Most of farmers in Argentina rely on their experience to cultivate vegetables, therefore, it is easy to cause the risk of supply and demand imbalance. In the supply risk category, there are two risk factors, namely, lack of information sharing among partners and poor planning. For example, one of the interviewees stated:

"…Sometimes, we may share some information, but we are reluctant to share information with them".

"There is no agreement/discussion among farmers about how much they need to produce… Another risk is that there are no clear plans for against diseases and pests".

There is one risk factor in the biological and environmental-related risk category, which is pest and diseases' risk. Pest and diseases' risks are normal in the four countries, therefore, it gained supports from the 22 interviews. As one of the interviewees stated:

"We have all types of risks in here…Biological risk such as pests and diseases' risk…"

There are three risk factors categorised into logistical and infrastructure risks category, including high energy costs, poor agricultural infrastructure, and rapid technological development. High energy costs and rapid technological development both gained full support from the 22 investigated companies. For example, one of the interviewees stated:

"The expenses are mainly the electricity fee because the water is free. We get water from the underground, so it is free. It is quite a lot of electricity fee – 3000 dollars per month in summer…"

"As time passes by, there are more innovations. In the past, we needed to do three things with three machines. Now, we only need one machine to do everything".

In France, Spain, and Italy, most of the investigated farmers are using soilless cultivation. There is no doubt that this technology uses a lot of electricity. Furthermore, the farmers in these three countries always collect rainwater to reduce the water fee because the rainwater is of high quality and is easy to be collected for use. In Argentina, farmers do not need to collect rainwater because underground water is free to use. It is interesting to note that all the investigated AFSC companies located in Argentina considered that their agricultural infrastructure is not good enough in comparison with other companies located in France, Italy, and Spain. There is one risk factor categorised into weather-related risks and one risk factor categorised into political and economic instability, respectively. As one of the interviewees stated:

"The most important thing is to know that there were four political and economic changes from 1989 to 2016, which had an impact on the agriculture value chain of Argentina".

"During the last ten years, we had very big thunderstorms. Some big thunderstorms destroyed all the mainly greenhouses. Today, I think this is the main risk for us".

Two risk factors were identified and categorised in the financial risk category, namely, bad debts and delay in payment. Bad debts and delay in payment gained all support from 22 investigated organisations, therefore, could be seen normal phenomenon in the AFSC. For example, one of the interviewees stated:

"Delay in payment existing in the AFSC of Argentina. For example, several supermarkets they pay the money to suppliers after sixty days".

Finally, four risk factors were identified and categorised in the management and operational risk category, namely, oral contract or agreement with partners, lack of investment in promoting agri-food products, tax evasion, and skill shortage. Almost all the risk factors in this category are new risk factors. As one of the interviewees stated:

"The second risk is the skill shortage. The number of skilled workers in this area is decreasing as time passes by, to be left with low-skilled workers".

"Not all the farmers pay their labour taxes… because the control system here is not so strict. So this is the problem that you can get a fine – a very huge fine…"

"In the past, people who worked in the shops would be knowledgeable and motivated to sell vegetables and fruits. Now, the people who are working there just want to get some income, and they may not be knowledgeable and very motivated to sell products".

"…They negotiate with each other on how much each family should pay for renting the land, there is no paperwork of the agreement since they do not need to sign an agreement to say that you are going to pay this and you are going to pay that".

All the investigated AFSC companies thought lacking sufficient skills to do works and lacking investment in promoting agri-food products as normal in the AFSCs of Argentina, France, Italy, and Spain. The empirical findings indicate that it is extremely difficult to hire skilled workers working in rural areas, despite providing proper salaries, permanent contracts, and proper training. It suggests that governments should provide preferential policies for people who want to work in farms like the ones implemented by the European Union to encourage people from Eastern Europe to work in France (Zhao et al. 2020).

Kleindl (2000) stated that the lack of investment was a common situation faced by SMEs, which was reinforced in this study. Additionally, experienced AFSC practitioners suggest that small farmers should cooperate to establish associations to tackle financial limitations, such as the Auction Market in southern France, the Association of Bolivian Farmers in Argentina, and the Association of Valencian farmers in Spain. However, other risk factors such as oral contract or agreement with partners, and tax evasion are more likely to happen in Argentina rather than in France, Italy, and Spain. The potential reason behind this phenomenon maybe because

Argentina is a developing country, AFSC related policies and infrastructures are under development.

4.5.4 Exploring AFSC key performance indicators

Table 4.6 shows different AFSC KPIs identified based on the data collected from Argentina, France, Italy, and Spain. The empirical findings reveal that the five types of AFSC KPIs (e.g., product quality, efficiency, flexibility, process quality, and responsiveness) are used by AFSC practitioners to evaluate the performance of AFSC. The first-order codes are the direct quotes from the interview transcript (see column one), while the second-order themes are the KPIs that represent the first-order codes (see column two). The third column indicates the presence or absence of evidence obtained from the interview cases. A tick (√) represents the presence of weak evidence, three ticks (√√√) mean strong evidence, whereas no ticks represent no evidence (see column three). For example, shape got three ticks from company A of Spain, which means that there was strong evidence in company A of using quality as a KPI to evaluate the performance of AFSC.

Table 4.6 Empirical evidence in discovering AFSC KPIs

First-order codes	Second-order themes	Support from cases for AFSC performance indicators																						Aggregate dimensions
		Spain				France					Italy			Argentina										
		A	B	C	D	A	B	C	D	E	A	B	C	A	B	C	D	E	F	G	H	I	J	
"If you sell products that are not perfect in shape, the consumers will not buy them".	**Shape**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Product quality**
"There are two different colours on these tomatoes. Some of the tomatoes are green colour".	**Colour**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"We gave different ways to make our tomatoes perfect. For example, we make our tomato juicy and sweet".	**Flavour**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"We know our tomatoes have good flavour and can keep for a long time. It is good for customers".	**Shelf life**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"Our marketing department is responsible for designing the packages. Further, they also invents new packages for different varieties of tomatoes".	**Packaging**	√	√	√	√ √	√ √	√ √	√ √ √	√	√ √	√ √	√ √	√	√		√			√ √	√			√ √	
"Further, you can see the new label, which is the standard that we created in Brittany, including taste and nature information".	**Labelling**	√	√ √	√	√ √	√	√ √	√	√ √ √	√	√	√ √	√		√			√			√ √ √		√	
"It is not like a tomato that you can eat with any kind of salads. Pepper is a special product to be consumed in here".	**Convenience**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"There are different quality standards for each variety of tomato. The quality standard can cover 30 different varieties of tomatoes".	**Satisfaction with quality standards**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"We build relationships with different research institutes. The main aim is to reduce the production cost".	**Production costs**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Efficiency**
"The ultimate goal of our company is to earn money. The profit can be seen as an important performance indicator".	**Profit**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	

“We have found some solutions not to waste vegetables. The solution is food-processing plans such as food-frozen plans, and donating some vegetables”.	**Waste reduction**	√	√ √	√	√ √	√ √ √	√	√ √ √	√ √	√ √	√ √	√ √	√	√	√			√ √				√	√	
“We would like to spend some money to build a collaborative relationship with the leading company in this field. This kind of investment would help us to earn money in the near future”.	**Return on investment**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
“From August to September in Brittany, we stocked lettuce and sold them to the fresh market before the buyer came here”.	**Inventory**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
“We continuously update our products to improve their quality, flavour, shape, and shelf life to satisfy our customer requirements”.	**Customer satisfaction**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
“The minimum is the six varieties of tomatoes in one box. For this type of tomato, 40 tomatoes are packed in one box”.	**Volume flexibility**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Flexibility**
“We build long-term relationship with distributors to acquire delivery flexibility”.	**Delivery flexibility**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
“We need to change products according to the seasons”.	**Product flexibility**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
“The traceability technology that we use to let people know where the station is, the producers’ number, the greenhouse number, and pick-up number”.	**Traceability**	√	√ √	√ √ √	√ √	√	√ √	√	√ √	√ √	√ √	√ √	√	√	√	√ √		√ √	√		√ √	√ √	√	
“The Buenos Aires province is strong enough to control agri-chemical contamination on vegetables”.	**Pesticide use**	√	√ √	√ √	√	√ √ √	√ √	√ √	√ √	√	√	√ √	√ √	√ √	√ √	√ √		√		√ √		√	√	
“Some supermarkets will not buy such red tomatoes for logistic reasons”.	**Storage and transportation**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Process quality**
“There are families that live with the amount of garbage very near the houses, and then they have drugs and water pollution. They may not have a toilet or they have one very near the houses for ten persons’ use”.	**Working condition**	√	√ √ √	√	√	√ √ √	√	√	√ √	√ √	√ √	√ √	√ √ √	√	√		√ √				√		√	

"It is quite a lot of electricity fee – 3000 dollars per month in the summer time".	**Energy use**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"We get water from the underground, so it is free".	**Water use**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"We have made some improvements. For example, farmers are worried about the quality of the water (the importance of the quality of the water)".	**Water quality**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	
"…We know the quality of this variety of tomato is not good enough because of customer complaints. Thus, most of the farmers decided to set a more strict quality standard next year".	**Customer complaints**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	**Responsiveness**
"We always deliver products in three days across the whole country".	**Lead time**	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	√ √ √	

Source: Zhao et al. (2020, p. 22).

The product quality category encompasses eight KPIs, which are shape, colour, flavour, shelf life, packaging, labelling, convenience, and satisfaction with quality standards. Packaging and satisfaction with quality standards can be seen as new KPIs for helping to evaluate the product quality. Previous studies such as Aramyan et al. (2007) identified seven KPIs in the category of product quality to evaluate the performance of the tomato supply chain, which are appearance, taste, shelf life, salubrity, safety, product reliability, and convenience. In contemporary society, providing high-quality and safety food is critical for AFSC practitioners, as unsafe food can cause chronic illness and reduce the bioavailability of nutrients (Unnevehr. 2015). Thus, more and more food providers form more strict quality standards in order to fulfil the requirements of markets and governments. Furthermore, sustainable packaging material is suggested for use in the AFSCs as more strict environmental legislation be announced (Sanders. 2012; Varsei et al. 2014). All the investigated AFSC companies are willing to use sustainable packaging material (e.g., wood and degradable material) in their operation management. For example, one of the interviewees stated:

"We also working on sustainable materials such as packaging fewer plastics, and more and more wood".

As for the satisfaction with quality standards, the successful application of quality standards can be seen as a competitive advantage. One of the interviewees from Southern France stated:

"This is the standard that we created in Brittany, including taste and nature information. For consumers, the standard means no pesticide, no artificial chemical on the products".

The process quality includes seven KPIs, namely, traceability, pesticide use, storage and transportation, working condition, energy use, water use, and water quality. Water quality can be seen as a new KPI for evaluating AFSC performance. Most of the investigated companies in developed countries are willing to improve the working condition, as it will help them to recruit new people. One of the interviewees from France stated:

"It is challenging to work here because this station is in rural areas. It is difficult for the growers and the station to find some people work here with sufficient skills".

However, most of the people who work in the farms of Argentina do not have a good working condition. One of the interviewees from Argentina stated:

"There are some families that are living with the amount of garbage very near the houses, and then they have drugs, water pollution. They have not have a toilet or they may have one near the houses for ten persons use. These are the economic and social problems".

This is the reason why most of the investigated firms from Argentina cannot provide evidence because they consider working condition improvement cannot contribute to process quality. Furthermore, under the efficiency category, there are five KPIs, which are production costs, profit, waste reduction, return on investment, and inventory. Waste reduction is a new KPI for evaluating AFSC performance, and gains support from the sixteen interview cases. For example, one of the interviewees from France stated:

"We find some solutions to reduce wastes. The solution is food-processing plans such as food-frozen plans and donate some vegetables. We cannot bear vegetables are wasted".

In some companies of Argentina, the irregular shape of peppers, tomatoes, and eggplants were sold to local restaurants for a lower price in order to reduce waste. In the category of flexibility, there are four KPIs, namely, customer satisfaction, volume flexibility, deliver flexibility, and product flexibility. Product flexibility can be seen as a new KPI and gained support from all the interview cases. Furthermore, product flexibility has the capacity to increase the resilience of the supply chain as more product categories mean more chances to be sold.

"Normally, farmers will cultivate the same vegetables year by year. However, for some products like tomatoes, pepper and eggplants, farmers will replace it with a near variety because the seed company will promote it".

Finally, there are two KPIs in the category of responsiveness, which are customer complaints and lead-time. Lead-time reduction and customer complaints acceptance help the company to increase its service level and occupy more market share. Thus, lead-time and customer complaints gained support from 22 interview cases.

4.6 Exploring relationships between different constructs

This section attempts to build the relationships between different constructs presented in the conceptual framework. TISM was used to build relationships between different constructs. The research results of thematic analysis in the aforementioned sections were used as inputs to process the TISM. The TISM analysis process will be discussed in the following sub-four sections.

4.6.1 Relationship between knowledge governance mechanisms and AFSC performance

Based on the author's knowledge, little research has been conducted to explore the impact of KGMs on AFSC performance (Fang et al. 2013; Cerchione and Esposito. 2016; Tan et al. 2018; Yang et al. 2019). After conducting a comprehensive literature review on supply chain KM, Marra et al. (2012) highlighted that there was a lack of studies measuring the impact of KGM practices on the AFSC performance. Therefore, the relationship between KGMs and AFSC performance has been investigated. The key point is that the researchers do not know whether the impact is positive or negative. Thus, this section explores the nature of the relationship between KGMs and AFSC performance. The theoretical framework between KGMs and AFSC performance is shown in Figure 4.3.

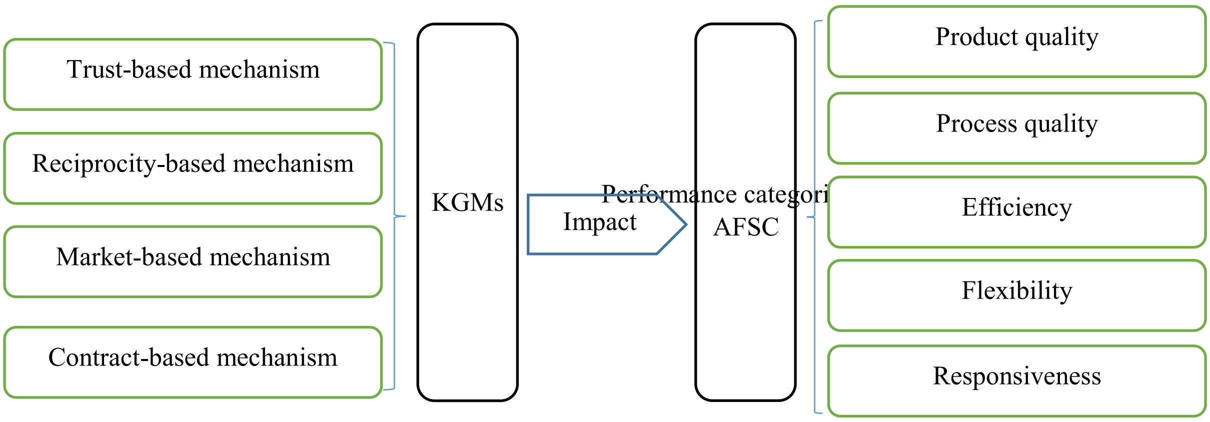


Figure 4.3 The theoretical framework of the impact of KGMs on AFSC performance (Source: Zhao et al. 2020, p. 6)

TISM was used to build relationships between KGMs and AFSC performance categories. AFSC performance categories rather than performance indicators were selected to build a relationship with KGMs as the TISM process is more difficult to use when the number of variables increases. The TISM process comprises nine steps (Sushil. 2012) (see Figure 4.4):

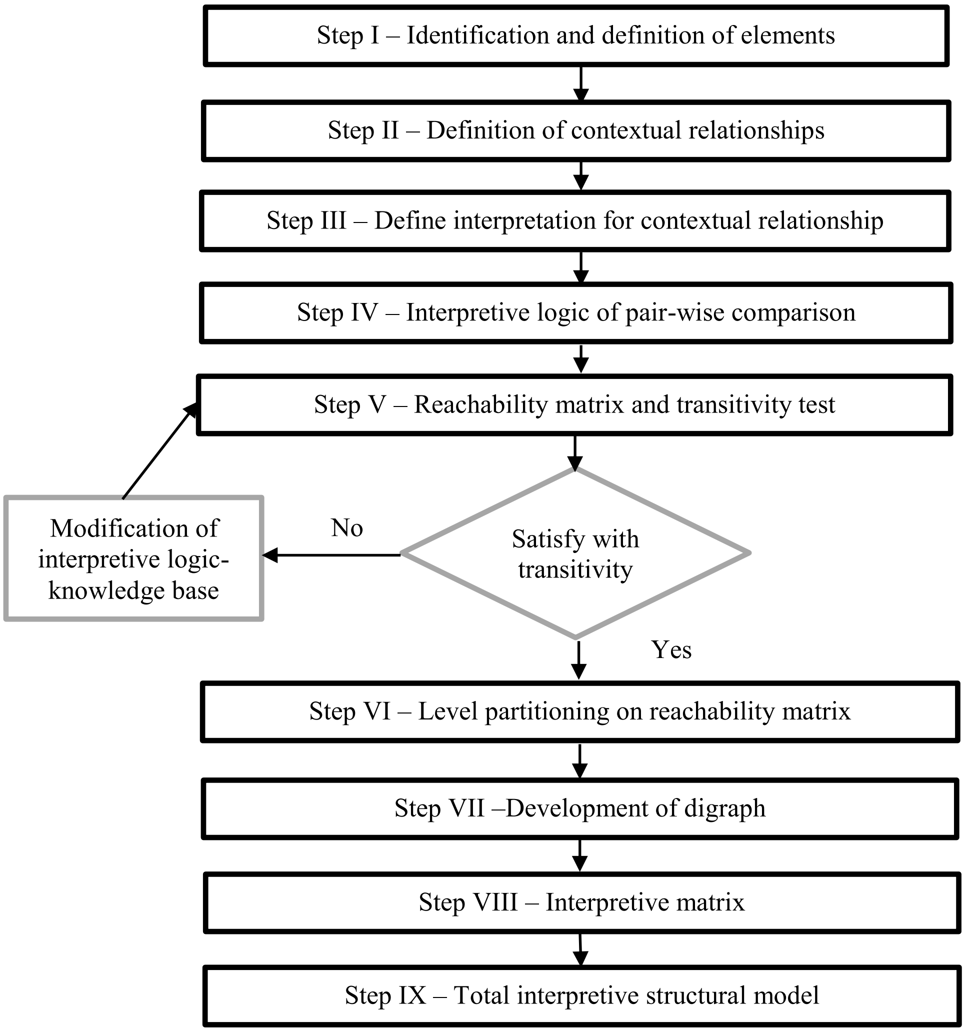


Figure 4.4 TISM analysis process (Source: Sushil. 2012)

Step I Identify and define the elements

Four KGMs (trust-based, reciprocity-based, market-based, and contract-based KGMs) and five AFSC performance categories (product quality, process quality, efficiency, flexibility, and responsiveness) were used as inputs to perform TISM.

Step II Determine the context relationship

To build the relationship between KGMs and AFSC performance categories, the contextual relationship between KGMs and AFSC performance categories is defined as "element A should/will help achieve element B".

Step III Interpret the relationship

Four experts from the agri-food industry were chosen based on the team syntegrity methodology proposed by Beer (1994), which is particularly useful in supporting teamwork related to knowledge acquisition (Espinosa and Harnden. 2007). First, a round table meeting was organised with a focus on the general topic of KM in AFSC. Second, participants' concerns regarding the general topic were clustered into 12 sub-topics, such as knowledge mobilisation crossing boundaries, AFSC performance, and knowledge transfer in AFSC, among others. Third, the participants' indicated which subtopics they would like to discuss the most, and teams were formed according to this criterion. As four experienced AFSC experts expressed interests in the subtopic of the impact of KGMs on AFSC performance, these experts were selected to conduct interviews. Experts' opinions on whether "element A should/will help achieve element B" were collected. If the contextual relationship pertains a yes, "in what way element A should/will help achieve element B" will also be asked. Experts' interpretation of the relationship would help to deepen our understanding and to manage these elements (Sushil. 2012; Jena et al. 2017).

Step IV Interpret logic of pair-wise comparison

Each element is individually compared with all other elements. Thus, there were 72 (n×(n-1), where n represents the number of elements) numbers of rows in the knowledge base to perform this study. An "interpretive logic knowledge base" is developed for the pair-wise comparison of identified elements. Based on the experts' opinion, if there was a relationship between two identified elements, code "Y" for yes was used and the relationship is further interpreted. Otherwise, code "N" for no was used.

Step V Reachability matrix and transitivity check

The initial reachability matrix (see Table 4.7) was developed with the help of interpretive logic-knowledge base by denoting 1 if there is code "Y"; else 0 if there is code "N". Then, the initial reachability matrix is checked for transitivity rule. If element A relates to element B, element B relates to element C, then element A necessarily relates to element C. The final reachability matrix is shown in Table 4.8.

Table 4.7 Initial reachability matrix

	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**
E1	1	1	0	1	1	1	1	1	1
E2	1	1	0	1	1	1	1	1	1
E3	0	1	1	1	1	1	1	1	1
E4	1	1	0	1	1	1	1	1	1
E5	0	0	0	0	1	0	0	0	1
E6	0	0	0	0	1	1	0	1	1
E7	0	0	0	0	1	1	1	0	0
E8	0	0	0	0	0	0	0	1	1
E9	0	0	0	0	0	0	0	0	1

Source: Zhao et al. (2020, p. 10)

Table 4.8 Final reachability matrix

	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**
E1	1	1	0	1	1	1	1	1	1
E2	1	1	0	1	1	1	1	1	1
E3	1*	1	1	1	1	1	1	1	1
E4	1	1	0	1	1	1	1	1	1
E5	0	0	0	0	1	0	0	0	1
E6	0	0	0	0	1	1	0	1	1
E7	0	0	0	0	1	1	1	1*	1*
E8	0	0	0	0	0	0	0	1	1
E9	0	0	0	0	0	0	0	0	1

Note: * represents transitivity Source: Zhao et al. (2020, p. 10)

Step VI Level determination by partitioning reachability matrix

The level partitioning is performed till the level of each element is determined and illustrated in Table 4.9.

Table 4.9 Level partitioning of reachability matrix

Elements	Reachability set	Antecedent set	Intersection	Level
Iteration 1				
E1	1,2,4,5,6,7,8,9	1,2,3,4	1,2,4	
E2	1,2,4,5,6,7,8,9	1,2,3,4	1,2,4	
E3	1,2,3,4,5,6,7,8,9	3	3	
E4	1,2,4,5,6,7,8,9	1,2,3,4	1,2,4	
E5	5,9	1,2,3,4,5,6,7	5	
E6	5,6,8,9	1,2,3,4,6,7	6	
E7	5,6,7,8,9	1,2,3,4,7	7	
E8	8,9	1,2,3,4,6,7,8	8	
E9	9	1,2,3,4,5,6,7,8,9	9	**Level I**
Iteration 2				
E1	1,2,4,5,6,7,8	1,2,3,4	1,2,4	
E2	1,2,4,5,6,7,8	1,2,3,4	1,2,4	
E3	1,2,3,4,5,6,7,8	3	3	
E4	1,2,4,5,6,7,8	1,2,3,4	1,2,4	
E5	5	1,2,3,4,5,6,7	5	**Level II**
E6	5,6,8	1,2,3,4,6,7	6	
E7	5,6,7,8	1,2,3,4,7	7	
E8	8	1,2,3,4,6,7,8	8	**Level II**
Iteration 3				
E1	1,2,4,6,7	1,2,3,4	1,2,4	
E2	1,2,4,6,7	1,2,3,4	1,2,4	
E3	1,2,3,4,6,7	3	3	
E4	1,2,4,6,7	1,2,3,4	1,2,4	
E6	6	1,2,3,4,6,7	6	**Level III**
E7	6,7	1,2,3,4,7	7	
Iteration 4				
E1	1,2,4,7	1,2,3,4	1,2,4	
E2	1,2,4,7	1,2,3,4	1,2,4	
E3	1,2,3,4,7	3	3	
E4	1,2,4,7	1,2,3,4	1,2,4	
E7	7	1,2,3,4,7	7	**Level IV**
Iteration 5				
E1	1,2,4	1,2,3,4	1,2,4	**Level V**
E2	1,2,4	1,2,3,4	1,2,4	**Level V**
E3	1,2,3,4	3	3	
E4	1,2,4	1,2,3,4	1,2,4	**Level V**
Iteration 6				
E3	3	3	3	**Level VI**

Source: Zhao et al. (2020, p. 23)

Step VII Develop digraph

All the elements are depicted in the form of a digraph. A digraph that illustrates the relationships among the elements is developed based on the final reachability. Thus, the elements, the relationships among the elements, and the transitive links are portrayed in the form of a directed graph (see Figure 4.5). Important transitive links are represented with dotted lines.

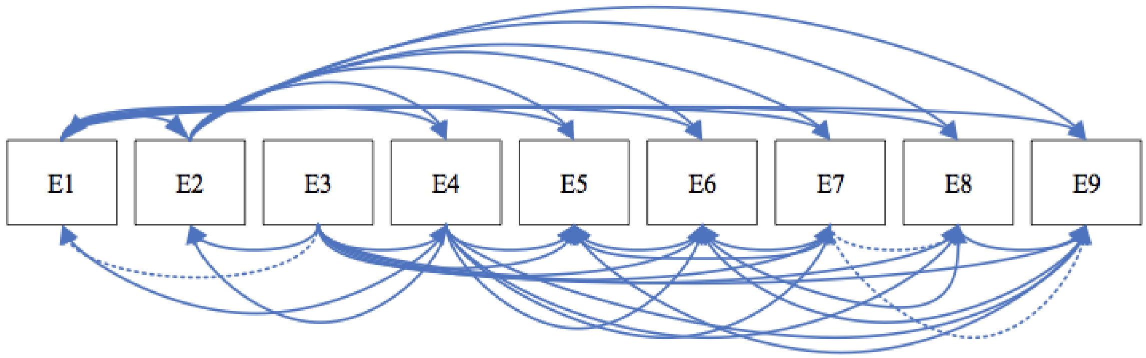


Figure 4.5 The digraph of the impact of KGMs on AFSC performance

Step VIII Develop interpretive matrix

A binary interaction matrix (see Table 4.10) is developed by translating all interactions of digraph by 1 in the respective cell.

Table 4.10 Binary interaction matrix

	E1	E2	E3	E4	E5	E6	E7	E8	E9
E1	0	1	0	1	1	1	1	1	1
E2	1	0	0	1	1	1	1	1	1
E3	1*	1	0	1	1	1	1	1	1
E4	1	1	0	0	1	1	1	1	1
E5	0	0	0	0	0	0	0	0	1
E6	0	0	0	0	1	0	0	1	1
E7	0	0	0	0	1	1	0	1*	1*
E8	0	0	0	0	0	0	0	0	1
E9	0	0	0	0	0	0	0	0	0

Step IX Total interpretive structural model

The TISM model (see Figure 4.6) is developed by using the information in the interpretive matrix and digraph. The interpretation of each link is written on the line representing the respective links in the TISM hierarchy model.

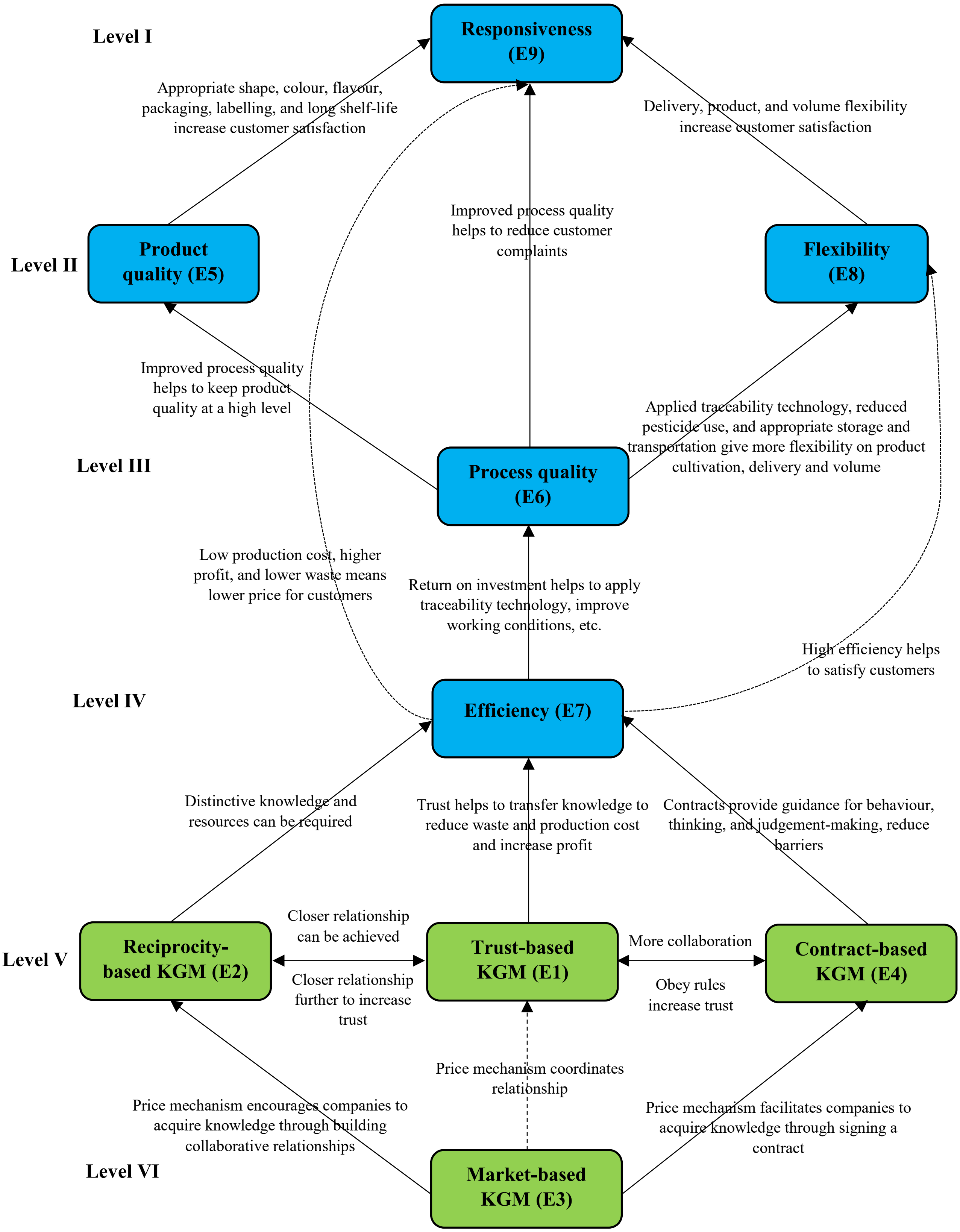


Figure 4.6 TISM model of KGMs and AFSC performance (Source: Zhao et al. 2020, p. 11)

As shown in Figure 4.6, the TISM analysis of KGMs and AFSC performance resulted in a TISM model of six levels. The elements locate in the lower level in the TISM hierarchy model, means that the element can have a bigger influence on the whole system. It can be observed that market-based (E3), trust-based (E1), contract-based (E4), and reciprocity-based (E2) KGMs constitute level five and level six of TISM-based model. While the AFSC performance such as efficiency (E7), process quality (E6), product quality (E5), flexibility (E8), and responsiveness (E9) occupy level four to level one in the TISM model. The TISM model of KGMs and AFSC performance clearly shows that KGMs have positive effects on AFSC performance.

Market-based KGM has an indirect positive impact on AFSC performance, whereas reciprocity-based, trust-based, and contract-based KGMs have direct positive impacts on AFSC performance. The lower level KGMs are the driving forces, which are going to drive the higher level of AFSC performance. The TISM model demonstrates that to enhance the effectiveness of KM activities and the performance of AFSC, market-based KGM is vital. Market price mechanism will facilitate agri-food companies to acquire new knowledge through building a collaborative relationship or signing a contract with the leading company or non-profit organisations. Furthermore, the market price mechanism will coordinate the relationship between AFSC practitioners. Thus, trust can be built between AFSC practitioners. Trust building between AFSC practitioners has positive effects in formulating a reciprocity relationship and strengthen the relationship between AFSC practitioners. Once a trust relationship has been built, distinctive knowledge and resources can be acquired by the AFSC practitioners. The efficiency of AFSC performance can be achieved through cost reduction, food waste reduction, and profit increase. Thus, new traceability technology can be applied and the working conditions of AFSC practitioners can be improved because of extra profits. Furthermore, applied traceability technology, reduced pesticide use, and appropriate storage and transportation give more flexibility on product cultivation, delivery, and volume. Simultaneously, improved process quality helps to keep product quality at a high level. As a result, the responsiveness of AFSC performance will be enhanced.

4.6.2 Relationship between AFSC resilience capabilities and AFSC risks

This section explores the relationship between AFSC resilience capabilities and AFSC risks. An AFSC's resilience capability to cope with AFSC risks is limited for AFSC practitioners' understanding of AFSC vulnerabilities and risks (Kochan and Nowicki. 2018). The focus on enhancing AFSC resilience capabilities is to ensure that safe and appropriate food can be sent to the final consumers in the face of disruption (Tendall et al. 2015). The relationship between AFSC resilience capabilities and AFSC risks based on the data collected from experienced AFSC practitioners is shown in Table 4.11. A tick (√) represents there is a positive relationship between the AFSC resilience capabilities and AFSC risks, and no tick means no relationship. The findings revealed from this section will help AFSC practitioners to indicate which AFSC resilience capability is effective in reducing which AFSC risk factors.

Table 4.11 AFSC resilience capabilities/AFSC risks

AFSC resilience	AFSC risks	Management and operational risks				Supply risks		Biological and environmental related risks	Weather-related risks	Logistical and infrastructure risks			Political and macroeconomic risks	Financial risks		Demand risks	
		Oral contract or agreement with partners	Lack of investment in promoting agri-food products	Tax evasion	Skill shortage	Lack of information sharing among partners	Poor planning	Pest and diseases' risk	Extreme weather conditions	High energy costs	Poor agricultural infrastructure	Rapid technological development	Political and economic instability	Bad debts	Delay in payment	Market price fluctuations	Supply and demand imbalance
Development and innovation	Training and development	√		√	√	√	√	√				√					
	Building a project partnership				√	√		√									
	Building shared understanding						√										
	Working team stability					√											
	Leadership		√								√						
Supply chain collaboration	Information sharing					√	√						√			√	√
	Joint decision-making					√	√						√			√	√
	Regularly meetings					√	√						√			√	√
	Trust					√	√						√	√	√		
Flexibility	Labour contract flexibility		√														
	Product differentiations		√														
	Frequent quality checks							√									
Redundancy	Multiple suppliers								√								
	Insurances								√								
	Reserve raw material stock								√				√				
Visibility	Traceability					√											
	Role clarity					√											
	ICT application					√		√									

4.6.2.1 Development and innovation

The data analysis results shown in Table 4.11, it indicates that the development and innovation capability have positive effects in reducing management and operational risks, supply risks, biological and environmental-related risks, as well as logistical and infrastructure risks. The discussion below will elaborate on the interactions between development and innovation and different types of risks.

There are five resilience capability factors in the development and innovation category, including training and development, building a project partnership, building shared understanding, working team stability, and leadership. Training and development is the most common practice used for enhancing resilience and reducing risks (Rice and Caniato. 2003). The results of this study show that training and development have positive effects on reducing oral contract or agreement with partners, tax evasion, skill shortage, lack of information sharing among partners, poor planning, and pest and diseases' risk. Most of the training courses provided by the AFSC practitioners focus on disseminating good agricultural practices, new agricultural policies, new agricultural technologies, how to use agri-chemical products, and how to prevent pests and diseases. Training and development help AFSC experts to transfer professional knowledge to AFSC practitioners, and help AFSC practitioners to perform better in their daily operation.

Building a project partnership also has the capability to transfer professional knowledge to other project partners with the result of reducing the effects of AFSC risks such as pest and diseases' risk, lack of information sharing among partners, and skill shortage. Different project partners conduct different secondments to other partners' organisation to disseminate knowledge and to help the local AFSC practitioners to solve problems.

As for the building shared understanding, it is very important to solve the risk of poor planning. In Argentina, most of the farmers are small farmers. Although different associations (e.g., Association of Bolivian farmers) have been built to connect small farmers together, however, this kind of association is useless. Association members are not willing to share their knowledge and plan with other association members. Thus, there is no doubt that the AFSC of Argentina has more risks than other investigated countries (e.g., France, Italy, and Spain). In comparison with France, small farmers cooperate with each other through joining the same association. Professional organisations have been built to coordinate activities among various farmers. For example, CUMER has been built in Southern France for small farmers to rent large agricultural machinery. French Chambers of Agriculture has been built and managed by electing farmers to provide services to farmers and to other rural stakeholders. With the help from professional organisations, there is no doubt that farmers in Southern France have a common understanding of the different dimensions of AFSC, such as product quality, risk management, and financial management. Therefore, farmers in Southern France can gain more profits.

Regarding working team stability and leadership, these two resilience capability factors are vital in solving three different AFSC risk factors: lack of investment in promoting agri-food products, lack of information sharing among partners, and poor agricultural infrastructure. Working team stability can help AFSC practitioners to share/transfer valuable knowledge and resources. Leadership is important in improving agricultural infrastructure and promoting agri-food products as team leader has more authorities to use the organisations' resources. As stated by Kamalahmadi and Parast (2016), the role of leaders and top managers were critical in deciding the culture and development of an organisation.

4.6.2.2 Supply chain collaboration

In the category of supply chain collaboration, there are four resilience capability factors, including information sharing, joint decision-making, regular meetings, and trust. Table 4.11 shows that that supply chain collaboration is effective in reducing the effects of four categories of risks such as supply risks, demand risks, political and macroeconomic risks, and financial risks.

The first priority for risk reduction is to build collaborative relationships and share information with supply chain members (Christopher and Peck. 2004). Sharing information such as sharing quantity information and the types of cultivated vegetables would help to reduce the effects of supply and demand imbalance and further help to reduce the negative impact of market price fluctuations. For example, three databases have been built in the south of France, Argentina, and Spain, respectively, used for sharing good agricultural practices and the methods for reducing AFSC risks. For example, some pest and diseases' risk information has been stored in the Spanish database. Once the farmer needs, they can collect the data from specific databases automatically.

Trust is a critical resilience capability factor, as it facilitates cooperation and collaboration both within the organisation and across supply chain partners (Faisal et al. 2007). Regarding the risk of bad debt, trust is effective in avoiding it. For example, if farmers want to borrow some seeds or agri-chemicals products in Argentina, their consumption record will be checked. Based on the consumption record, if the farmer has a very good credit guarantee, agri-food products will be lent to them. Thus, bad debts can be avoided. However, delay in payment only can be reduced through a building a trust relationship with partners, rather than being avoided. There is 60 days payment delay after the consumers received the agri-food products. This is a normal phenomenon in Argentina, France, Italy, and Spain. If the consumers are the focal companies, delay in payment will be severer. A possible method to alleviate the negative effect of political and economic instability is to strengthen the partnership with the suppliers and relationship with local government and non-profit organisations.

4.6.2.3 Flexibility

In the category of flexibility, there are three resilience capability factors, including labour contract flexibility, product differentiation, and frequent quality checks. Labour contract flexibility is a useful strategy used by the organisation managers in the harvesting time to increase profit and working efficiency. For example, 25 % employees will be hired in the harvesting time of a big farm in Argentina. It is interesting to note that most of the people hired in the harvesting time of Argentina are immigrants from Bolivia, Peru, and Uruguay, due to the lower salaries in their countries compared with Argentina. In the harvesting time of France, AFSC companies are more likely to recruit people from Romania, Poland, and Greek. It is important to note that the number of people to be hired in the harvesting time depends on many factors, including product types and field acreage. In France, most of the growers need to hire two times in one year. Thus, they can get the number of people they required. Although the temporary workers do not have sufficient skills, they can help to complete harvesting in a relatively short period after proper training. For keeping fresh and high quality vegetables (e.g., broccoli, lettuce, tomato, eggplant, and green pepper), it is critical to reducing the harvesting time. High quality fresh vegetables mean extra profits. Thus, extra profits can be used for designing new brands, applying new quality certification, and updating sustainable packaging material. Finally, the effects of a lack of investment in promoting agri-food products can be reduced.

For the product differentiations, most of the farmers, based on their experience, are chosen to cultivate vegetables. In Argentina, France, Italy, and Spain, tomatoes, lettuces, and eggplants are always chosen by the local farmers because they know the customer preference. Furthermore, farmers will adjust the product types based on different seasons. For example, more varieties of tomatoes will be cultivated in the summertime. Thus, farmers can earn more profits by deploying product differentiations. There is no doubt that the lack of investment in promoting agri-food products will be reduced.

Frequent quality checks can reduce pest and disease risks, most of experienced farmers choose visual checks to identify potential pests and diseases, whereas, big farmers would recruit professional experts to visit their farms regularly (normally once a week) to identify potential pests and diseases.

4.6.2.4 Redundancy

In the category of redundancy, the research finds that there are three resilience capability factors, including multiple suppliers, insurance, and reserve raw material stock. These resilience capability factors have been identified as effective in reducing the effects of extreme weather conditions and political and economic instability. To mitigate the effect of extreme weather conditions, the large agri-food companies are suggested to get weather damage and business insurance, whereas the SMEs are suggested to apply for disaster relief emergency funds if the agricultural infrastructure is destroyed by extreme weathers. Furthermore, some AFSC practitioners prepared some raw materials (e.g., woods and plastics) at the beginning of the year in case of severe weather conditions. For some agri-food input suppliers such as seeds and agri-chemical providers, they choose to reserve seeds and agri-chemical products because these products can be kept for a relatively long time in a dry and ventilated place. Although political and economic instability cannot be avoided, the effects of this risk can be reduced through reserving raw material stocks.

4.6.2.5 Visibility

There are three resilience capability factors in the category of visibility, including traceability, role clarity, and ICT application. These three resilience capability factors all have the ability to reduce the risk of lack of information sharing among partners. For example, traceability facilitates information sharing through sharing traceability data (Zhao et al. 2018). It is interesting to note that the ICT application can help to reduce pest and diseases' risk through sharing the high-resolution photos of vegetables with the professional experts. Thus, experts can give their professional advice based on the real situation of vegetables and fruits. Simultaneously, on-site visits can be avoided, especially in critical situations such as the pandemic of Covid-19 and protests across the whole country. Through applying ICT, the efficiency to reduce pests and disease will be improved.

From the above analysis of different resilience capability factors in tackling different types of risks, this study draws the following conclusions:

- No resilience capability factors have been identified as effective in tackling the risk of high energy costs, especially in the era of electrification. Potential methods to solve high energy costs such as collecting rainwater and staggering power consumption, have been applied in Argentina, France, Italy, and Spain.
- The effects of pest and diseases' risk, extreme weather conditions, high energy costs, poor agricultural infrastructure, rapid technological development, and political and economic instability can be weakened rather than avoided as these risk factors are largely affected by the external environment.
- Development and innovation have the capability to solve three types of risks: management and operational risks, supply risks, and biological and environmental risks. Supply chain collaboration has positive effects in reducing supply risks, demand risks, financial risks, and political and macroeconomic risks. Redundancy is effective in reducing weather-related risks. As for flexibility and visibility, these resilience capabilities are both effective in tackling specific risk factors such as lack of information sharing among partners, pest and diseases' risks, and lack of investment in promoting agri-food products.

4.6.3 Relationship between AFSC risks and AFSC key performance indicators

This section explores the relationship between AFSC risks and AFSC KPIs. Based on the data collected from Argentina, France, Italy, and Spain, the impact of different AFSC risks on AFSC KPIs has been summarised. The findings revealed in this section will help AFSC managers to have a comprehensive understanding of which AFSC KPIs are largely affected by which AFSC risks. Thus, AFSC managers are able to predict the worst scenarios for their company and develop contingency plans when AFSC risk occurs. Whilst it is impossible for AFSC managers to eliminate AFSC risks, their negative effects on AFSCs can be minimised (Quang and Hara. 2018). The relationship between AFSC risks and AFSC KPIs based on the data collected from 22 experienced AFSC practitioners is shown in Table 4.12. A tick (√) represents that there is a relationship between the AFSC risks and AFSC KPIs, and no tick means no relationships. For example, there is a tick between management and operational risks and product quality, which means that management and operational risks have negative effects on product quality. Detailed explanations are demonstrated in the following subsections.

Table 4.12 Relationships between AFSC risks and AFSC KPIs

AFSC KPIs / AFSC risks	Product quality	Process quality	Efficiency	Flexibility	Responsiveness
Management and operational risks	√	√			
Supply risks	√			√	
Biological and environmental-related risks	√	√	√		
Weather-related risks	√	√	√		√
Logistical and infrastructure risks	√	√	√		√
Political and macroeconomic risks		√	√	√	√
Financial risks			√		
Demand risks			√	√	

Note: Detailed relationship between AFSC risks and AFSC KPIs is shown in Appendix B.

4.6.3.1 Product quality

The summarised relationships between AFSC risks and AFSC KPIs shown in Table 4.12, it indicates that product quality are affected by five types of AFSC risks, including management and operational risks, supply risks, biological and environmental-related risks, weather-related risks, and logistical and infrastructure risks. Management and operational risks are considered to have negative effects on product quality as most of the employees working in the AFSC do not have sufficient skills as time passes by. For example, a problem existing in the south of France is most young employees do not know how to harvest broccoli even after receiving a proper training. Damaged broccoli cannot be sold at a good price because of imperfect shape. In Argentina, some farmers do not know how to use agri-chemical products. An excessive dose of agri-chemical products will damage human health because of pesticide residues. However, inappropriately use of agri-food chemical products would damage the quality of agri-food products because of pests and diseases.

Supply risks such as poor planning is a common problem existing in Argentina, France, Italy, and Spain. Lacking a long-term plan against pest and diseases risks would damage the product quality. Furthermore, most of the agri-food research institutions lack a long-term plan to develop new pest-resistant seeds.

There are no doubt that biological and environmental-related risks will damage the product quality, especially for organic farmers. Organic farmers have serious problems with biological and environmental risks because they are not allowed to use chemical fertilizer. Therefore, organic fertilizers are the first choice for organic farmers though organic fertilizers are considered without strong effects on pests and diseases.

Weather-related risks may cause severe effects on product quality because extreme-weather conditions will provide suitable humidity for pests and diseases. Extreme weather conditions such as big thunderstorms, floods, and hails will destroy the greenhouses and related agricultural facilities. In other words, vegetables will be totally destroyed.

Finally, logistical and infrastructure risks would reduce the shelf life of agri-food products because of the poor agricultural infrastructure. Cold chain logistics have been largely applied in France, Italy, and Spain, to ensure the quality of agri-food products, especially for the perishability products. However, most of the framers in Argentina use their own trucks to deliver the agri-food products to the central market because of the relatively lower cost in comparison with cold chain logistics.

4.6.3.2 Process quality

The process quality is effected by five categories of risks, including management and operational risks, biological and environmental-related risks, weather-related risks, logistical and infrastructure risks, and political and macroeconomic risks (see Table 4.12). Management and operational risks such as skills shortage would deteriorate the process quality because some farmers do not know how to use agri-chemical products. It is a common phenomenon in Argentina as most of the farmers are illiterate. This limitation would limit farmers' potential abilities to learn new agricultural skills.

Biological and environmental-related risks are considered to have effects on process quality because of two reasons. First, pesticide residues such as Bromacil, Diquat, and Ametryne will be absorbed by soil and further have a negative impact on the environment and process quality. Second, most of the empty bottles of pesticides are not handled in a proper way in Argentina, which may cause the working condition to worsen. Furthermore, the situation may damage children's health because most of the Bolivian workers are living on the farm with their family members.

Weather-related risks are considered to have negative effects on the process quality, as extreme weather conditions (e.g., thunderstorms and floods) would destroy the agricultural and transportation infrastructure. For example, severe flooding in the south of France, northern Italy, and Spain in 2019 cause serious damage to the region; there is no doubt that agricultural infrastructure was destroyed.

Logistical and infrastructure risks such as no traceability and cold chain technology applied in the AFSC of Argentina is a common phenomenon. The quality of agri-food products will be lower after harvesting with time passing by. Proper packaging and appropriate infrastructures such as refrigerated trucks and cold storage will help to keep agri-food products' quality for a longer time.

Finally, political and macroeconomic risks are considered to have negative effects because of several reasons. For example, economic instability, such as currency fluctuations, happened four times in Argentina from 1989 to 2016. Now, one United States dollar equals almost 60 Argentine Pesos in comparison with one United States dollar equalled to one Argentine Pesos in 1989. It is a huge difference in currency between 1989 and 2019. This caused serious problems to the AFSC of Argentina, such as low agricultural technology development.

4.6.3.3 Efficiency

All categories of AFSC risks (e.g., management and operational risks, supply risks, biological and environmental-related risks, weather-related risks, logistical and infrastructure risks, political and macroeconomic risks, financial risks , and demand risks) have been identified to have negative effects on the efficiency of AFSC performance. For example, logistical and infrastructure risks such as poor agricultural infrastructure would increase the harvesting time and lead time of AFSC practitioners, especially for the AFSC practitioners in Argentina. In Argentina, most of the farm jobs were done manually, including crop picking, plant breeding, and vegetable packing. However, this situation is completely different in Southern France. In Southern France, AFSC practitioners rely on the machine to harvest and process tomatoes. In the harvesting time, tomato harvesters would be used to cut, shake, sort, and load tomatoes. Afterwards, tomatoes would be sent to the processing centre for further processing. In this process, tomato-processing machines would be used to pack tomatoes in different packages based on the tomatoes' shape, weight, and quality. Finally, fresh-packed tomatoes would be sent to different supermarkets with cold chain logistics. Thus, the efficiency would be increased as different machines are involved in harvesting, processing, and transporting.

Other AFSC risks may have negative effects on efficiency. For example, financial risks such as bad debts would cause AFSC practitioners' lack of investment to update their technologies and machines. Without helping of the latest technology, it is difficult for AFSC practitioners to increase their efficiency. Political and macroeconomic risks also have negative effects on the efficiency of AFSCs. Argentina experienced four times of economic crises; these crises caused a huge currency depreciation of Argentina Pesos. This means that Argentinians do not want to buy technologies from the international market, which would have a negative effect on the efficiency of AFSCs.

Furthermore, supply and demand imbalance would cause negative effects on the efficiency of AFSC because of the lower price of agri-food products. In Argentina, most of the farmers rely on their experience to cultivate products rather than statistical data. For example, most Argentinians would like to eat tomatoes in Christmas; therefore, farmers are more willing to prepare more tomatoes than normal time in Christmas. Considering that there is a limitation in Argentina for exporting tomatoes, it is not difficult to imagine that supply and demand imbalance always happens in Argentina. This would cause AFSC practitioners not to have extra money to invest in technologies.

In summary, supply risks, biological and environmental-related risks, weather-related risks, political and macroeconomic risks, logistical and infrastructure risks, financial risks, management and operational risks, and demand risks are all considered to have negative effects on increasing the efficiency of AFSC performance.

4.6.3.4 Flexibility

All categories of AFSC risks were identified to have negative effects on the flexibility of AFSC performance. Supply risks such as lack of information sharing among partners would cause farmers not knowing the customer preference. Most of the farmers cultivated vegetables based on their experience and seasonal variation. For example, cucumber and lettuce are mostly cultivated in summer, whereas broccoli is always cultivated in winter. As for tomatoes, it has been cultivated in the whole year because of strong requirements from markets. Lack of effective communication between farmers and supermarkets, there is no doubt that supply and demand imbalance always happens in the AFSC of Argentina, France, Italy, and Spain. Further, to induce market price fluctuations. Thus, customer satisfaction will be influenced because of the price of agri-food products increasing. Political and macroeconomic risks are considered to have negative effects on flexibility because they will cause customers' general purchasing power to decrease. Thus, customer satisfaction will decrease. Furthermore, it is important to note that weather-related risks would cause delivery flexibility to decrease as roads may be destroyed by extreme weather conditions.

4.6.3.5 Responsiveness

There are five categories of AFSC risks that can influence the responsiveness of AFSC performance, including supply risks, demand risks, weather-related risks, political and macroeconomic risks, and logistical and infrastructure risks. These risks have been identified to have negative effects on responsiveness because they can influence the lead-time of responsiveness. For example, extreme weather conditions and poor agricultural infrastructure will influence the logistics' speed. Since a new highway has been built between the north of Argentina and Buenos Aires, farmers can send their products to the central market of Buenos Aires in three days. Lead-time reduction means a higher price of agri-food products. It is important to note that customer complaints should be disseminated among AFSC practitioners. An efficient and effective response to customer complaints will help to increase the whole performance of the AFSC. However, it is difficult to tackle customer complaints because of the lack of information sharing among AFSC partners.

4.6.4 Relationship between knowledge governance mechanisms and AFSC resilience capabilities

This section explores the relationship between KGMs and AFSC resilience capabilities. KGMs play a critical role in establishing knowledge-sharing opportunities and facilitating knowledge-sharing (Huang et al. 2013). Five AFSC resilience capabilities identified from the empirical study are flexibility, redundancy, supply chain collaboration, visibility, and development and innovation. In this section, TISM is used to build relationships between KGMs and AFSC resilience capabilities. The proposed model offers valuable insights to AFSC managers in understanding the relationships between KGMs and AFSC resilience capabilities.

By using similar nine steps of TISM described in section 4.6.1, a TISM model of the relationship between KGMs and AFSC resilience capabilities was built (see Figure 4.7).

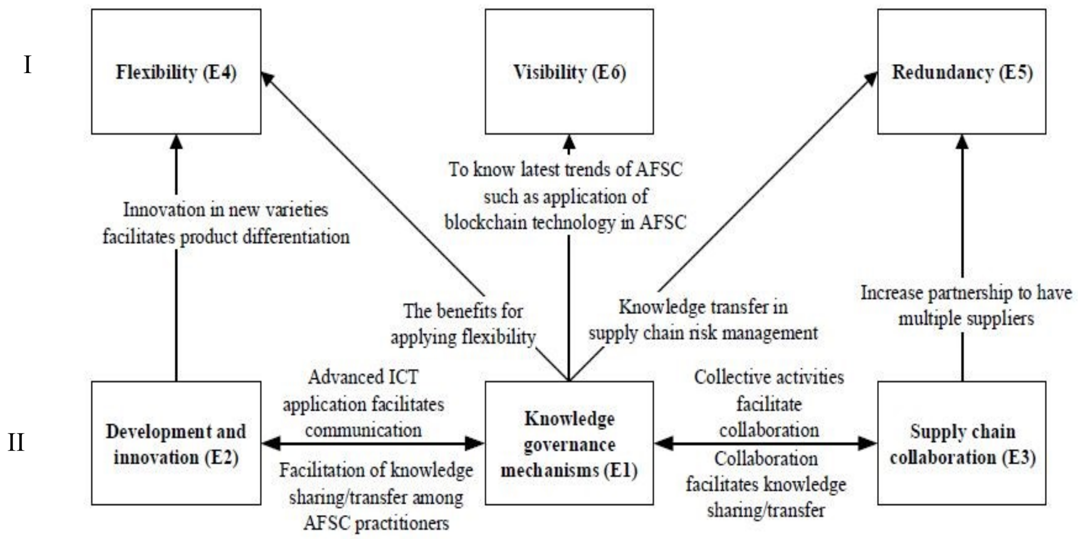


Figure 4.7 Relationship between KGMs and AFSC resilience capabilities

From Figure 4.6, it shows that KGMs (E1), development and innovation (E2), and supply chain collaboration (E3) occupies level II in the TISM hierarchy model, whereas flexibility (E4), redundancy (E5), and visibility (E6) occupies the level I in the TISM hierarchy model. The TISM model demonstrates that to enhance the resilience of AFSC, KGMs are vital. This will facilitate development and innovation through sharing/transferring knowledge among AFSC practitioners. For example, building a project partnership, facilitating consistent communications, and strengthening personal ties, all these methods have positive effects in sharing/transferring knowledge to farmers. It is important to note that KGMs not only can help to facilitate development and innovation, but also can improve supply chain collaboration. For example, collective activities such as joint decision-making, research institution open days, and technical conference for farmers, all these activities have potentially positive impacts on facilitating supply chain collaboration. Besides, experts can disseminate the latest technology news to AFSC practitioners. This will facilitate AFSC practitioners to increase their visibility by applying the latest technologies such as blockchain technology, internet of things, and artificial intelligence. Adopting appropriate KGMs would help to increase the flexibility and redundancy of AFSC. In Argentina, most of the big farmers are willing to build long-term stable relationships with the wholesalers in Europe in order to resist the negative effects of political and economic instability. Argentina experienced four political and economic changes from 1989 to 2016, which has a significant negative impact on the local AFSC (Zhao et al. 2020). Therefore, most of the big farmers in Argentina want to acquire a stable and reliable relationship with the partners outside Argentina in order to increase their flexibility and redundancy. However, most of the big farmers in Argentina lack of channels to acquire the information and knowledge even the agri-food products' price in the market of Europe. Thus, applying appropriate KGMs for facilitating knowledge sharing/transfer plays a critical role in improving AFSC resilience.

4.7 The refined KRRP framework (1) based on phase one of the empirical study

A refined KRRP framework as illustrated in Figure 4.8 has been built based on the data collected from experienced AFSC practitioners. Semi-structured interview was used to collect data from experienced AFSC practitioners. Then, thematic analysis was adopted to allow themes to emerge from the collected data. Finally, the relationships between different constructs have been built through TISM. In comparison with the KRRP conceptual framework, the refined KRRP framework adds a more in-depth understandings of the four constructs (e.g. KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs) and their relationships. For example, the relationship between KGMs and AFSC resilience capabilities presented in the KRRP conceptual framework was KGMs had an impact on AFSC resilience capabilities. This means that KGMs have an impact on AFSC resilience capabilities, but no studies point out the relationship between these two constructs is positive or negative. The same situation also happens between KGMs and AFSC KPIs. Based on the author's knowledge, there is no previous research indicates that KGMs can be used for enhancing AFSC KPIs. Based on phase one of the empirical study, it concludes that KGMs have positive effects in enhancing AFSC resilience capabilities and AFSC KPIs. Furthermore, AFSC resilience capabilities have been proven positively reducing AFSC risks because most of the resilience capabilities identified in the empirical study are perceived as proactive efforts towards being prepared for disruptions and risks. However, some researchers mentioned that resilience capabilities were reactive capabilities for using after a disruption (Melnyk et al. 2014; Fiksel et al. 2015). Phase one of the empirical study highlights that AFSC resilience capabilities are effective in repositioning the firm to its previous status or better status, no matter deploying it as proactive or reactive efforts. Finally, phase one of the empirical study also demonstrates how the AFSC risks deteriorate the performance of AFSC. The findings show that five perspectives of AFSC performance are negatively influenced by AFSC risks, including product quality, efficiency, flexibility, process quality, and responsiveness.

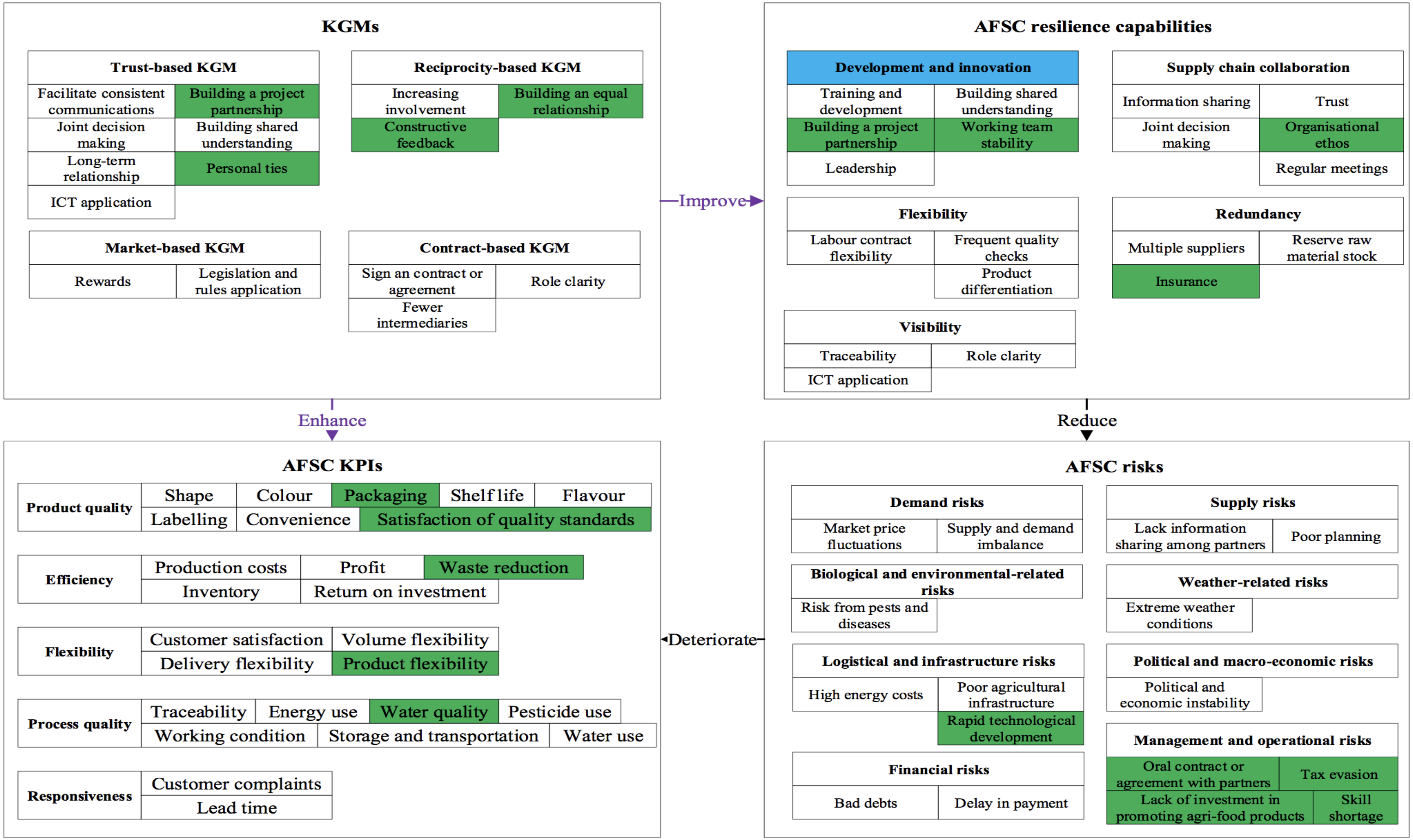


Figure 4.8 The refined KRRP framework (1) based on phase one of the empirical study (Note: green represents new factors, purple represents new relationships, and blue represent new resilience capabilities)

There are four clusters in the refined KRRP conceptual framework (1), including the cluster of KGMs, the cluster of AFSC resilience capabilities, the cluster of AFSC risks, and the cluster of AFSC KPIs.

The first cluster of KGMs illustrated in the top-left corner of Figure 4.8 includes four different KGMs: trust-based, reciprocity-based, market-based, and contract-based KGMs. Trust has been defined as a willingness to take risks (Mayer et al. 1995). It has been identified as the pivot of the factors influencing knowledge sharing/transfer. The more a factor contributes to trust positively, the more positive results of knowledge sharing/transfer (Cheng et al. 2008). In phase one of the empirical study, seven factors have been identified to be positive in building trust-based KGM: facilitate consistent communications, building a project partnership, joint decision making, building shared understanding, long-term relationship, personal ties, and ICT application. However, the research conducted by Cheng et al. (2008) on green supply chains reinforced that building shared understanding had no significant influence on trust. This study holds an opposite view that most of the farmers who participated in this research are family business, and they obtain agricultural knowledge from their relatives. They have not received any systematic professional training from universities, research institutes, and non-profit organisations. Thus, building a shared understanding between farmers and research institutions is critical if they want to receive knowledge from the universities, non-profit organisations, and research institutions. The study carried out by Fischer (2013) illustrated that effective communication and positive past collaboration was vital for building trust relationships in the context of European AFSCs. This study also supports this point because facilitating consistent communications, building a project partnership, and joint decision-making are considered as antecedents of effective communication.

There are three factors of reciprocity-based KGM, including increasing involvement, building an equal relationship and constructive feedback. Increasing involvement means increasing

AFSC practitioners' participation in decision-making and goal setting. It has been identified as important because increasing involvement can improve the quality of inter-organisational relationships. The study conducted by Henderson (1990) and Lee and Kim (1999) supports this point. Constructive feedback can be used to improve reciprocity-based KGM as it increases self-awareness, improves the quality of learning, and contributes to relationship development. The research conducted by Lancaster et al. (2006) construed that feedback exchanged between partners in the context of E-SCM, helped to increase the quality of customer service and contributed to the management of the whole supply chain. This study extends their results to the context of AFSC. Building an equal relationship and constructive feedback have been reinforced in the area of education, human resource management, and nursing management (Clynes and Raftery. 2008; Sommer and Kulkarni. 2012). However, there are limited researchers investigated their important role in building reciprocity-based KGM in the context of AFSC. To the best of the author's knowledge, this is the first study to identify their positive effects in facilitating reciprocity-based KGM.

There are two factors in the category of market-based KGM: legislation and rules application and rewards. Rewards are a normal measure for facilitating knowledge sharing/transfer. In Argentina, the government will provide a certificate for the farmers who successfully pass the training courses of good agricultural practices. In France, agri-food products can be sold in a higher price if a green-white logo "AB – agriculture biologique" has been labelled in the packaging. The logo "AB" represents that the products are organic, which is well-known by French consumers. The study conducted by Asrar-ul-Haq and Anwar (2016) reinforced that rewards facilitated knowledge sharing and transfer.

Finally, three factors have been identified as effective in building contract-based KGM: sign a contract or agreement, role clarity and less intermediaries. In Argentina, most AFSC practitioners do not like to use contracts or agreements to build business relationships with other AFSC practitioners. However, some big farmers in Argentina need to sign a contract or agreement with private research institutions to ensure they obtain sufficient knowledge. For example, experts will come to the farm once a week to ensure the vegetables being in good status. In comparison with Argentina, contracts are normally used in France, Italy, and Spain to regulate their business partners' practices. Most contracts refer to more than one aspect, for example, side selling, pricing, delivery, products' quality, and production process, which is reinforced by Schipmann and Qaim (2011).

The second cluster of AFSC resilience capabilities illustrated in the top-right corner of Figure 4.8 includes five different AFSC resilience capabilities: development and innovation, supply chain collaboration, flexibility, redundancy, and visibility. At the supply chain level, collaboration, flexibility, agility, visibility, and adaptability are the most commonly cited capabilities for building supply chain resilience (Stone and Rahimifard. 2018). Development and innovation have been considered as a key capability for a firm's long-term survival and growth. However, the research on investigating the role of development and innovation in increasing resilience of an AFSC is still in its infancy (Kamalahmadi and Parast. 2016).

Five resilience capability factors have been identified as effective in developing the resilience capability of development and innovation, including training and development, building shared understanding, building a project partnership, working team stability, and leadership. Working team stability and building a project partnership have been considered as new resilience capability factors for fostering innovation (Zhao et al. 2018). It should be supported by leadership through support and commitment to building a stable team. Thus, team members understanding each other's needs and satisfying the needs accordingly, which have a positive effect on acquiring valuable knowledge. Besides, other resilience capability factors of development and innovation got support in the literature. For example, building shared understanding, openness to learning, and joint decision-making have been reported as critical factors of innovation; both feed into the ability of an organisation to anticipate and respond to risk (Stone and Rahimifard. 2018). Training and development is also necessary for building resilience and developing innovation, as indicated by Rice and Caniato (2003) and Blackhurst et al. (2011). Training courses such as good agricultural practices, instructions for using agri-chemical products, and creative problem solving are all provided by the AFSC companies for increasing their employees' knowledge, skills, and risk awareness.

In the category of supply chain collaboration, five resilience capability factors have been identified: information sharing, trust, joint decision-making, regular meetings, and organisational ethos. Organisational ethos is the code of conduct and principles that guide the behaviour of the employees and the management in an organisation. In the wholesale distribution company of Southern France, strict rules have been implemented in order to prevent farmers from competing with each other using a lower product price strategy. Farmers will be eliminated from the company if they are breaking the rules. Thus, collaborating with each other is the only choice for most of the farmers in Southern France. The organisational ethos can have an impact on the whole AFSC as the investigated company is the focal company in the AFSC of Southern France. Thus, organisational ethos can be disseminated to the whole AFSC. The study carried out by Burnard and Bhamra (2011) shows that organisational ethos is necessary for building resilience at the organisational level. This study extends the results to the supply chain level. Other resilience capability factors identified have positive effects for building AFSC resilience are categorised into three categories: flexibility, redundancy, and visibility. It is important to note that labour contract flexibility has been adopted by all the investigated companies to reduce their operation costs. Furthermore, some big companies are likely to have insurance in case of environmental risks.

The third cluster of AFSC risks illustrated in the bottom-right corner of Figure 4.8 includes eight different types of AFSC risks: demand risks, supply risks, biological and environmental-related risks, weather-related risks, logistical and infrastructure risks, political and macroeconomic risks, financial risks, and management and operational risks. Among the 16 AFSC risk factors identified in phase one of the empirical study, a minority of the determinants such as oral contract or agreement with partners, skill shortage, tax evasion, lack of investment in promoting agri-food products, and rapid technological development are new AFSC risk factors. However, there are several determinants that support the literature (Zhao et al. 2020). Prakash et al. (2017) revealed that rapid technological development should be tackled as the second priority following by forecast error, but the findings of this study show that rapid technological development does not have so much influence on the AFSC. This may be because most AFSC practitioners, such as farmers, are reluctant to use the latest technologies to share information, change the flavour, and improve the quality of agri-food products. Mostly, they rely on their experience rather than on technology to cultivate, prevent pests and diseases, and harvest. Howland et al. (2015) identified a lack of skilled workers who can share data and use ICT, and this study confirms the result in the context of AFSC. Sharing information is critical for AFSC because it helps to reduce uncertainty in supply and demand, decrease inventory levels, increase food quality and safety, and reduce food wastage due to expiration (Ferguson and Ketzenberg. 2006; Kaipia et al. 2013). The empirical findings indicate that it is extremely difficult to hire skilled workers that work in rural areas, despite providing proper salaries, permanent contracts, and proper training. It suggests that the government should introduce preferential policies for people who want to work on farms like the ones implemented by the EU to encourage people from Eastern Europe to work in France. Kleindl (2000) stated that the lack of investment is a common situation faced by SMEs, which is reinforced in this study. Additionally, experienced AFSC practitioners suggest that small farmers should cooperate to establish associations to tackle financial limitations, such as the Auction Market in southern

France, the Association of Bolivian Farmers in Argentina, and the Association of Valencian farmers in Spain (Zhao et al. 2020).

The final cluster of AFSC KPIs illustrated in the bottom-left corner of Figure 4.8 includes five different types of AFSC KPIs: product quality, efficiency, flexibility, process quality, and responsiveness. AFSC KPIs such as packaging and satisfaction of quality standards in the category of product quality, waste reduction in the category of efficiency, product flexibility in the category of flexibility, and water quality in the category of process quality, all can be seen as new KPIs for evaluating AFSC performance. In the contemporary business world, focus is not only placed on reducing costs to increase profits but also on achieving sustainability through developing sustainable SCM practices (Sgarbossa and Russo. 2017). This study supports this viewpoint. For example, wood and degradable plastic both have been used by distributors and wholesalers in avoiding causing burdens to environments. In order to reduce waste, various methods have been used, including donation of fresh agri-food products to charities, sale of agri-food products in secondary markets with a lower price, and generation electricity. Furthermore, this study revealed that European countries have more interest in the environmental and social sustainability of agri-food products than the South America countries. The study conducted by Banterle et al. (2013) highlighted this point. Former studies (e.g., Aramyan et al. (2007)) mainly considers water use - the amount of water used during the production process as a KPI in the category of process quality. Phase one of the empirical study highlights water quality also has been considered by AFSC practitioners as a main KPI in the category of process quality. For example, rainwater has been collected in Southern France for irrigating purpose because rainwater’s high quality. In Argentina, a professional irrigating system has been used to irrigate vegetables and monitor the quality of water.

4.8 Summary

This chapter describes phase one of the empirical study and its findings. According to the work done in phase one of the empirical study, purposive sampling and snowing sampling have been used to identify suitable participants to participate in this research. Once suitable participants have been identified, semi-structured interviews have been used to collect data from the participants. Then, thematic analysis has been used to generate themes among the data collected. Furthermore, TISM has been used to build relationships between different constructs. Thus, a refined KRRP framework (1) has been built based on phase one of the empirical study. Important findings of phase one of the empirical study are summarised as below:

(1) Seventeen new factors have been identified through phase one of the empirical study, including building an equal relationship and constructive feedback in the reciprocity-based KGM, building a project partnership and personal ties in the trust-based KGM, working team stability and building a project partnership in the category of development and innovation, organisational ethos in the category of supply chain collaboration, insurance in the category of redundancy, rapid technological development in the category of logistical and infrastructure risks, and tax evasion, oral contract or agreement with partners, skill shortage and lack of investment in promoting agri-food products in the category of management and operational risks. Considering the new KPIs of AFSC KPIs, four new KPIs have been identified: packaging and satisfaction of quality standards in the category of product quality, waste reduction in the category of efficiency, product flexibility in the category of flexibility, and water quality in the category of process quality.

(2) A new capability for building AFSC resilience has been identified, which is development and innovation.

(3) New relationships have been established between different constructs through conducting the empirical study, including KGMs have positive effects in improving AFSC resilience capabilities, and KGMs have positive effects in enhancing AFSC KPIs.

Chapter five: Phase two of the empirical study - Prioritisation of resilience capability factors and risk factors

5.1 Introduction

This chapter concentrates on prioritisation of resilience capability factors and risk factors. Prioritisation of resilience capability factors and risk factors is considered together in this chapter, as resilience is a risk management approach that needs consider thoroughly multiple risks, shocks and their impacts on AFSCs, and then to develop suitable resilient strategy (Mitchell and Harris. 2012). Prioritisation of resilience capability factors and risk factors is considered as necessary because AFSC companies do not have unlimited resources to deploy resilience strategies for tackling AFSC risks (Adobor and McMullen. 2018). Through prioritising of resilience capability factors and risk factors, key resilience capability factors and key risk factors can be identified. Key resilience capability factors are the critical enablers for helping build AFSC resilience, whereas key AFSC risk factors are the risks that have the most severe effects on the AFSCs and may induce other risks.

This chapter uses the results of phase one of the empirical study as inputs to process TISM and fuzzy MICMAC analysis. TISM is used to build interrelationships among different resilience capability factors and among different AFSC risk factors, respectively. Afterwards, fuzzy MICMAC analysis is deployed for identifying key resilience capability factors and key AFSC risk factors, respectively. Insights from interrelationships of AFSC resilience capability factors and AFSC risk factors have the potential for helping AFSC practitioners to build resilience and reduce the impact of possible inevitable disruptions. Hence, the findings of this chapter provide AFSC managers' guidance on how to build AFSC resilience through deploying key resilience capability factors and minimise the effects of key AFSC risk factors.

5.2 Resilience hierarchy model and risk hierarchy model built from TISM analysis

Supply chain research on risk and resilience is evolving, from focusing on analysing supply chain risks, analysing supply chain resilience, to analyse these two terms together (Macdonald et al. 2018). Have a thoroughly consideration on AFSC resilience capabilities and AFSC risk factors will have positive effects in forming a holistic approach to risk management (Peck. 2010). Thus, a resilience hierarchy model and a risk hierarchy model were considered in this chapter together to achieve a holistic view on AFSC risk management.

Five AFSC resilience capabilities and nineteen AFSC resilience capability factors were identified in phase one of the empirical study (refer to Section 4.5.2). Supply chain resilience capabilities are the critical enables for building supply chain resilience principles, whereas supply chain resilience capability factors are the detailed managerial practices that can be used for building supply chain resilience capabilities. Nineteen AFSC resilience capability factors are: training and development, building shared understanding, building a project partnership, working team stability, leadership, information sharing, trust, joint decision making, organisational ethos, regularly meetings, labour contract flexibility, frequently quality checks, product differentiation, multiple suppliers, reserve raw material stock, insurance, traceability, role clarity, and ICT application.

Eight types of AFSC risks and sixteen AFSC risk factors were identified in phase one of the empirical study (refer to Section 4.5.3). Sixteen AFSC risk factors are: lack of information sharing among partners, poor planning, supply and demand imbalance, market price fluctuations, delay in payment, bad debts, skill shortage, tax evasion, lack of investment in promoting agri-food products, oral contract or agreement with partners, political and economic instability, high energy costs, poor agricultural infrastructure, rapid technological development, risks from pests and diseases, and extreme weather conditions.

The identified AFSC resilience capability factors and AFSC risk factors were used as inputs to process the TISM analysis to build a resilience hierarchy model and a risk hierarchy model, respectively. A resilience hierarchy model depicts the interrelationships among different resilience capability factors, which is considered as necessary for effectively nurturing supply chain resilience and implementing supply chain resilience capability factors (Jain et al. 2017; Sangari and Dashtpeyma. 2019). Though several studies in literature (Ponis and Koronis. 2012; Munoz and Dunbar. 2015; Ali et al. 2017) reports how to define, build, and measure supply chain resilience, very few of them portrays the interactions among the resilience factors/enablers. This chapter helps to fill this gap through modelling the interactions among different AFSC resilience capability factors. Identifying and understanding the interrelationships among different AFSC risk factors also considered plays a critical role in managing AFSC risks, as the hidden effects of one risk related to other risks may cause substantial damage to AFSCs (Chopra and Sodhi. 2004; Zhao et al. 2020). The TISM analysis consists nine steps (refer to Figure 4.4).

(1) Identification and definition of elements: Nineteen resilience capability factors and sixteen AFSC risk factors identified in phase one of the empirical study were used as inputs to process TISM analysis.
(2) Definition of contextual relationships: The contextual relationship between two resilience capability factors is defined as “Resilience capability factor A influences Resilience capability factor B.” Whereas the contextual relationship between two AFSC risk factors is defined as “Risk factor A influences/causes Risk factor B.”
(3) Interpretation of the relationship: eight experts involved in phase one of the empirical study were selected based on their nationality, working experience, job specialisation, and current management level (see Table 5.1), to obtain their opinions on whether the relationship “Resilience capability factor A influences Resilience capability factor B”

and “Risk factor A influences/causes Risk factor B” actually exists or not (Yes or Not). Rajesh (2017) suggested that it is essential for the participants to have the necessary technical knowledge. Thus, the selected eight participants have been working for more than ten years in the area of agro-business management, pests and diseases control, digital agriculture transformation, agricultural policy-making, and AFSC risk management. This ensures the selected participants have professional knowledge and expertise in agricultural related areas.

Table 5.1 Detailed information of eight experts

Experts	Nationality	Working experience	Job specialisation	Current management level
1	Argentina	More than 20 years	1. Pest and disease control; 2. Agro-business management.	Farm owner Professor of Agriculture
2		More than 20 years	1. Pest and disease control; 2. Agro-business management.	Professor of Agriculture
3	France	More than 10 years	1. Agro-business innovation; 2. Digital agriculture transformation.	Director of project department
4		More than 10 years	1. Agro-business innovation; 2. Digital agriculture transformation.	Director of technological department
5	Italy	More than 15 years	1. Disease and pest control; 2. New variety development.	Director of agriculture research institute
6		More than 10 years	1. Digital agriculture transformation; 2. Agro-business management.	Director of wholesale distribution company
7	Spain	More than 15 years	1. Operation management; 2. AFSC risk management.	Professor of operation management
8		More than 15 years	1. Policy maker; 2. Agro-business management.	Director of government agricultural department

(4) Interpretive logic of the pair-wise comparison: A “interpretive logic-knowledge base” was developed for a pairwise comparison of the nineteen identified resilience capability factors and sixteen identified AFSC risks, respectively. There are in total 342 (i.e., 19×19-19=342) rows in the resilience knowledge base and 240 (i.e., 16×16-16=240) rows in the risk knowledge base, respectively, for implementing phase two of the empirical study.

(5) Reachability matrix and transitivity test: An initial reachability matrix of resilience capability factors (see Table 5.2) and AFSC risk factors (see Table 5.4) was developed

from the interpretive logic-knowledge base by entering “1” for “yes” and “0” for “No”. Then, the initial reachability matrix was checked for transitivity rules and further converted it into a final reachability matrix (see Table 5.3 and Table 5.5). The transitivity rules are that: if element “A” relates to element “B” and element “B” relates to element “C”, then it is implied that element “A” necessarily relates to element “C”.

Table 5.2 Initial reachability matrix of AFSC resilience capability factors

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19
F1	1	1	1	1	0	1	1	0	0	0	0	1	1	1	1	1	1	1	1
F2	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0
F3	0	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0
F4	0	1	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0
F5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F6	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	1	0
F7	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
F8	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
F9	1	1	1	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0
F10	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0
F11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F13	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1
F15	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
F18	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
F19	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	1

Table 5.3 Final reachability matrix of AFSC resilience capability factors

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19
F1	1	1	1	1	0	1	1	1*	1*	1*	1*	1	1	1	1	1	1	1	1
F2	1*	1	1*	1	0	1	1	1*	1	0	0	1*	0	1*	1*	1*	0	1	0
F3	0	1	1	1	0	1	1	1	1*	1	0	0	1*	0	1*	1*	0	1	0
F4	0	1	0	1	0	1	1	1	1*	1	0	0	1*	0	1*	1*	0	1	0
F5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F6	0	1	0	1*	0	1	1*	0	1*	0	1*	1*	1	0	1	1	0	1	0
F7	0	1	0	1*	0	1	1	1	1*	0	0	0	1*	0	1*	1*	0	1*	0
F8	0	1	0	1*	0	1	1*	1	1*	0	0	0	1*	0	1*	1*	0	1*	0
F9	1	1	1	1*	0	1	1*	1*	1	1*	1*	1	1*	1	1*	1*	1*	1*	1*
F10	0	1	0	1*	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0
F11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F13	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
F14	0	1*	0	0	0	1*	1*	1*	0	1*	1*	1	1	1	1	0	1	1	1
F15	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
F17	0	1*	0	0	0	1*	1*	1*	0	1*	0	0	0	0	0	0	1	0	1
F18	0	1*	0	0	0	1*	0	1	0	0	0	0	0	0	0	0	0	1	0
F19	0	1	0	1*	0	1	1	1	1*	1	0	0	1*	0	1*	1*	0	1*	1

Note: 1* entries refer to depict transitivity relationship

Table 5.4 Initial reachability matrix of AFSC risk factors

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
E2	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0
E3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
E6	1	1	0	1	0	1	1	0	0	1	0	0	0	0	0	1
E7	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
E8	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
E9	0	0	0	1	0	1	1	0	1	1	0	0	0	0	0	0
E10	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
E11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
E12	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0
E13	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	1
E14	0	0	0	1	0	1	1	1	0	1	0	1	0	1	0	0
E15	0	0	0	1	1	0	1	0	0	1	0	1	0	0	1	0
E16	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1

Source: Zhao et al. (2020, p. 4873)

Table 5.5 Final reachability matrix of AFSC risk factors

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	1	1	1*	1*	1*	0	1	0	0	0	0	0	0	0	0	0
E2	1	1	1	1*	1	0	1	0	0	0	0	0	0	0	0	0
E3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
E6	1	1	1*	1	1*	1	1	1*	0	1	1*	0	0	0	0	1
E7	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
E8	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
E9	1*	1*	1*	1	1*	1	1	1*	1	1	1*	0	0	0	0	1*
E10	1	1	1*	1	1*	0	1*	0	0	1	0	0	0	0	0	0
E11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
E12	1*	1*	1*	1*	1*	0	1*	0	0	1	0	1	1	0	0	0
E13	1*	1*	1*	1	1*	1*	1*	1*	1	1	1*	0	1	0	0	0
E14	1*	1*	1*	1	1*	1	1	1	0	1	1*	1	1*	1	0	1*
E15	1*	1*	1*	1	1	1*	1	1*	1*	1	1*	1	1*	0	1	1*
E16	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1

Note: 1* entries refer to depict transitivity relationship
Source: Zhao et al. (2020, p. 4874)

(6) Level partitioning of the reachability matrix: The final reachability matrix obtained from the previous step was partitioned into different levels based on the reachability and antecedents set for each element through a series of iterations (Singh and Sushil. 2013). The level partitioning was performed until the levels of all resilience capability factors and AFSC risk factors were determined. The partitioning process of resilience capability factors and AFSC risk factors are illustrated in Appendix C and Appendix D, respectively. Lastly, the nineteen resilience capability factors and sixteen AFSC risk factors were partitioned into eleven and nine levels respectively, as shown in Table 5.6

and Table 5.7. These determined levels were used to develop a digraph and a TISM-based hierarchy model.

Table 5.6 Final levels of each AFSC resilience capability factor

Code	AFSC resilience capability factors	Level
F11	Labour contract flexibility	I
F16	Insurance	I
F18	Role clarity	I
F12	Frequently quality checks	II
F13	Product differentiation	III
F15	Reserve raw material stock	III
F2	Building shared understanding	IV
F4	Working team stability	IV
F6	Information sharing	IV
F7	Trust	IV
F8	Joint decision making	V
F10	Regularly meetings	VI
F3	Building a project partnership	VII
F19	ICT application	VII
F17	Traceability	VIII
F14	Multiple suppliers	IX
F1	Training and development	X
F9	Organisational ethos	X
F5	Leadership	XI

Table 5.7 Final levels of each AFSC risk factor

Code	AFSC risk factors	Level
E3	Skill shortage	I
E4	Market price fluctuations	I
E5	Tax evasion	I
E11	Oral contract or agreement with partners	I
E7	Lack of investment in promoting agri-food products	II
E8	High energy costs	II
E1	Delay in payment	III
E2	Bad debts	III
E16	Rapid technological development	III
E10	Supply and demand imbalance	IV
E6	Risks from pests and diseases	V
E9	Poor planning	VI
E13	Lack of information sharing among partners	VII
E12	Poor agricultural infrastructure	VIII
E14	Extreme weather conditions	IX
E15	Political and economic instability	IX

Source: Zhao et al. (2020, p. 4864)

(7) Development of the digraph: For visualisation purposes, the nineteen AFSC resilience capability factors and 16 AFSC risk factors were depicted as a digraph, respectively, in which direct links were drawn as per the relationships shown in the final reachability matrix, with dotted lines used to represent significant transitive links in the digraph.

The arrangement of AFSC resilience capability factors and AFSC risk factors graphically in levels with direct and transitive links is a diagraph.

(8) Interpretive matrix: Through translating all interactions in the digraph by 1 in the respective cell, a binary interaction matrix was developed. The cells with a “1” entry was interpreted by selecting the appropriate interpretation from the knowledge-base in the form of an interpretive matrix (Jayalakshmi and Pramod. 2015).

(9) Hierarchy model of AFSC resilience capability factors and AFSC risk factors: The relevant and interpretive information from the interpretive matrix and digraph was used to develop the TISM hierarchy model of AFSC resilience capability factors and AFSC risk factors, respectively, as shown in Figure 5.1 and Figure 5.2. The interpretation of each link was written on the line representing the respective links in the TISM hierarchy model.

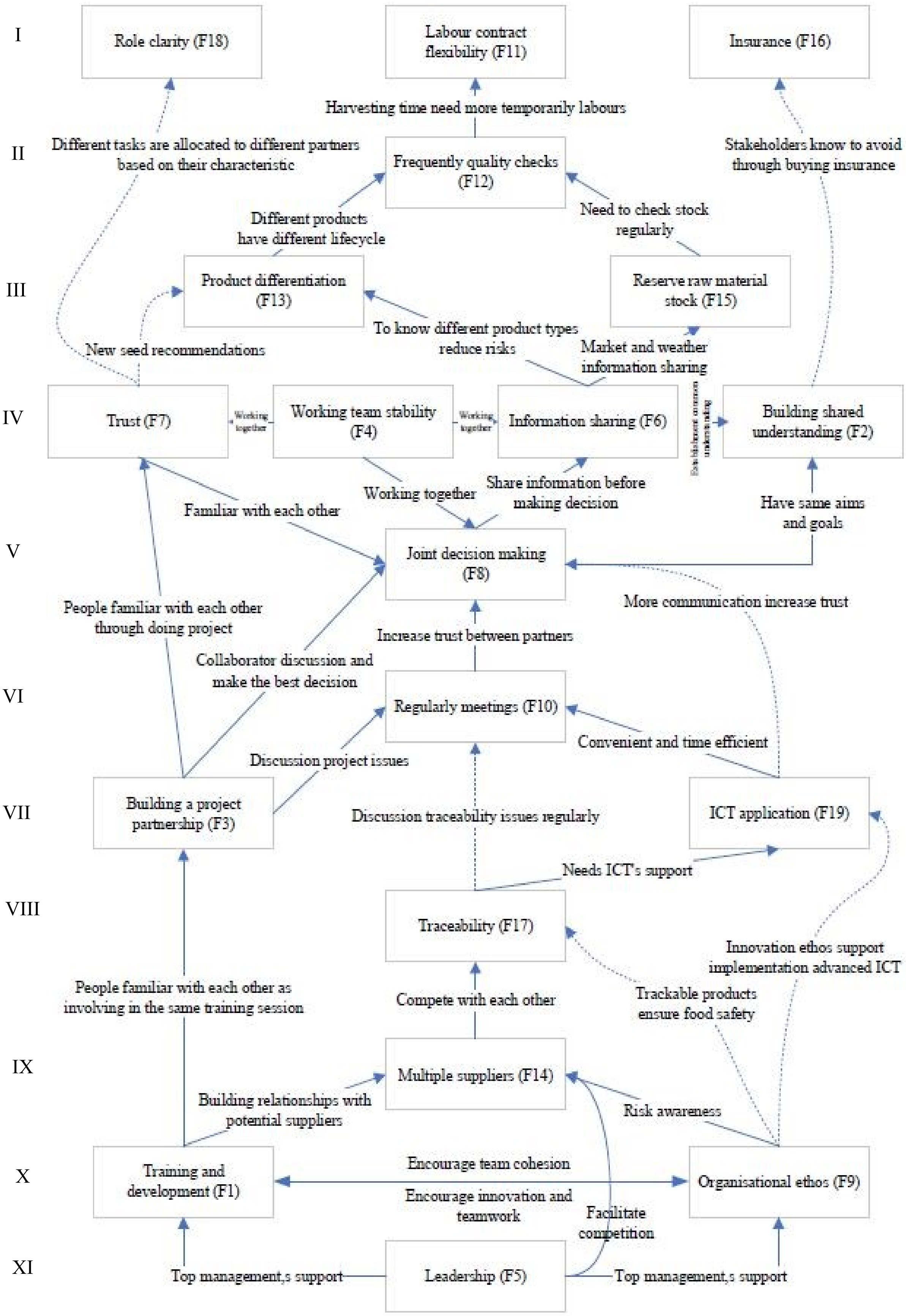


Figure 5.1 TISM model of AFSC resilience capability factors

The TISM analysis of AFSC resilience capability factors resulted in a TISM model of eleven levels (see Figure 5.1). The resilience capability factor locates in the lowest level in the TISM hierarchy, indicates the factor has the highest driving power and the lowest dependence power, which can drive the whole system. In other words, the factor locates in the lowest level in the TISM hierarchy has the biggest influence on the whole system. Whereas the factor locates in the highest level of the TISM hierarchy model, meaning it has the highest dependence power and the lowest driving power. The factor needs all the other factors to contribute that can achieve themselves.

It has been observed that leadership (F5) (Level XI) is placed at the bottom of the TISM model. This means that leadership is the most important resilience capability factor for enhancing AFSC resilience. This facilitates to develop training sessions for their employees and form an appropriate organisational ethos (F9) (Level X) for their company through support and commitment from the leadership. Collective activities such as training and development (F1) (Level X) helps to increase the whole team cohesion and creativity, further fostering a positive organisational learning culture, as pointed by Joo et al. (2012). Conversely, a developed positive organisational ethos facilitates employees to be more innovative. For example, agricultural research institution located in Southern France allows their employees to try their experimental errors in order to foster their exploratory spirit. Appreciation of differences and openness to new ideas helps employees to explore the unknown and spark fresh thinking, which is reinforced by Garvin (2008). It is important to note that training and development help agricultural organisations to find potential project partners as they participated in the same training sessions. Therefore, training and development have the potential to build a project partnership (F1) (Level X).

Multiple suppliers' strategy (F14) (Level IX) also can be achieved through leaders' support as AFSC practitioners want to acquire high-quality products with relatively low price. There is no doubt that a multiple suppliers' strategy can lead to fierce competition among suppliers. However, there is an interesting phenomenon that needs to be noted. In order to increase the profit of farmers, an auction market has been established in Southern France. Furthermore, a farmers' association has been built and the lowest price for each type of vegetables has been established in order to avoid malignant competition among farmers. Thus, fierce competition has shifted from between farmers to between buyers. Buyers need to compete with each other in order to get high-quality agri-food products. Another advantage of implementing multiple suppliers' strategy is to force suppliers to apply traceability technology (F17) (Level VIII) because of fierce competition. Traceability technology can be seen as a competitive advantage if it can be used in the AFSC. Three benefits can be achieved through applying traceability technology in AFSC: (1) improve supply management; (2) improve food safety and quality; and (3) differentiate food markets to eliminate undetectable quality attributes of agri-food products (Golan et al. 2004). Furthermore, implementation traceability technology has a positive effect on deploying ICT (F19) (Level VII), and further supporting regularly meetings (F10) (Level VI) among AFSC practitioners. AFSC practitioners meet their partners regularly would help to increase their trust relations and further to support joint decision-making (F8) (Level V).

In the meeting and decision-making process, AFSC practitioners talk to each other, problems and challenges are openly discussed, and thus facilitates information sharing among partners (F6) (Level IV). A shared understanding also can be built because of frequent communication and a shared goal. Afterwards, product differentiation (F13) (Level III) and reserve raw material stock (F15) (Level III) can be achieved, as weather, market, and product information are shared among different AFSC practitioners. For example, different vegetables such as broccoli, tomato, potato, eggplant are prepared for the coming high consuming season, based on the historical data and information shared among different wholesalers. Different materials are all prepared for extreme weather conditions such as big thunderstorm in Argentina, flood in France, and drought in Italy. It is interesting to note that although pepper is not a popular product in Argentina, some farmers still choose to cultivate it in a low volume because of product differentiation. Additionally, experienced technical people are invited to check the vegetables regularly to ensure the vegetables healthy and of good quality. This results frequently quality checks (F12) (Level II).

Finally, labour contract flexibility (F11) (Level I) can be achieved as most of pests and diseases are usually happening in summer and autumn. Signing a flexible contract with the technique people helps to reduce the operational cost. Furthermore, labour contract flexibility (F11) (Level I), role clarity (F18) (Level I), and insurance (F16) (Level I) locates at the top of the TISM hierarchy model. This means that these three resilience capability factors are easily affected by other resilience capability factors in the lower levels.

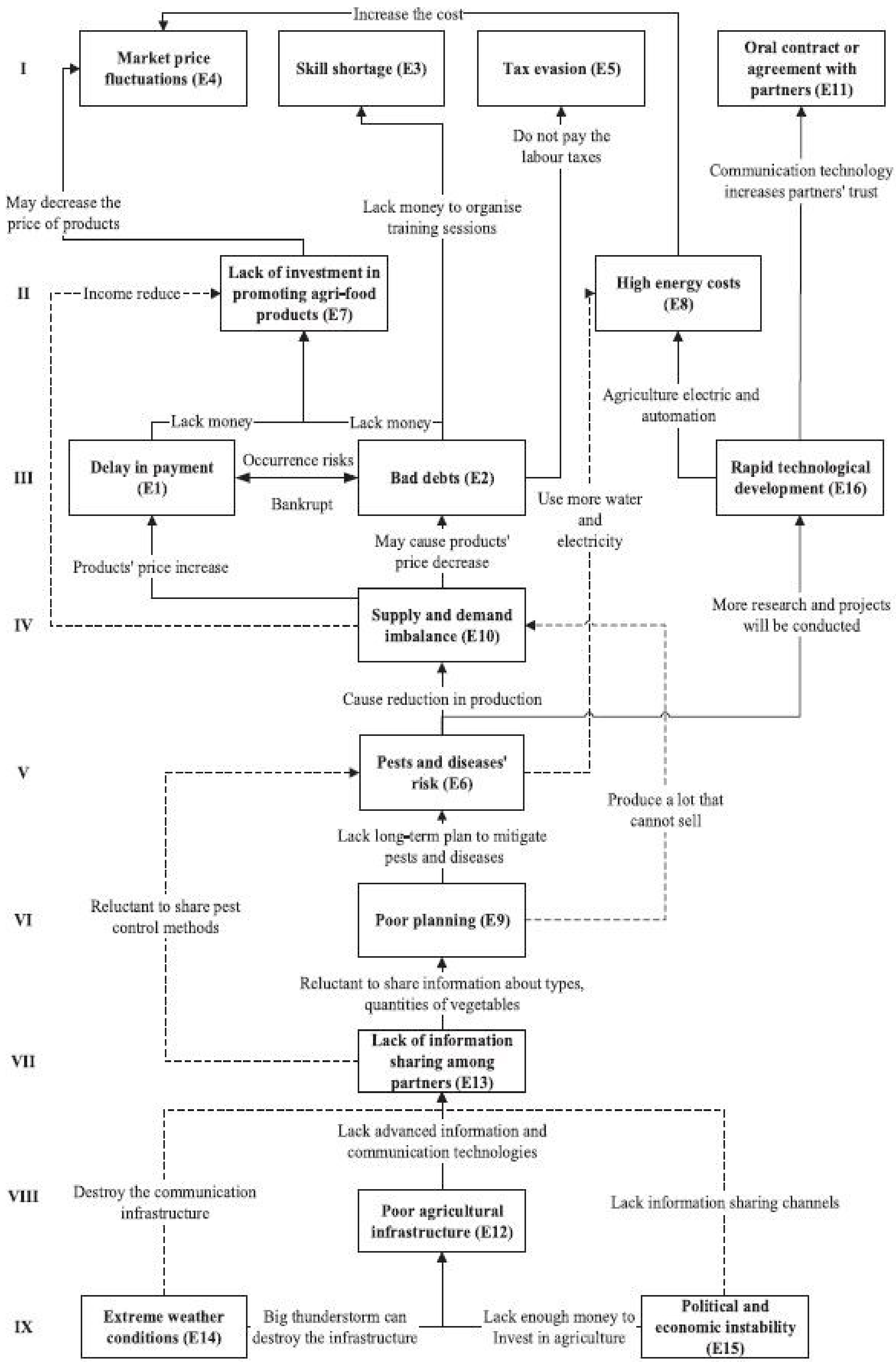


Figure 5.2 TISM model of AFSC risk factors (Source: Zhao et al. 2020)

The TISM analysis of AFSC risk factors resulted in a TISM model of nine levels (see Figure 5.2). The AFSC risk factors locate in the lowest level meaning that they have the highest driving power can drive the whole system. In other words, these risks may induce more risks happening in comparison with the risk locates in the higher levels of the TISM hierarchy. For example, the risks locate in the Level IX may induce the other fourteen risks happening. However, the risk in the Level I cannot induce other risks. Therefore, the risks locate in the level I have the lowest driving power.

It can be observed that extreme weather conditions (E14) (Level IX), political and economic instability (E15) (Level IX), poor agricultural infrastructure (E12) (Level VIII), risks from pests and diseases (E6) (Level V), poor planning (E9) (Level VI), lack of information sharing among partners (E13) (Level VII), and supply and demand imbalance (E10) (Level IV) constitute levels four to nine in the TISM hierarchy model. Delay in payment (E1) (Level III), bad debts (E2) (Level III), and rapid technological development (E16) (Level III) are at the third level followed by the lack of investment in promoting agri-food products (E7) (Level II) and high energy costs (E8) (Level II) which occupy the second level. Finally, market price fluctuations (E4) (Level I), skill shortage (E3) (Level I), tax evasion (E5) (Level I), and oral contract or agreement with partners (E11) (Level I), constitute the first level in the TISM hierarchy model.

The TISM model demonstrates that extreme weather conditions and political and economic instability are the biggest threats to the AFSC, since they cause poor agricultural infrastructure. Poor infrastructure, such as the lack of advanced ICTs, makes the AFSC practitioners reluctant to share information among partners (Zhao et al. 2020). Computers are more used in the AFSCs of France, Italy and Spain as an ICT and management tool. Whereas in Argentina, AFSC practitioners always record information and manage their farms manually. Thus, the lack of information sharing and its direct result of poor planning are common phenomena in AFSCs.

Other technologies such as soilless farming, farm automation, modern greenhouses and modern agriculture are more used in the AFSC of France. Specifically, France needs more advanced agricultural technologies to be applied in their AFSCs in comparison with other countries, as the number of persons regularly working in the agricultural sector dropped by 26.7% over the last decade from 2008 to 2018 (European Commission. 2019). Simultaneously, the lack of long-term planning against pests and diseases makes agri-food products susceptible to them, resulting in less production and more investment in pest and disease research. Therefore, more projects on new seed development and gene modification will be conducted to facilitate technological development.

It is important to note that pests and diseases drive up energy costs because more water and energy should be used to tackle this problem. Furthermore, poor planning aggravates the supply and demand imbalance. The drop in agri-food products' price causes a reduction in the AFSC practitioners' income. Therefore, AFSC practitioners always experience delays in payment and even bad debts. Thus, lacking the money to organise training sessions for employees, avoiding paying labour taxes, and lacking investment in promoting agri-food products are normal phenomenon. The TISM hierarchy model of AFSC risk factors, which shows direct and transitive relationships between various identified risk factors, will improve the performance of AFSC by avoiding an increase in the level of some risks when other risks are mitigated (Zhao et al. 2020).

5.3 Fuzzy MICMAC analysis: classification of AFSC resilience capability factors and AFSC risk factors respectively

The TISM hierarchy model is developed by computing the relationships between two AFSC resilience capability factors (or two AFSC risk factors) as '0' or '1'. If there is no relationship between two AFSC resilience capability factors (or two AFSC risk factors), then it is denoted by '0', whereas if there is a relationship, then it is denoted by '1'. However, the relationships between these resilience capability factors/risk factors cannot always be equal. Some relations may be strong, some may be significantly strong, while other relations may be weak (Yadav and Barve. 2016). To overcome the drawbacks of the TISM model, the fuzzy MICMAC analysis was used to assess the strength of relationships to increase the sensitivity of the analysis rather than for the mere evaluation of relationships so far (Zhao et al. 2020).

Fuzzy MICMAC analysis was adopted in this chapter, as deep insights and rich source of information can be obtained through comparing the hierarchy of risk factors/resilience capability factors in the various classifications (Pfohl et al. 2011). Regarding relationship strength, a higher driving power means a higher driver of the whole system, and a higher dependence power means a higher dependency on the whole system. In other words, a factor characterise a higher driving power means it is more influential on other factors, whereas a factor characterise a higher dependency power means the factor need all the other factors' contribute that can be achieved. The fuzzy MICMAC analysis was conducted in three steps.

Step 1: the binary direct relationship matrix

A binary direct reachability matrix was obtained by converting the diagonal entries into zeros and ignoring transitivity in the final reachability matrix of AFSC resilience capability factors and AFSC risk factors, respectively, as shown in Table 5.8 and Table 5.9.

Table 5.8 Binary direct reachability matrix of AFSC resilience capability factors

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19
F1	0	1	1	1	0	1	1	0	0	0	0	1	1	1	1	1	1	1	1
F2	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0
F3	0	1	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0
F4	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0
F5	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F6	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0
F7	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
F8	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	1	1	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
F10	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
F13	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	1	1
F15	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F18	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F19	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0

Table 5.9 Binary direct reachability matrix of AFSC risk factors

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
E2	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E6	1	1	0	1	0	0	1	0	0	1	0	0	0	0	0	1
E7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E8	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E9	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
E10	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E12	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
E13	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1
E14	0	0	0	1	0	1	1	1	0	1	0	1	0	0	0	0
E15	0	0	0	1	1	0	1	0	0	1	0	1	0	0	0	0
E16	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0

Source: Zhao et al. (2020, p. 4876)

Step 2: development of the fuzzy direct relationship matrix

The conventional MICMAC analysis considers only binary types of relationships, and therefore, to improve its sensitivity, the fuzzy set theory was applied. According to the fuzzy set theory, the possibility of interaction can be defined by a qualitative consideration on a 0-1 scale (i.e., no: 0, very low: 0.1, low: 0.3, medium: 0.5, high: 0.7, very high: 0.9, and complete: 1) (Zhao et al. 2020). Using these values, the opinions of the aforementioned experts in the TISM analysis were used to rate the relationship between two AFSC risk factors and between two AFSC resilience capability factors. Then, the values were superimposed on the binary direct reachability matrix to obtain a fuzzy direct reachability matrix, thus enhancing the research robustness, as it considers the reachability possibility instead of the simple consideration of reachability used so far. The fuzzy direct reachability matrix is shown in Table 5.10 and Table 5.11.

Table 5.10 Fuzzy direct reachability matrix of AFSC resilience factors

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19
F1	0	0.7	0.3	0.3	0	0.9	0.3	0	0	0	0	0.1	0.3	0.3	0.1	0.1	0.3	0.3	0.3
F2	0	0	0	0.5	0	0.7	0.9	0	0.3	0	0	0	0	0	0	0	0	0.9	0
F3	0	0.3	0	0.5	0	0.7	0.7	0.1	0	0.3	0	0	0	0	0	0	0	0.5	0
F4	0	0.9	0	0	0	0.9	0.9	0.7	0	0.5	0	0	0	0	0	0	0	0.9	0
F5	0.7	0.3	0.3	0.5	0	0.3	0.5	0.5	0.3	0.3	0.7	0.7	0.7	0.7	0.7	0.3	0.7	0.3	0.7
F6	0	0.9	0	0	0	0	0	0	0	0	0	0	0.1	0	0.1	0.3	0	0.9	0
F7	0	0.9	0	0	0	0.9	0	0.7	0	0	0	0	0	0	0	0	0	0	0
F8	0	0.3	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0
F9	0.5	0.7	0.1	0	0	0.3	0	0	0	0	0	0.1	0	0.3	0	0	0	0	0
F10	0	0.9	0	0	0	0.9	0.5	0.3	0	0	0	0	0	0	0	0	0	0.3	0
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
F13	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0	0.1	0	0.3	0.3	0.5
F15	0	0	0	0	0	0	0	0	0	0	0.1	0.7	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9
F18	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0
F19	0	0.3	0	0	0	0.5	0.3	0.3	0	0.3	0	0	0	0	0	0	0	0	0

Table 5.11 Fuzzy direct reachability matrix of AFSC risks

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
E1	0	0.3	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0
E2	0.9	0	0.7	0	0.7	0	0.7	0	0	0	0	0	0	0	0	0
E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E6	0.5	0.3	0	0.7	0	0	0.5	0	0	0.3	0	0	0	0	0	0.7
E7	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0
E8	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0
E9	0	0	0	0.9	0	0.7	0.9	0	0	0.7	0	0	0	0	0	0
E10	0.7	0.5	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0
E11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E12	0	0	0	0	0	0	0	0	0	0.3	0	0	0.3	0	0	0
E13	0	0	0	0.3	0	0	0	0	0.3	0.7	0	0	0	0	0	0.3
E14	0	0	0	0.7	0	0.3	0.3	0.7	0	0.7	0.7	0.9	0	0	0	0
E15	0	0	0	0.7	0.9	0	0.5	0	0	0.3	0	0.5	0	0	0	0
E16	0	0	0.7	0.3	0	0	0	0.7	0	0	0.5	0	0	0	0	0

Source: Zhao et al. (2020, p. 4876)

Step 3: generation of fuzzy MICMAC stabilised matrix

The principle of fuzzy matrix multiplication proposed by Kandasamy et al. (2007) was used as guidance for the multiplication process to obtain stabilisation. Fuzzy matrix multiplication is fundamentally a generalisation of the Boolean matrix multiplication. As per the fuzzy set theory, when two fuzzy matrices are multiplied, the outcome is also a fuzzy matrix. The matrix is multiplied repeatedly until the dependence and driving power are constant. Dependence and driving power were obtained by summing the entries of interaction possibilities in the rows and columns separately. The rule of multiplication is shown as follows:

$$C = A, B = \max k (\min (a_{ik}, b_{kj})) \quad \text{where } A = [a_{ik}] \text{ and } B = [b_{kj}]$$

Using MATLAB to calculate the matrices following the aforementioned rule, two stabilised matrices were obtained as shown in Table 5.12 and Table 5.13, respectively. Figure 5.3 and Figure 5.4 present the visualisation of the AFSC resilience capability factors and AFSC risk factors along two dimensions: dependence and driving power.

Table 5.12 The fuzzy MICMAC stabilized matrix of AFSC resilience capability factors

	F 1	F 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10	F 11	F 12	F 13	F 14	F 15	F 16	F 17	F 18	F 19	Driving power
F1	0.3	0.9	0.5	0.5	0	0.9	0.9	0.1	0.3	0.5	0.7	0.9	0.9	0.3	0.9	0.9	0.3	0.9	0.3	11
F2	0.3	0.1	0.3	0.5	0	0.9	0.9	0.7	0.3	0.1	0.5	0.1	0.1	0.3	0.1	0.3	0.1	0.3	0.3	6.2
F3	0.1	0.7	0.1	0.5	0	0.7	0.7	0.7	0.3	0.5	0.7	0.9	0.3	0.3	0.9	0.3	0.3	0.7	0.1	8.8
F4	0.3	0.1	0.3	0.5	0	0.1	0.1	0.3	0.3	0.5	0.5	0.3	0.3	0.3	0.1	0.3	0.3	0.9	0.3	6.8
F5	0.3	0.9	0.7	0.5	0	0.5	0.9	0.9	0.1	0.5	0.7	0.9	0.9	0.3	0.9	0.9	0.5	0.9	0.7	12
F6	0.3	0.1	0.3	0.5	0	0.1	0.1	0.1	0.3	0.5	0.5	0.3	0.3	0.3	0.1	0.3	0.3	0.9	0.3	5.6
F7	0.1	0.5	0.3	0.5	0	0.1	0.1	0.7	0.3	0.5	0.5	0.3	0.3	0.3	0.1	0.3	0.3	0.3	0.3	5.8
F8	0.3	0.7	0.3	0.5	0	0.5	0.1	0.5	0.3	0.5	0.7	0.9	0.3	0.3	0.1	0.9	0.3	0.3	0.3	7.8
F9	0.3	0.7	0.7	0.5	0	0.7	0.7	0.1	0.3	0.5	0.7	0.9	0.6	0.3	0.9	0.9	0.3	0.9	0.3	10.3
F10	0.1	0.7	0.1	0.5	0	0.5	0.5	0.7	0.3	0.5	0.7	0.9	0.3	0.3	0.9	0.3	0.3	0.3	0.3	8.2
F11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F14	0.3	0.5	0.3	0.5	0	0.9	0.5	0.5	0.3	0.5	0.7	0.3	0.9	0.3	0.9	0.9	0.3	0.7	0.7	10
F15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F17	0.3	0.5	0.3	0.5	0	0.5	0.5	0.5	0.3	0.5	0.7	0.9	0.9	0.3	0.7	0.9	0.3	0.5	0.3	9.4
F18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F19	0.3	0.5	0.3	0.5	0	0.5	0.5	0.5	0.3	0.5	0.7	0.3	0.9	0.3	0.9	0.9	0.3	0.5	0.3	9
Dependence power	3.3	6.9	4.5	6.5	0	6.9	6.5	6.3	3.7	6.1	8.3	7.9	7	3.9	7.5	8.1	3.9	8.1	4.5	

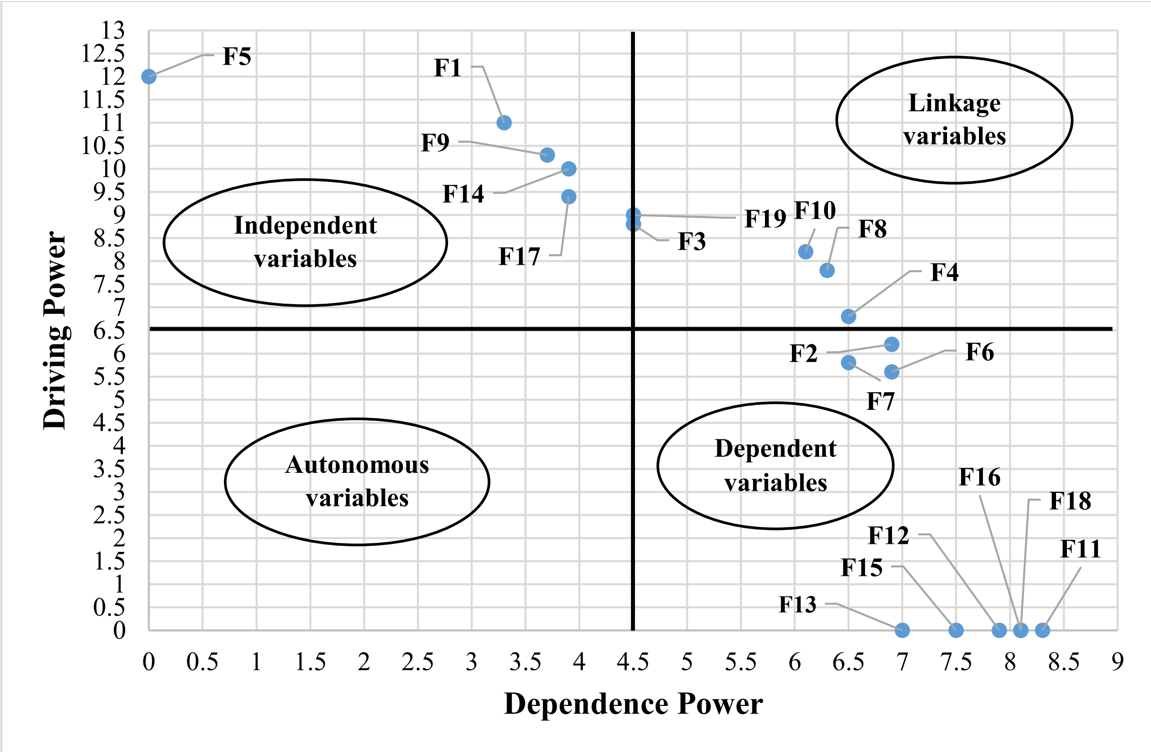


Figure 5.3 Classification of AFSC resilience capability factors based on driving and dependence power

Figure 5.3 shows there are no resilience capability factors under autonomous variables' quadrant. Five resilience capability factors under the linkage variable's quadrant, nine resilience capability factors under the dependent variables' quadrant, and remaining five resilience capability factors under the independent variables' quadrant.

(1) Linkage variables group: Linkage variables have relatively strong driving power as well as strong dependence. Therefore, these variables occupy the middle of the TISM hierarchy model. These variables are highly sensitive, thus, any change in the system or other variables will affect these linkage variables. For example, building a project partnership (F3), working team stability (F4), joint decision-making (F8), regular meetings (F10), and ICT application (F19) are linkage variables and are characterised by their relatively strong driving and dependence power.

(2) Independent variables group: Independent variables have strong driving power and weak dependence. Therefore, these variables form the lowest levels in the TISM hierarchy. These variables act as the drivers of the whole system and may induce other

resilience capability factors. The fuzzy MICMAC analysis result indicates that training and development (F1), leadership (F5), organisational ethos (F9), multiple suppliers (F14), and traceability (F17) are independent variables. Thus, these resilience capability factors should be given a critical focus by AFSC managers, as aforementioned factors have positive effects in achieving other resilience capability factors. Therefore, AFSC managers should work out some strategies to facilitate that these independent resilience capability factors are implemented in AFSCs.

(3) Dependent variables group: Dependent variables characterise weak driving power and strong dependence. Therefore, these variables occupy the highest level of the TISM hierarchy. Their strong dependence indicates that they require all the other resilience capability factors to minimise the effect of these dependent variables on the AFSC resilience strategies' implementation. Therefore, AFSC managers should put high priority on dealing with these resilience capability factors. The dependent variables like build shared understanding (F2), information sharing (F6), trust (F7), labour contract flexibility (F11), frequently quality checks (F12), product differentiation (F13), reserve raw material stock (F15), insurance (F16), and role clarity (F18) that have a weak driving power and strong dependence power form the top level in the TISM hierarchy.

(4) Autonomous variables group: Autonomous variables have weak driving and dependence power. They are relatively disconnected with few links in the TISM hierarchy model. However, there are no autonomous variables have been identified in this study.

By a combination use of TISM and fuzzy MICMAC analysis, an understanding on the position of a resilience capability factor in the hierarchy model and in the classification schemes can be achieved. From the TISM hierarchy model (see Figure 5.1) and fuzzy MICMAC analysis of AFSC resilience capability factors (see Figure 5.3), it suggests that leadership is critical for building AFSC resilience as it has been placed at the lowest level in the TISM hierarchy model and has the highest driving power for driving the whole system. Leadership has been perceived as a determinant component for building trust and creating system learning at the supply chain level, as well as plays an important role in supply chain wide collaboration (Adobor and McMullen. 2018). Garvin et al. (2008) summarised that leadership has five advantages in facilitating learning, including invite inputs from others, acknowledge own limitations, encourage multiple points of view, provide resources for identifying problems and challenges, and provide resources for reflecting and improving. This study confirms its role in fostering organisational wide learning environment.

However, Jain et al. (2017) considered information sharing as the most important component for enhancing the resilience of the supply chain. This contrast shows the difference in research context may cause results variable. In the context of AFSC, AFSC practitioners are reluctant to share information unless gaining supports from their leaders. The potential reason behind this phenomenon is that information sharing would contribute to their potential competitors. Furthermore, information sharing was classified into independent variables group based on the research of Jain et al. (2017). In this study, information sharing has been categorised into dependent variables group. The difference shows that information sharing is not an easy task to be implemented. It requires continuous inputs from human resources, financial resources, technological implementation, and network building. Other dependent variables such as building shared understanding, trust, labour contract flexibility, frequently quality checks, product differentiation, reserve raw material stock, insurance, and role clarity have relative high dependence power, thus, form the relatively high level in the TISM hierarchy. The research conducted by Rajesh (2017) supports this result partly as they considered supply chain flexibility is a dependent variable. Scholars considered supply chain flexibility as a dependent variable because supply chain flexibility needs to be supported by a series of measures. For example, flexible supply via multiple suppliers need to be supported by suppliers to shift their order quantities (Fan et al. 2017).

Table 5.13 The fuzzy MICMAC stabilised matrix of AFSC risk factors

	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**Driving Power**
E1	0	0.3	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0.3	0.9
E2	0.3	0	0.3	0.3	0.3	0	0	0	0	0	0.3	0	0	0	0	0.3	1.8
E3	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.3
E4	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.3
E5	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0.3
E6	0.3	0.3	0.3	0.5	0.3	0	0.3	0	0	0	0	0	0	0	0	0	2
E7	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0.3
E8	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0.3
E9	0.3	0.3	0.5	0.3	0.3	0	0.3	0	0	0	0	0	0	0	0	0	2
E10	0.3	0.3	0.3	0.3	0.3	0	0.3	0	0	0	0	0	0	0	0	0	1.8
E11	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.3
E12	0.1	0.1	0.3	0.3	0.3	0	0.3	0.3	0	0	0.3	0	0	0	0	0.3	2.3
E13	0.3	0.3	0.3	0.3	0.3	0	0.3	0	0	0	0.3	0	0	0	0	0	2.1
E14	0.3	0.1	0.3	0.3	0.3	0	0.3	0.5	0	0.3	0.5	0	0	0	0	0.3	3.2
E15	0.1	0.3	0.3	0.3	0.3	0	0.3	0.5	0	0.3	0.5	0	0	0	0	0.3	3.2
E16	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0.7
Dependence power	2	2	2.6	3.4	2.4	0	2.1	2.2	0	0.6	2.8	0	0	0	0	1.5	

Source: Zhao et al. (2020, p. 4866)

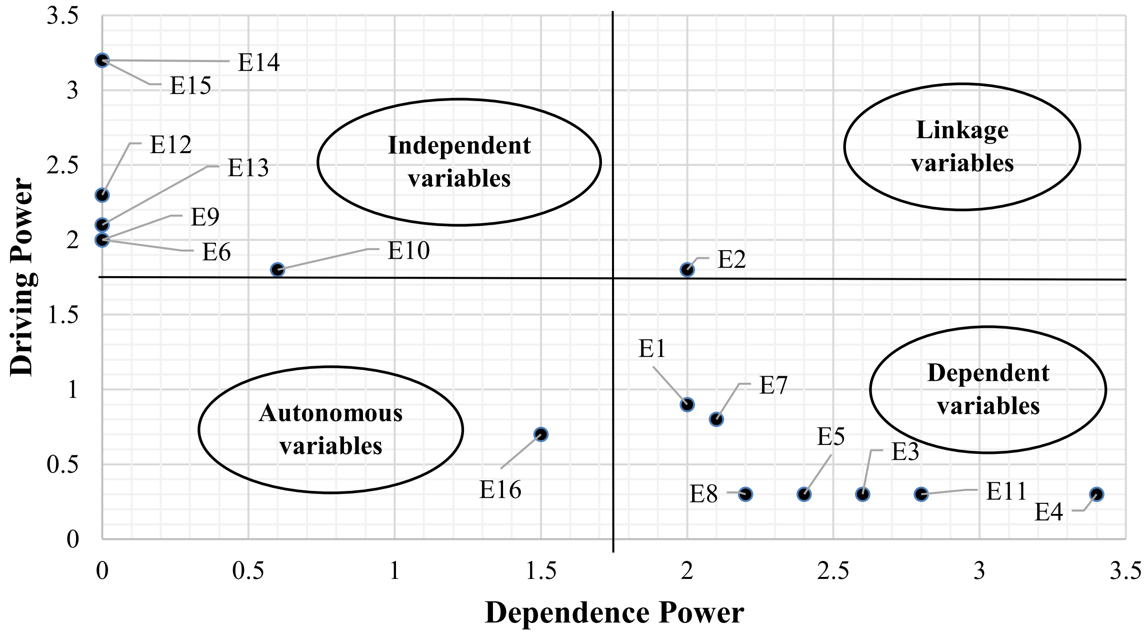


Figure 5.4 Classification of AFSC risk factors based on driving and dependence power
(Source: Zhao et al. 2020, p. 4865)

As shown in Figure 5.4, the sixteen AFSC risk factors are classified into four groups:

(1) Linkage variables group: Factors in this group have both high driving and dependence power. A high driving power has a significant effect on the system, whereas high dependence power is highly dependent on the system. There is only one risk factor in this group, which is a bad debt (E2). Any change in this system will have an effect on

this risk factor and give feedback on itself. Although the lower level risks in the TISM hierarchy may induce or affect this risk, it also has a significant driving power to influence some other risks (Zhao et al. 2020).

(2) Independent variables group: The risk factors in independent variables group are characterised by high driving and low dependence power. These risks act as inputs and key variables of the system and lie at the bottom of the TISM hierarchy model, which can induce a series of other AFSC risks and have a severe impact on AFSC. It includes risks from pests and diseases (E6), poor planning (E9), supply and demand imbalance (E10), poor agricultural infrastructure (E12), lack of information sharing among partners (E13), extreme weather conditions (E14), political and economic instability (E15) (Zhao et al. 2020).

(3) Dependent variables group: The dependent variables have high dependence and low driving power. These risks are highly dependent on the inputs of the system, which indicates that these risk factors require all the other risk factors to minimise the effect on AFSC. The dependent variables are delay in payment (E1), skill shortage (E3), market price fluctuations (E4), tax evasion (E5), lack of investment in promoting agri-food products (E7), high energy costs (E8), and oral contract or agreement with partners (E11) (Zhao et al. 2020).

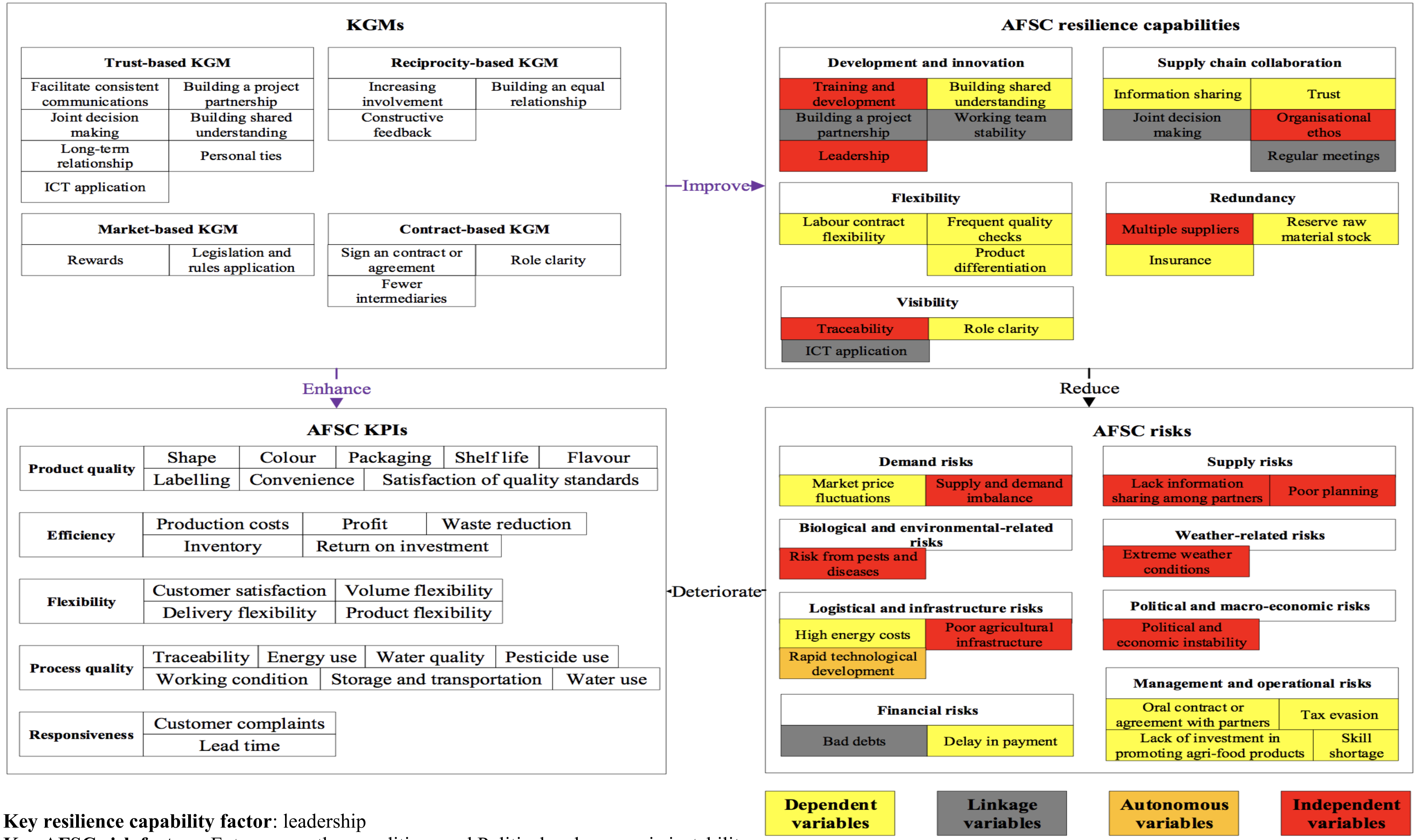
(4) Autonomous variables group: Factors in this group have less driving and dependence power. There is only one risk factor in this group, which is rapid technological development (E16). This risk factor is always disconnected from the system, with which it has only a few links in the TISM hierarchy model. Noticeably, it does not have much influence on the system (Zhao et al. 2020).

With the help of TISM and fuzzy MICMAC analyses (see Figure 5.2 and Figure 5.4), it indicates that the biggest threats to the AFSC are political and weather-related risks, since the resulting dependencies might lead to logistical and infrastructure risk and further induce or affect existing risks such as demand, financial, and management and operational risks. Peck (2005) illustrated that risks emanating from the political, economic, social, technological and natural environments with the highest driving power can affect the whole AFSC. For example, independent variables such as extreme weather conditions and political and economic instability, which have the highest driving power and form the lowest level in the TISM hierarchy model, are considered as the key risk factors. The research conducted by Alesina et al. (1996) highlighted that political instability would cause low economic growth – even recession, and further induce a series of problems such as lack of investment in agricultural infrastructure. Thus, a focus on mitigating extreme weather conditions and political and economic instability will help to control other AFSC risks. Therefore, these risks should be tackled as a high priority.

A comparison of present results with previous studies like the work done by Diabat et al. (2012) on modelling the risks of the food supply chain supports the results of this study to some degree by placing political and weather-related risks at the bottom of the TISM hierarchy. But, while the risks of the present study are in the independent variables group, they are classified under the linkage variables group in earlier works. This contrast shows that the current AFSCs of Argentina, France, Spain and Italy are experiencing more threats from the political and weather-related risks. For example, Argentina experienced four political and economic changes from 1989 to 2016, which had a significant impact on the local AFSC. Market price fluctuations, skill shortage, tax evasion, and oral contract or agreement with partners are the dependent risks and have relatively high dependence power, thus forming the top level in the TISM hierarchy model. These risks are greatly affected by many other risks. However, market price fluctuations are placed in the linkage variables group in previous studies (Diabat et al. 2012). This difference is because market price fluctuations identified in the present study is affected by many other risks and their relative significance and interdependencies also differ from those reported in other studies (Zhao et al. 2020).

5.4 The refined KRRP framework (2) based on phase two of the empirical study

A refined KRRP framework (2) has been built based on phase two of the empirical study, as shown in Figure 5.5. There are four constructs in the refined KRRP framework (2), including KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. The main aim of phase two of the empirical study is prioritisation of resilience capability factors and risk factors. Thus, the resilience hierarchy model (see Figure 5.1) and the risk hierarchy model (see Figure 5.2) were built. Different resilience capability factors and different risk factors were categorised into four groups, including dependent variables, independent variables, linkage variables, and autonomous variables. Based on the results of TISM and fuzzy MICMAC analysis, key AFSC resilience capability factors (e.g., leadership) and key AFSC risk factors (e.g., extreme weather conditions and political and economic instability) were identified.



Key resilience capability factor: leadership
Key AFSC risk factors: Extreme weather conditions and Political and economic instability

Figure 5.5 The refined KRRP framework (2) based on phase two of the empirical study

5.5 Summary

This chapter presents phase two of the empirical study and its related findings. The main aim of this chapter is to prioritise of resilience capability factors and risk factors. Thus, TISM was adopted to build interrelationships among different AFSC resilience capability factors and AFSC risk factors, respectively. Fuzzy MICMAC analysis was used to categorise different AFSC resilience capability factors and AFSC risk factors into different categories, respectively. The research results indicate that leadership should be given a critical focus for building AFSC resilience. Key AFSC risk factors such as extreme weather conditions and political and economic instability should be tackled as a priority, as both risk factors could induce other kinds of risks.

Based on phase two of the empirical study, the refined KRRP framework (2) has been built with the categorisations of AFSC resilience capability factors and AFSC risk factors, as well as highlights on the key AFSC resilience capability factors and key AFSC risk factors.

Chapter six: Evaluating empirical research findings

6.1 Introduction

This chapter provides an evaluation of the research results obtained through phase one and phase two of the empirical study. Research results evaluation is essential, as it can be used as a complement of this research to make the research results more reliable. Thus, this chapter explains how the structured interview was adopted to evaluate the research results, how the interview guide was designed, and how the data were collected and analysed.

6.2 Results evaluation using structured interview

Structured interviews were conducted in November, 2019 in Chile with five experienced AFSC experts from academia and the agri-food industry. The five experts were selected based on their working experience and expertise. All the selected interviewees have been working in the field of AFSC for more than ten years, and have expertise in AFSC sustainable management, pesticide residue in agri-food, plant breeding, and AFSC information technology (see Table 6.1). Chile was selected to verify and evaluate the theoretical and empirical findings as its agricultural industry is one of the backbones of Chile's economy. The agriculture industry is responsible for 28% of the total Chilean trade, as well as 11% of its total GDP. Furthermore, 20% of Chile's labour force is engaged in agriculture (USDA Foreign Agricultural Service. 2017). Finally, the value added by agriculture, forestry and fishing sector to GDP in Chile has experienced constant growth from 7.9% to 9.85% between 2010 and 2018 (Statista. 2019). In the era of the knowledge economy, economic growth cannot happen without the great contribution of knowledge (Tchamyou. 2017). The critical role of the agriculture industry in Chile provided me an excellent opportunity to evaluate the theoretical and empirical findings obtained in previous research phases.

Table 6.1 Experts involved in the structured interview

Number	Role	Working experience	Expertise
1	Senior lecturer in operations, modelling & simulation	More than 10 years	Modelling and simulation, multi-agent system, collaboration in the supply chain and operational research, within the main application to manufacturing, healthcare and agribusiness industries.
2	Lab head of pesticide residues and environment	More than 10 years	Experienced researcher with a demonstrated history of working in the farming industry, environment and pesticide research. Skilled in agronomy and risk assessment.
3	Vegetable breeder	More than 10 years	Skilled in genetics, molecular biology and agricultural plant science.
4	Professor in agro-economy	More than 20 years	AFSC management, agro-economy, and plant breeding.
5	Specialist in data management	More than 10 years	ICT application in AFSC management, blockchain technology and traceability application in AFSC

The interview guide was designed into four parts, including KGMs evaluation, AFSC resilience framework evaluation, AFSC risk framework evaluation, and AFSC KPIs evaluation, as shown in Appendix E. Pilot tests were conducted with one professor in operations management and two doctors in agri-food research at the institute of Chile. Their comments were minor. As a result, the wording of some questions was modified.

Detailed explanations on the topic, related definitions, and vivid examples were given before the interview session, so interviewees have sufficient understandings of this research. All responses were collected through face-to-face structured interviews. Initially, the responses were recorded manually, on paper in the form of questionnaires and then entered into a computer. The interview guide was sent to the potential participants three days before the interview date for interviewees familiarising with the template and organising their answers in a logical way. For clarification purposes, interviewees were free to present their opinions and ideas regarding the questions in the interview guide during the interview. Each interview lasted between 45 to 60 minutes. After each interview, interviewees were asked to check their answers in order to avoid any misunderstandings. The feedbacks collected through structured interviews were shown below.

6.3 Knowledge governance mechanisms evaluation

The results of KGMs evaluation are shown in Table 6.2. Ticks were used with the purpose of measuring the intensity to which a respondent feels toward or about KGMs. For example, all the five respondents hold strongly agree on the element of facilitating consistent communications for build trust-based KGM. Thus, there are five ticks in the cell of strongly agree. There are three respondents hold strongly agree, one respondent holds agree, and one respondent holds neutral on the element of building a project partnership for building trust-based KGM. Thus, there are three ticks in the cell of strongly agree, one tick in the cell of agree, and one tick in the cell of neutral. If there was a respondent hold neutral, disagree, or strongly agree on the elements, an explanation was asked.

Table 6.2 Evaluation of KGMs

KGMs	**Elements for building KGMs**	**Descriptor**				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Trust-based KGM	Facilitate consistent communications	√√√√√				
	Building a project partnership	√√√	√	√		
	Joint decision-making	√√	√√√			
	Long-term relationship	√√√√	√			
	Building shared understanding	√√√√√				
	Personal ties		√√√√√			
	ICT applications	√√√√√				
Market-based KGM	Rewards	√√√√√				
	Legislation and rules application	√√	√√√			
Reciprocity-based KGM	Increasing involvement	√	√√√√			
	Building an equal relationship	√√	√√√			
	Constructive feedback	√√√√√				
Any other elements?	Collaboration with the leading company					
Contract-based KGM	Sign a contract or agreement	√√√√√				
	Role clarity	√√√√√				
	Fewer intermediaries	√√√√√				

All five respondents strongly agree or agree on the elements of different KGMs. All statements rated relatively positive, indicating that respondents highly agree with the elements identified in the empirical findings. However, one of the five respondents holds neutral on building a project partnership of trust-based KGM. The respondent supposed that it was difficult for the participants to build solid relationships with other project partners, particularly in a large or huge project. Most participants do not have a chance to talk with other project partners, even when the project is completed. A new element – a collaboration with the leading company was suggested by respondents for building reciprocity-based KGM.

6.4 AFSC resilience framework evaluation

There are three parts in the interview template of resilience framework evaluation, including evaluation of AFSC resilience capability factors, evaluation of interactions among different AFSC resilience capability factors, and evaluation of AFSC resilience categories. Ticks were used with the purpose of measuring the intensity to which a respondent feels toward or about AFSC resilience framework. Thus, strongly agree, agree, neutral, disagree, strongly disagree were used. If there was a respondent hold neutral, disagree, or strongly agree on the answers, an explanation was asked. The results of each part are shown below.

6.4.1 Evaluation of AFSC resilience capability factors

From Table 6.3, it is easy to identify that AFSC resilience capability factors in the category of supply chain collaboration, flexibility and visibility gained full support from the five AFSC experts, as the five respondents all hold strongly agree or agree on the resilience capability factors for building different resilience capabilities. The resilience capability factors in the category of development and innovation and redundancy gained some support, as there were some respondents hold neutral on the resilience capability factors for building different resilience capabilities.

One of the five respondents holds neutral on building a project partnership of development and innovation. Different partners from various cultural backgrounds involve in one project may facilitate knowledge mobilisation, but only when the knowledge has been embedded in the working processes, the development and innovation can be facilitated. From knowledge mobilisation to knowledge utilisation, the partners need to spend a lot of time and resources to tackle the problems encountered. Thus, it is difficult to facilitate development and innovation only by implementing one project.

Table 6.3 Evaluation of AFSC resilience capability factors

AFSC resilience capabilities	**AFSC resilience capability factors**	**Descriptor**				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Development and innovation	Training and development	√√√√	√			
	Building shared understanding	√√√	√√			
	Building a project partnership		√√√√	√		
	Working team stability	√√√	√√			
	Leadership	√√√√√				
Any other resilience capability factors?	Risk management					
Supply chain collaboration	Information sharing	√√√√	√			
	Trust	√√√√√				
	Joint decision making	√	√√√√			
	Organisational ethos	√√	√√√			
	Regularly meetings	√√	√√√			
Flexibility	Labour contract flexibility	√√√√	√			
	Frequent quality checks	√√√√	√			
	Product differentiation		√√√√√			
Redundancy	Multiple suppliers	√√√√	√			
	Reserve raw material stock		√√√√	√		
	Insurance		√√	√√√		
Visibility	Traceability	√√√√	√			
	Role clarity	√√	√√√			
	ICT application	√	√√√√			

A new resilience capability factor has been identified in the evaluation process, which is risk management in the category of development and innovation. Risk management has been identified as a new resilience capability factor, as it is effective in facilitating employees to learn from previous mistakes and errors. Thus, avoiding the same mistakes/errors in the future. A database/repository has been built in different organisations for storing the effective methods for tackling risks. Thus, AFSC practitioners may have the opportunity to learn from previous risk tackling experience or even make innovation through analysing risk tackling methods.

From this perspective, risk management can be seen as a new resilience capability factor for facilitating development and innovation.

Reserve raw material stock gained four agree and one neutral from the five respondents. Reserve raw material stock is a prevalent strategy that has been used by large agricultural organisations, since these organisations have sufficient financial and human resources. However, the situation in Chile is totally different, as a large number of AFSC practitioners in Chile are SMEs. Lack of necessary agricultural infrastructures, governments support, and financial resources are a common phenomenon for these SMEs. For example, most farmers chose to send their products to the markets with their own vehicles rather than using refrigerated food vehicles.

Three of the respondents hold neutral on the insurance of redundancy. Insurance is a common tool for companies to avoid risks. For example, insurance is used by large organisations for reducing loss in the face of environmental risks. However, it is not a good choice for SMEs in Chile because of two reasons. First, the insurance fee is expensive, especially after the Chilean protest, as the insurance rates have climbed. Second, environmental risks such as floods and droughts have an extremely low chance to happen. It is not worth to spend money every year in case of environmental risks.

6.4.2 Evaluation of interactions among different AFSC resilience capability factors

Three respondents also hold neutral on the interaction of training and development will facilitate organisational ethos, multiple suppliers, and building a project partnership.

"*Most of the training and development are happening at the inside of the company. The experienced labours teach new employees. This can be seen as a kind of training and development. For agricultural research institutes, they may have the opportunity to require partners to participate in a project through training and development (e.g., international conferences, workshops and professional training)*".

Table 6.4 Evaluation of interactions among different AFSC resilience capability factors

Interrelationships between different resilience capability factors	Descriptor				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Leadership will facilitate training and development, organisational ethos and multiple suppliers	√√√	√√			
Training and development will facilitate organisational ethos, multiple suppliers and building a project partnership		√√	√√√		
Organisational ethos will facilitate training and development and multiple suppliers	√	√√√√			
Multiple suppliers will facilitate traceability		√√√√√			
Traceability will facilitate ICT application	√	√√√	√		
ICT application will facilitate regular meetings		√√	√√√		
Regular meetings will facilitate joint decision-making	√√	√√√			
Building a project partnership will facilitate regular meetings, joint decision-making and trust	√√√	√√			
Trust will facilitate joint decision making	√√√√√				
Joint decision-making will facilitate build a shared understanding and information sharing	√√√√	√			
Building shared understanding will facilitate joint decision-making		√√√√√			
Working team stability will facilitate trust and information sharing	√	√√√√			
Information sharing will facilitate building shared understanding, reserve raw material stock and product differentiation		√√√	√√		
Reserve raw material stock will facilitate frequent quality checks	√√√	√√			
Production differentiation will facilitate frequent quality checks	√	√√√√			
Frequently quality checks will facilitate labour contract flexibility				√√√	√√

Furthermore, three respondents hold neutral on ICT application will facilitate regular meetings. Honestly, the widespread of ICT in agriculture offers a new opportunity for farmers to communicate with other AFSC practitioners in a timely and effective manner, as well as assist in coordinating agricultural agents (Aker et al. 2016).

"ICT may help farmers to share information, but it is difficult for farmers to have a regular meeting".

Afterwards, two respondents chose neutral on the interaction of information sharing will facilitate building shared understanding, reserve raw material stock, and product differentiation. The respondents suspected that the relationship between information sharing and reserve raw material stock.

"*To be honest, almost all farmers in Chile reserve their stock based on their personal experience rather than others".*

Finally, all five respondents chose disagree or strongly disagree that the interaction of frequently quality checks will facilitate labour contract flexibility (see Table 6.4). Managers implement flexible labour contracts because of two reasons. First, flexible labour contract has positive effects in reducing the cost of the operations. Second, more labours are required in the harvesting time. Therefore, a flexible labour contract is the best choice for AFSC managers to improve the company's efficiency and reduce operational costs.

6.4.3 Evaluation of AFSC resilience categories

Almost all respondents agree or strongly agree with the research results on the category of AFSC resilience capability factors (see Table 6.5). However, there are divergences on the resilience capability factors of building shared understanding, information sharing, and trust in the category of dependent variables. Thus, some respondents chose neutral for these three resilience capability factors. One of the respondents stated:

"Information sharing, trust and building shared understanding are more like a linkage to facilitate other supply chain practices. For example, it may improve the supply chain planning and delivery practice. Also, it can help supply chain to recover efficiently from supply chain disruptions".

Other respondents also hold the same view that:

"Trust cannot happening in vacuum, it should rely on other resilience factors to be built and then have positive effects on other factors".

Based on the aforementioned statements, these respondents chose neutral on building shared understanding, information sharing, and trust.

Table 6.5 Evaluation of AFSC resilience categories

Different groups	Resilience capability factors	Descriptor				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Independent variables	Training and development		√√√√√			
	Leadership	√√√√	√			
	Organisational ethos	√√	√√√			
	Multiple suppliers		√√√√√			
	Traceability	√	√√√√			
Linkage variables	Building a project partnership		√√√√√			
	Working team stability		√√√√√			
	Joint decision making	√√√√	√			
	Regular meetings	√√√	√√			
	ICT application	√√√	√√			
Dependent variables	Build shared understanding		√√√√	√		
	Information sharing		√√√	√√		
	Trust		√√√√	√		
	Labour contract flexibility		√√√√√			
	Frequently quality checks		√√√√√			
	Reserve raw material stock		√√√√√			
	Insurance		√√√√√			
	Role clarity	√√√	√√			
	Product differentiation		√√√√√			

6.5 AFSC risk framework evaluation

There are three parts in the interview template of risk framework evaluation, including evaluation of AFSC risk factors, evaluation of interactions among the identified risk factors, and evaluation of risk categories. Ticks were used with the purpose of measuring the intensity to which a respondent feels toward or about AFSC risk framework. The results of each part are shown as below.

6.5.1 Evaluation of AFSC risk factors

Almost all respondents strongly agree or agree on the AFSC risk factors identified in the empirical findings (see Table 6.6). However, one of the five respondents holds disagreement on the poor agricultural infrastructure of Chile. In Chile, the quality of agricultural infrastructure depends on the industry. For example, farmers focusing on processing grapes and tomatoes have a very good agricultural infrastructure, as they have sustainable strategies to improve their infrastructure. Furthermore, agricultural infrastructure also depends on the local government. If the local government has extra financial resources and willing to invest in agricultural infrastructure, a large number of farmers will benefit from the investment.

Table 6.6 Evaluation of AFSC risk factors

Risk categories	**Risk factors**	**Descriptor**				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Supply risks	Lack of information sharing among partners	√√	√√√			
	Poor planning	√√√√√				
Demand risks	Supply and demand imbalance	√√√√√				
	Market price fluctuations	√√√√	√			
Management and operational risks	Lack of investment in promoting agri-food products	√√	√√√			
	Skill shortage	√	√√√√			
	Tax evasion	√√√√	√			
	Oral contract or agreement with partners	√	√√√√			
Financial risks	Delay in payment	√√√√	√			
	Bad debts	√	√√√√			
Political and macroeconomic risks	Political and economic instability	√√√√√				
Logistical and infrastructure risks	High energy costs	√√√√	√			
	Poor agricultural infrastructure	√√√	√		√	
	Rapid technological development	√√	√√√			
Biological and environmental related risks	Risk from pests and diseases	√√√√√				
Any other risk factors?	Social ethos					
Weather-related risks	Extreme weather conditions	√√	√√√			

It is important to note that poor planning and supply and demand imbalance gained all support from the five respondents. The key reason behind this phenomenon is that farmers do not have data about plant information of the country. For example, farmers cultivated tomatoes in this region, while farmers in other regions also cultivated tomatoes. This caused the supply and demand imbalance and further caused the price of tomato to go down, as farmers in these two regions did not have data about each other's production volume, production type, and harvesting time.

Political and economic instability also gained all support from the five participants as the civil protests were taking place in November 2019 in Chile. The critical situation in Chile at that time strengthened the impression of the implications of political and economic instability. In the process of evaluating risk factors, one new risk factor social ethos was identified. The respondent stated:

"The culture in Chile makes people avoid paying the labour taxes, even though the farmers do not have an economic problem. Additionally, the big producers they always try to avoid paying labour taxes".

The reason behind this phenomenon can be summarised in two key points: (1) The monitor system is not so strict in Chile. The Chilean government hopes farmers and AFSC practitioners can submit their tax declaration automatically. However, it is impossible for AFSC practitioners to do that because all AFSC practitioners want to avoid paying labour taxes; and (2) Most of the farmers may lose their competitive advantage if they pay labour taxes, while others do not pay the labour taxes. It is a significant portion of money of labour taxes that can be used in other perspectives, including update agricultural infrastructure, training employees and improve their skills, and improve the working conditions. Thus, most of the AFSC practitioners chose to avoid paying labour taxes.

6.5.2 Evaluation of interactions among different AFSC risk factors

Most of the respondents strongly agree/agree/neutral on the interactions between different risk factors, whereas a few respondents hold an opposite view (see Table 6.7). For example, all five respondents hold strongly agree on extreme weather conditions and political and economic instability will cause poor agricultural infrastructure. Political and economic instability such as

Chilean's protest destroyed a large number of infrastructures (e.g., supermarkets, subways, and roads) and caused severe effects on the Chile's economy.

Table 6.7 Evaluation of interactions among different AFSC risk factors

Interrelationships between different risk factors	**Descriptor**				
	Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Extreme weather conditions and political and economic instability will cause poor agricultural infrastructure	√√√√√				
Poor agricultural infrastructure will cause lack of information sharing among partners		√√√	√	√	
Lack of information sharing among partner will cause poor planning	√√	√√√			
Poor planning will cause risk from pests and diseases	√√	√√√			
Risk from pests and diseases will cause supply and demand imbalance	√	√√√√			
Risk from pests and diseases will cause rapid technological development		√√√√		√	
Supply and demand imbalance will cause bad debts and delay in payment		√√√√√			
Delay in payment and bad debts will cause lack of investment in promoting agri-food products	√√	√√	√		
Bad debts will cause skill shortage and tax evasion	√	√√√√			
Lack of investment in promoting agri-food products will cause market price fluctuations	√	√√√		√	
Rapid evolution in technology will cause high energy costs and oral contract or agreement with partners		√√	√√	√	
High energy costs will cause market price fluctuations		√√√√√			

It is interesting to note that only one respondent disagree that the interaction of poor agricultural infrastructure will cause a lack of information sharing among partners. The respondent supposed that reluctance to share information was the main reason of lack of information sharing among partners rather than poor agricultural infrastructure.

"*To be honest, most of the farmers do not care about sharing information, they just focus on how to cultivate high quality agri-food products. I think if the farmer want to share information, they will generate a network to share. Agricultural infrastructure may boost information sharing".*

Furthermore, one of the five respondents holds disagree on the interaction of risk from pests and diseases will cause rapid technological development.

"Agri-chemical products are mainly used by farmers to tackle pests and diseases. The main difference is the quantity used by farmers. We have not used any advanced technology to tackle pests and diseases because of the higher cost in comparison with agri-chemical products".

One of the five respondents holds disagreement on lacking investment in promoting agri-food products will cause market price fluctuations. The respondent supposed that market price fluctuations are mainly caused by the imbalance in offer and demand.

Finally, one respondent holds an opposite view that a rapid evolution in technology will cause high energy costs and oral contract or agreement with partners, as high energy costs were caused by political and economic reasons.

6.5.3 Evaluation of AFSC risk categories

One of the five respondents holds disagreement on the lack of information sharing among partners of independent variables. Lack of information sharing was considered not belongs to independent variables, as it did not has big effects on other variables in the system. The respondent stated:

"*Lack of information sharing exists in the AFSC of Chile, but I think it is not a very important risk because some information you do not need to share with others. We do not need to share information with others and we also can do agriculture very well".*

One of the five respondents holds neutral on the rapid technological development of autonomous variables. The respondent considered:

"Technology is an important element for facilitating the development of agriculture. In Chile, we have a lot of costs related to energy. Therefore, I would like to use technology to tackle the problems related to high energy costs. To be honest, there are not so many technologies that have been applied to the farm".

In the category of dependent variables, one of the five respondents holds neutral on skill-shortage of dependent variables. The respondent chose neutral on skill shortage because of three reasons. First, not so many people want to work in the agriculture industry, especially for young people. Second, Chile's economy is better than its neighbour countries (e.g., Peru, Bolivia, Paraguay, Argentina, and Uruguay). Therefore, the agriculture industry is the first choice for migrants to work, especially for illegal immigrants. Finally, rapid evolution in machines provides opportunities for AFSC practitioners to release their hands.

Table 6.8 Evaluation of AFSC risk categories

Different groups	Risk factors	Descriptor				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Independent variables	Risk from pests and diseases	√	√√√√			
	Poor planning	√	√√√√			
	Supply and demand imbalance	√	√√√√			
	Poor agricultural infrastructure	√	√√√√			
	Lack of information sharing among partners		√√√√		√	
	Extreme weather conditions	√√	√√√			
	Political and economic instability	√√√	√√			
Linkage variables	Bad debts	√√	√√√			
Autonomous variables	Rapid technological development		√√√√	√		
Dependent variables	Delay in payment	√√√√	√			
	Skill shortage	√√	√√	√		
	Oral contract or agreement with partners	√	√√√√			
	Market price fluctuations	√√	√√√			
	Tax evasion	√√	√√√			
	Lack of investment in promoting agri-food products	√√	√√√			
	High energy costs	√√	√√√			

6.6 AFSC key performance indicators evaluation

All respondents agree or strongly agree on the elements of evaluating AFSC performance (see Table 6.9). The respondent further elaborated that all the KPIs were more suitable for evaluating the performance of the Chilean food exportation as the Chilean government imposed strict standards for ensuring the food quality and process quality to satisfy their international customers. A new element - food safety and maximum residues limits (MRLs) of pesticides compliance (FS-MRLs pesticides compliance) – was suggested by our respondents to be included in the product quality to evaluate the AFSC performance.

Table 6.9 Evaluation of AFSC KPIs

AFSC performance categories	**AFSC KPIs**	**Descriptor**				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Product quality	Shape	√√√√√				
	Colour	√√√√√				
	Flavour	√√√√√				
	Shelf life	√√√√	√			
	Packaging	√√√√√				
	Labelling	√√√√√				
	Convenience	√√√√	√			
	Satisfaction of quality standards	√√√√√				
Any other KPIs?	Food safety and maximum residues limits					
Efficiency	Production costs	√√√√	√			
	Profit	√√√√√				
	Waste reduction	√√√√√				
	Return on investment	√√√	√			
	Inventory	√	√√√√			
Flexibility	Customer satisfaction	√√√√√				
	Volume flexibility	√√√√√				
	Delivery flexibility		√√√√√			
	Product flexibility	√√√√√				
Process quality	Traceability	√√√√√				
	Pesticide use	√√√√√				
	Storage and transportation	√√√√√				
	Working condition	√	√√√√			
	Energy use	√√√√√				
	Water use	√√√√√				
	Water quality	√√√	√√			
Responsiveness	Customer complaints	√√√√√				
	Lead time	√√√√√				

6.7 Overview of the main feedback from evaluation

The overview of the main feedback is summarised in Figure 6.1. First, all five respondents hold strongly agree, agree, or neutral on the elements for building different KGMs. A new element collaboration with the leading company was suggested for building reciprocity-based KGM. Furthermore, one of the five respondents holds neutral on building a project partnership for facilitating trust-based KGM. The respondent supposed that building a project partnership might facilitate trust-based KGM, as a project might involve a number of partners. Thus, it is difficult for some project partners to build trust relationship in a big or a huge project. However, it may be easier for core project partners to build trust relationship with others. Second, all five respondents strongly agree, agree, or neutral on the resilience capability factors for building AFSC resilience capabilities. Risk management was considered as a new resilience capability factor for building development and innovation. Moreover, one out of five respondents holds neutral on building a project partnership for facilitating development and innovation. One out of five respondents holds neutral on reserve raw material stock for building redundancy. Additionally, three out of five respondents hold neutral on insurance for building redundancy. Third, all five respondents rated positively on the AFSC risk factors. However, one out of five respondents holds disagree on poor agricultural infrastructure. In Chile, the agricultural infrastructure for cultivating, processing, and manufacturing grape is better in comparison with the agricultural infrastructure for vegetables. Social ethos was considered as a new AFSC risk factor in the category of biological and environmental risks. Finally, all five respondents hold strong agree and agree on the KPIs for evaluating AFSC performance. A new KPI FS-MRLs was identified necessary for evaluating AFSC performance.

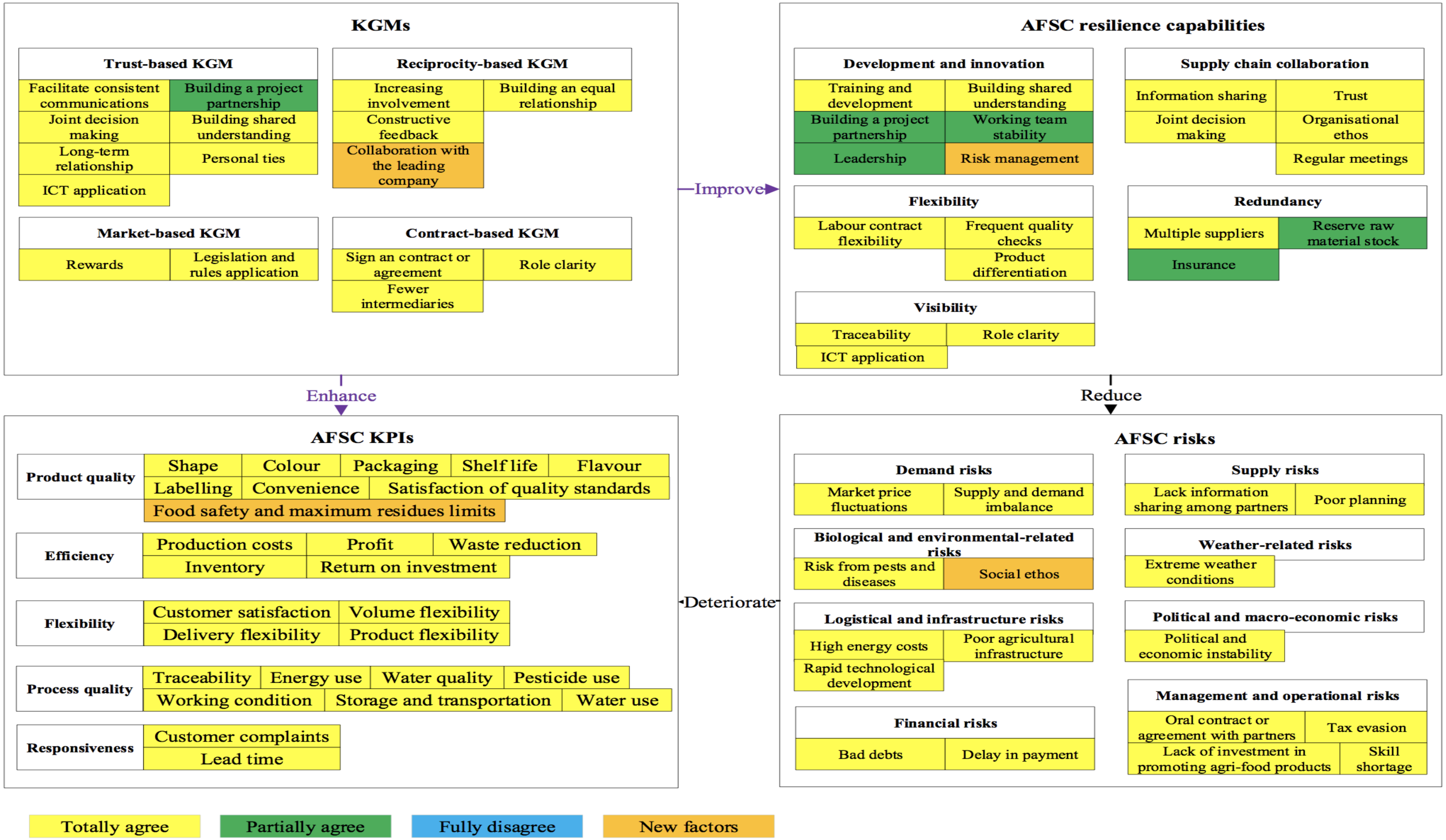


Figure 6.1 The overview of the main feedback from evaluation

6.8 Summary

This chapter evaluated the empirical findings. Structured interviews were conducted in Chile with five experienced AFSC experts to evaluate KGMs, AFSC resilience framework, AFSC risk framework, and AFSC KPIs. The key research findings are summarised as follows:

(1) Almost all respondents agree or strongly agree on the empirical findings identified in previous research phases, indicating that respondents highly agree with the research results. The respondents keep neutral, disagree, or strongly disagree on the empirical findings were all asked to give their explanations.

(2) Four new factors were identified through the evaluation process, including collaboration with the leading company in the category of reciprocity-based KGM, risk management in the category of development and innovation, social ethos in the category of biological and environmental-related risks, and FS-MRLs in the category of product quality.

(3) Finally, the AFSC KPIs identified in previous research phases were more suitable for evaluating the performance of Chilean food exportation supply chain.

Chapter seven: Discussion

7.1 Introduction

The main aim of this chapter is to compare the empirical findings with those in the literature. The findings of this study are consistent with some of the literature and do not support some literature as well. Thus, the empirical findings revealed from different research phases in terms of the literature review, the KRRP conceptual framework versus refined KRRP framework (1), refined KRRP framework (1) versus refined KRRP framework (2), and refined KRRP framework (2) versus main feedback from the evaluation are discussed. Furthermore, the evolution of relationships among KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs is also discussed in this chapter.

7.2 Evolution of knowledge governance mechanisms across the different research phases

Figure 7.1 illustrates the evolution of KGMs across different research phases. In the conceptual phase, definitions and related concepts of different KGMs, as well as empirical studies on KGMs were reviewed. In phase one of the empirical study, different factors of KGMs were revealed through thematic analysis with the data collected from experienced AFSC practitioners. This helps to achieve the research objective one – To investigate different KGMs that can be used by AFSC practitioners for managing knowledge. Phase two of the empirical study has focused on the prioritisation of different AFSC resilience capability factors and AFSC risk factors. Thus, the evolution of AFSC resilience and AFSC risks were neglected in Figure 7.1. In the evaluation phase, different factors obtained in the empirical studies were evaluated in Chile.

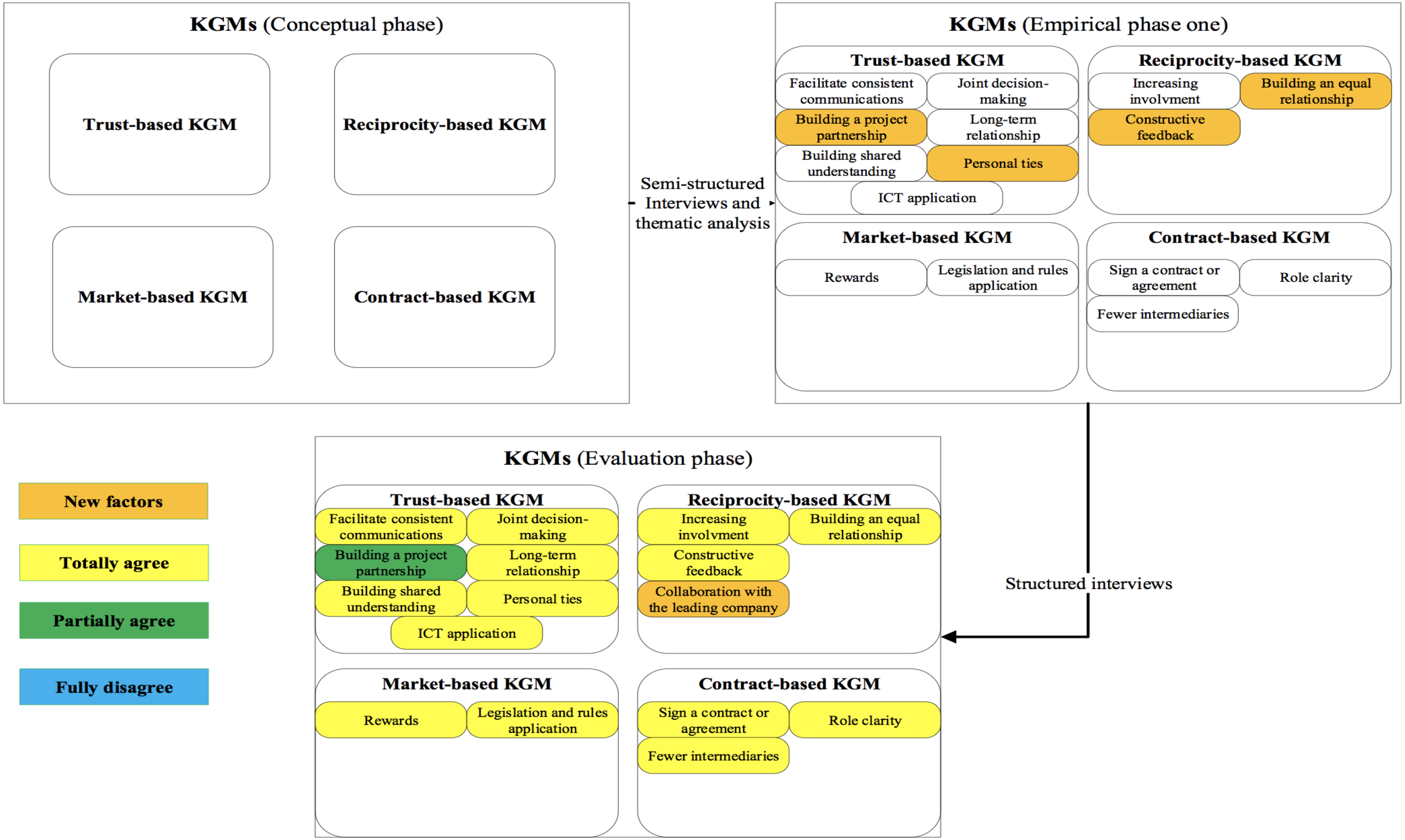


Figure 7.1 Evolution of KGMs across the different research phases

Five factors were identified as new factors for building different KGMs because these factors were not identified in existing literature, including building a project partnership, personal ties, building an equal relationship, constructive feedback, and collaboration with the leading company. Detailed discussion is shown as below. For example, seven factors (e.g., facilitate consistent communications, personal ties, and building project partnership) were identified having positive effects for building trust-based KGM. Earlier works (e.g., Bstieler. 2006; Cheng et al. 2008; Fischer. 2013; Oliveira et al. 2017) have indicated that trust can be significantly improved by effective communication, positive past collaboration, existing relationships, ICT application, third party referrals, and shared values, whereas personal ties and project partnership do not seem to have a significant effect. The empirical findings of this study reveal that personal ties and building a project partnership help to build trust significantly (Zhao et al. 2020). The development of a project partnership requires partners to learn other's operations and expertise for improving the whole project performance. In Argentina and Chile, trust-building is a real management concern, as most of the AFSC practitioners are reluctant to share knowledge because of the lack of confidence and trust.

Among the three factors for building reciprocity-based KGM, building an equal relationship and constructive feedback are new factors for building reciprocal relationships. The benefits of constructive feedback have been highlighted in the area of TQM, team working, empowerment, and organisational performance (Silvervarg et al. 2020). The study carried out by Buckley et al. (2006) illustrated that equal relationship built on personal trust was essential to keep the company functioning. However, building an equal relationship and constructive feedback seem to be neglected by researchers for building reciprocity-based KGM (Jimenez-Jimenez et al. 2019; Mokhtar et al. 2019). The empirical findings of this study indicate that equal relationship helps to reduce discrimination between researchers and farmers, which makes farmers more active in the research process. Therefore, farmers are more willing to contribute and researchers are more likely to share their knowledge with farmers.

Among the factors of market-based and contract-based KGMs, the majority of factors are new to the KGMs. However, there are several factors that support the literature. Bock et al. (2005) highlighted the important role of rewards and incentives in supporting knowledge workers to exploit and create knowledge, which was reinforced by this study. The empirical findings of this study indicate that the quality certificate acquired by AFSC practitioners will force other AFSC practitioners to learn new knowledge. After evaluating the research results in Chile, collaboration with the leading company was suggested to include in the category of reciprocity-based KGM. Collaboration has been reinforced as an important factor for building supply chain resilience, reducing risks, and facilitating knowledge transfer, but its role for building KGMs seems to be neglected (Ramanathan and Gunasekaran. 2014). Fang et al. (2013) indicated the importance of role clarity and application of legislations and rules applicable in the KGMs. This study also supports this point. Smedlund (2006) revealed the important role of intermediaries in forming innovation strategies and transferring knowledge in the regional system, but the findings of this study showed that intermediaries' effect was weakened as most farmers in Argentina and Chile were more likely to sign a contract with private research institution directly to acquire knowledge.

7.3 Evolution of AFSC resilience capabilities across the different research phases

Based on the literature on AFSC resilience, four resilience capabilities are frequently cited by other scholars – supply chain collaboration, flexibility, redundancy, and visibility (Min et al. 2005; Cao and Zhang. 2011; Blome et al. 2014; Sreedevi and Saranga. 2017; Sirirat et al. 2018; Dubey et al. 2020). Thus, these four AFSC resilience capabilities are included in Figure 7.2. After phase one of the empirical study, the empirical findings revealed a new category of AFSC resilience capability – development and innovation. Currently, AFSCs are equipped with different digital technologies (e.g., wireless connectivity, internet of things, artificial intelligence, and blockchain) in order to survive in the volatile business environment (Zhao et al. 2019; Lezoche et al. 2020). Therefore, development and innovation are necessary for the AFSC's resilience building. Furthermore, four factors are considered as new resilience capability factors for building AFSC resilience: building a project partnership, working team stability, organisational ethos, and insurance. Previous studies on supply chain resilience only mentioned that information sharing, goal congruence, trust, joint decision-making, collaborative communication, joint knowledge creation, and resource-sharing are effectively for building supply chain resilience (Christopher and Peck. 2004; Cao et al. 2010; Yi et al. 2011; Tukamuhabwa et al. 2015; Li et al. 2020). The phase one of the empirical study also contributes to achieve the research objective two – To investigate AFSC resilience capabilities and corresponding resilience capability factors that can be used by AFSC practitioners for building AFSC resilience.

To extend the findings revealed in phase one of the empirical study, interrelationships among different AFSC resilience capability factors were built by using TISM, and different resilience capability factors were categorised into four categories by using fuzzy MICMAC analysis. The research result indicates that leadership is a key factor for building AFSC resilience. Therefore, the phase two of the empirical study contributes to the research objective nine – To investigate the key AFSC resilience capability factors and key AFSC risk factors. Previous studies (e.g., Kamalahmadi and Parast. 2016; Li et al. 2017; Han et al. 2020; Tan et al. 2020) on supply chain resilience have focused on several dimensions, for example, supply chain resilience definition, supply chain resilience principles, supply chain resilience strategies, and supply chain resilience measurement. However, scant of studies have focused on the categorisation of AFSC resilience capability factors and identification of key resilience capability factors for building AFSC resilience (Zhao et al. 2018). This study plays an extremely important role in helping AFSC practitioners to build a resilient AFSC, as most AFSC practitioners are SMEs and they do not have unlimited resources.

Finally, the research results obtained in the previous research phases were evaluated by AFSC experts in the evaluation phase. A new resilience capability factor has been identified positively for building AFSC resilience – risk management in the category of development and innovation. In the previous studies, only SCRM culture (Christopher and Peck. 2004; Moore and Manring. 2009; Kamalahmadi and Parast. 2016) has been considered as a key capability for building supply chain resilience, a rare of scholars considered risk management under the category of development and innovation. In the investigated AFSC companies, especially for the agri-food research institutes, risks are controlled well under the new product development and innovation because risks are recorded and allowed for analysis. Thus, risks are controlled at an acceptable level.

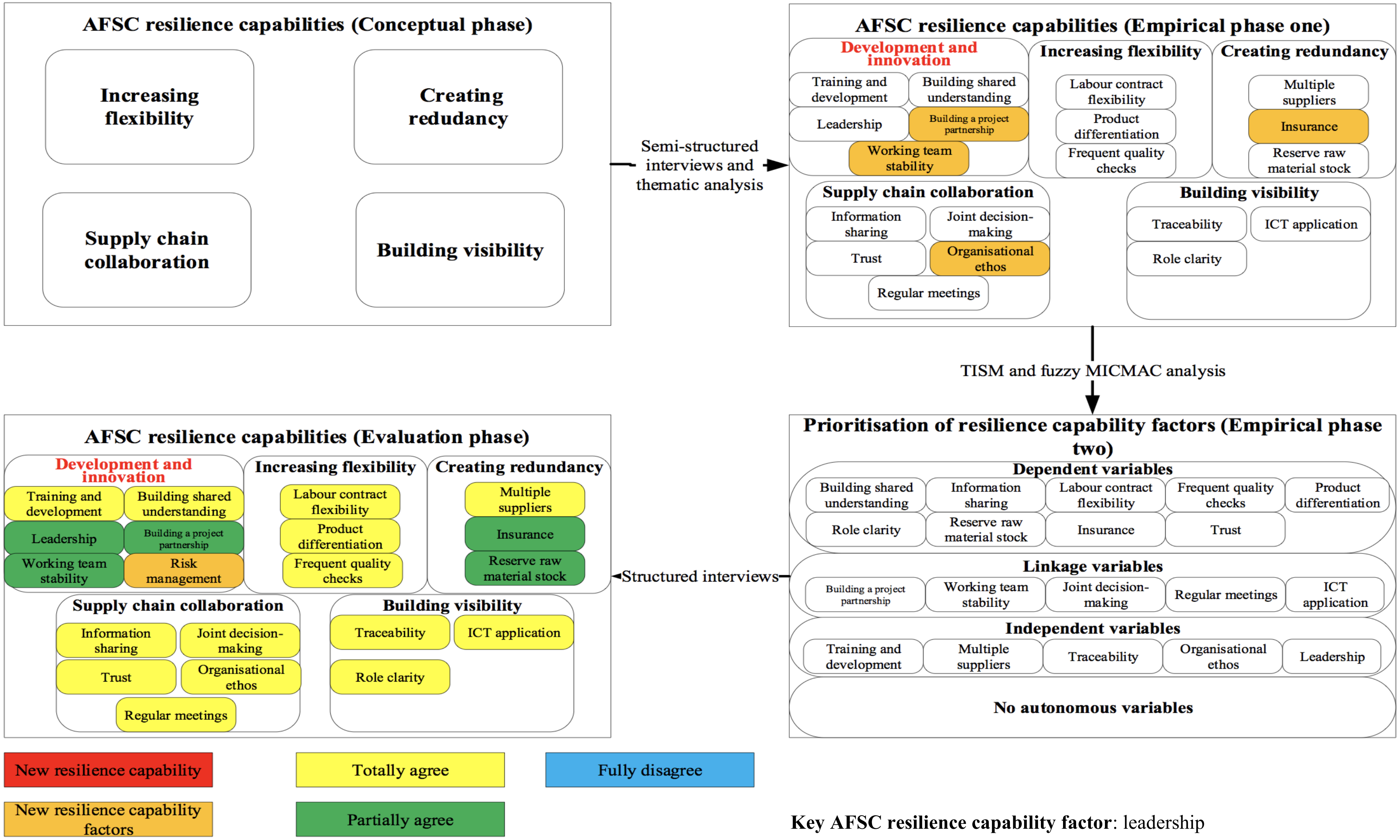


Figure 7.2 Evolution of AFSC resilience capabilities across the different research phases

7.4 Evolution of AFSC risks across the different research phases

As seen from Figure 7.3, AFSC risks are categorised into nine categories in the conceptual phase, namely, supply risks, demand risks, biological and environmental-related risks, political and macroeconomic risks, weather-related risks, logistical and infrastructure risks, policy and regulatory risks, financial risks, and management and operational risks. This categorisation is different with previous research on supply chain risks (e.g., Christopher and Peck. 2004; Kleindorfer and Saad. 2005; Kumar et al. 2010; Lin and Zhou. 2011; Pereira et al. 2020) due to the research context of this study is AFSC, therefore, the categorisation should reflect more on the factors that can have an impact on agri-food products.

After conducting phase one of the empirical study in Argentina, France, Italy, and Spain, 16 AFSC risk factors are revealed. This helps to achieve research objective three – To investigate AFSC risk types and corresponding risk factors that can cause vulnerabilities to the AFSCs. A majority of AFSC risk factors are supported from the literature, whereas a minority of the AFSC risk factors are new. For example, rapid technological development, lack of investment in promoting agri-food products, oral contract or agreement with partners, skill shortage, and tax evasion are new AFSC risk factors that have minor evidence from the literature (see Table 7.1). It is interesting to note that no policy and regulatory risks were identified from the empirical study, as semi-structured interviews were conducted with experienced AFSC managers who have more than ten years of working experience in the AFSC industry. This means that misunderstanding policies or misapplication of rules are impossible for them (Zhao et al. 2020).

After conducting phase two of the empirical study with AFSC experts, AFSC risk factors are categorised into four categories (e.g., independent variables, dependent variables, linkage variables, and autonomous variables) based on their influence on the whole AFSC system (refer to Section 5.3) and interrelationships among different AFSC risk factors are built. Two AFSC risk factors (e.g., political and economic instability and extreme weather conditions) were identified as key AFSC risk factors that have the most severe impact on the whole AFSCs and may induce most of other AFSC risk factors. This contributes to achieve the research objective nine – To investigate key AFSC resilience capability factors and key AFSC risk factors. These risk factors should be given critical focus to mitigate their impact. Practical measures for mitigating the effect of political and economic instability such as building a solid relationship with other agri-food companies in different countries is suggested to be used. For mitigating the extreme weather conditions, buy disaster risk insurance and apply for disaster relief emergency funding are all applicable if the agricultural infrastructure is destroyed by extreme weather conditions (Zhao et al. 2020).

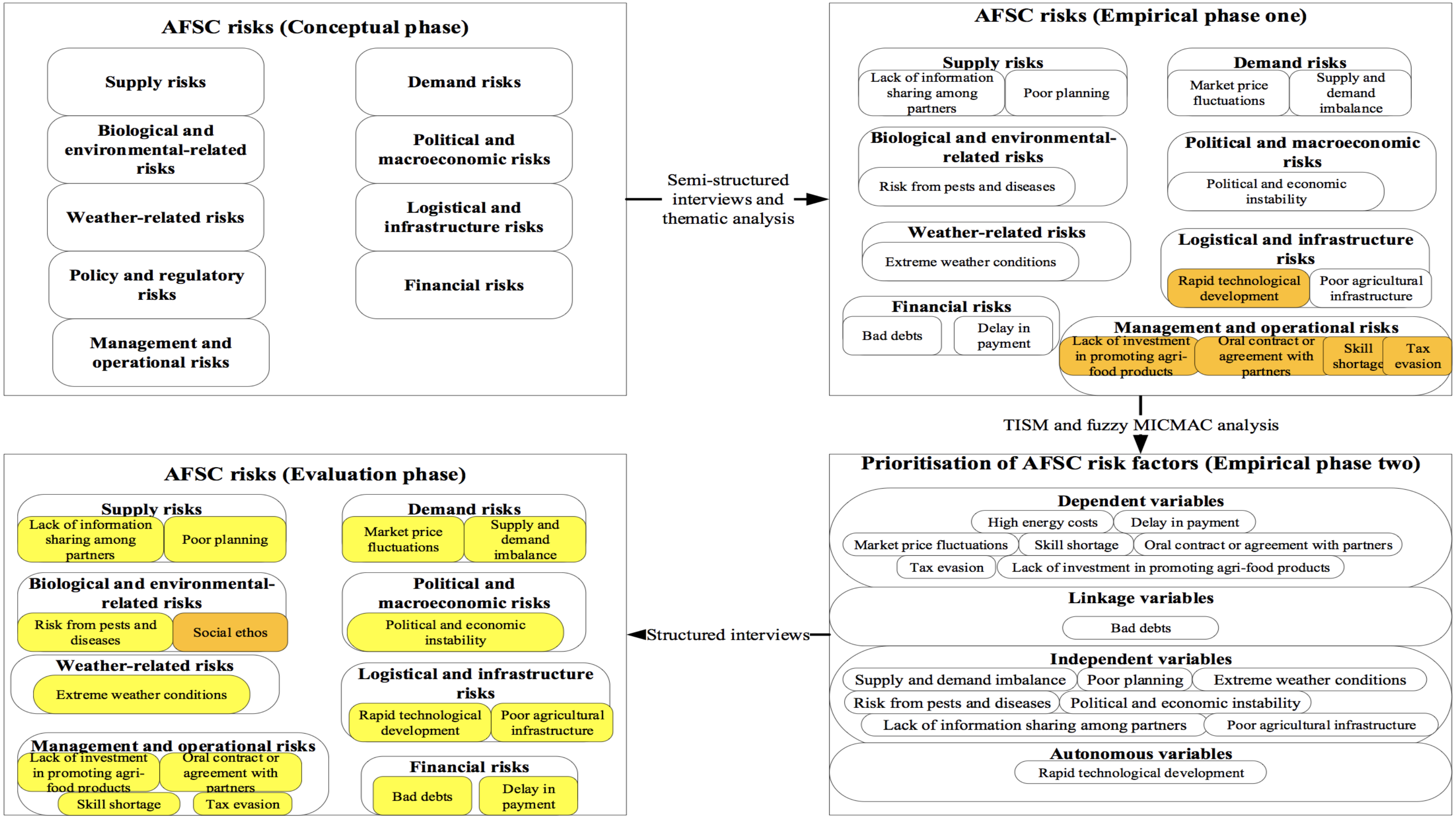
However, some studies stated a contrast result. For example, Ramos et al. (2021) developed a model for managing AFSC risks based on the data collected from the Andean region of Peru. Their research results indicated that natural disaster, environmental, and legal risks were the most critical that have the severe effects to the AFSCs. Prakash et al. (2017) conducted a risk analysis on the dairy industry using ISM and MICMAC analysis. Their research results indicated that natural disaster and terrorist attack were the key risks for the dairy industry, whereas political instability was placed in a less critical place. The contrast generated among these studies because the research context was different, as this research was conducted in Argentina, France, Italy, and Spain, while Ramos's research was conducted in Peru and Prakash's research was conducted in India.

Table 7.1 AFSC risk factors in literature vs AFSC risk factors revealed from the empirical

Risk types	Risk factors listed in the literature	Risk factors revealed from the empirical study
Supply risks	(1) supplier bankruptcy; (2) volatility in fertiliser cost; (3) delay in securing financial support; (4) poor planning; (5) yield uncertainty; (6) supplier quality problem; (7) capacity fluctuations/shortages in the supply market;	Lack of information sharing among partners, poor planning
Demand risks	(1) insufficient information from customers; (2) volatile of customer demand; (3) market price volatility; (4) changes in food safety requirements;	Market price fluctuations, supply and demand imbalance
Biological and environmental-related risks	(1) pests and diseases risk; (2) contamination related to poor sanitation and illnesses; (3) contamination affecting food safety; (4) contamination and degradation of production and processing processes;	Risk from pests and diseases
Political and macroeconomic related risks	(1) political instability, war, civil unrest or other socio-political crises; (2) interruption of trade due to disputes with other countries; (3) nationalisation/confiscation of assets, especially belonging to foreign investors; (4) changes in the political environment due to introduction of new laws or stipulations;	Political and economic instability
Weather-related risks	(1) periodic deficit/excess rainfall; (2) extreme drought; (3) Flooding; (4) extreme wind; (5) cold weather; (6) hailstorms;	Extreme weather conditions
Logistical and infrastructure-related risks	(1) poor infrastructure and services; (2) volatility in fuel price; (3) unreliable transport; (4) changes in transportation; (5) lack of infrastructure and service units; (6) poor performance of logistics service providers; (7) lack of effective system integration; (8) labour disputes;	Rapid technological development, poor agricultural infrastructure, high energy costs
Policy and regulatory risks	(1) stricter food quality and safety standards; (2) animal welfare legislation negatively affecting the competiveness; (3) potential restrictions on waste disposal; (4) weak institutional capacity to implement regulatory mandates;	No policy and regulatory risks identified from empirical
Financial risks	(1) uncertain trade, market, land and tax policies; (2) Inadequate financial support; (3) delay in payment and even possible non-payment; (4) change in exchange rate; (5) insufficient credit;	Bad debts, delay in payment
Management and operational risks	(1) poor management decisions on asset allocation; (2) use of expired seeds; (3) poor quality control; (4) poor decision making in use of inputs; (5) farm and firm equipment breakdowns; (6) inability to adapt to changes in cash and labour flows (7) forecast and planning errors;	Lack of investment in promoting agri-food products, oral contract or agreement with partners, skill shortage, tax evasion

Source: Zhao et al. (2020)

In the evaluation phase, AFSC risk factors, AFSC risk categorisations, and AFSC risk interrelationships were evaluated in Chile with experienced AFSC experts. The AFSC risk factors, AFSC risk categorisations, and AFSC risk interrelationships were assessed as appropriate for practical use. Furthermore, social ethos was identified as a new risk factor in the category of biological and environmental related risks.



Key AFSC risk factors: Political and economic instability and extreme weather conditions

Figure 7.3 Evolution of AFSC risks across the different research phases

7.5 Evolution of AFSC key performance indicators across the different research phases

Measuring the performance of AFSCs has been identified as a difficult task, because the special characteristics of agri-food products and the actors involved in the AFSCs (Zhao et al. 2020). Previous studies (e.g., Lambert and Pohlen. 2001; Akyuz and Erkan. 2010; Balfaqih et al. 2016) proposed different PMSs to evaluate the performance of supply chains, such as supply chain balanced scorecard, supply chain operations reference model, resource output flexibility model, and process-based supply chain PMS. However, based on the author's knowledge, a rare of literature have focused on evaluating the performance of AFSCs (Zhao et al. 2020). This study aims to fill this gap by proposing a new PMS to evaluate the performance of AFSCs.

In the conceptual phase, a PMS that reflects the characteristics of agri-food products is proposed, including five performance metrics: product quality, efficiency, flexibility, process quality, and responsiveness. After phase one of the empirical study, nineteen AFSC KPIs have been identified through conducting semi-structured interviews with experienced AFSC experts. This contributes to achieve research objective four – To investigate KPIs that can be used by AFSC practitioners to measure the performance of AFSCs. Five new AFSC KPIs were identified, including packaging, satisfaction with quality standards, waste reduction, product flexibility, and water quality. In the evaluation phase, the obtained AFSC KPIs were evaluated in Chile to check its practical use, which resulted in another new AFSC KPI was identified - FS-MRLs pesticide compliance.

The difference of AFSC KPIs across different research phases due to several reasons (see Table 7.2). First, AFSC is a broad item that may include different types of supply chains, such as fruit supply chains, vegetable supply chains, and meat supply chains. This study mainly focuses on the vegetable supply chains. Second, previous studies may be conducted in different countries. Different countries have different cultures, this may result the difference between the empirical study and the literature. Finally, governments are formulating more strict standards to protect the natural environment and increase the agri-food products' quality (Mangla et al. 2018). Therefore, it is not difficult to identify that AFSC KPIs were reflected more on quality and environmental issues.

Table 7.2 AFSC KPIs

AFSC KPIs in literature		**Identified AFSC KPIs through the phase one of the empirical study**	**Identified AFSC KPIs through the evaluation process**	**New KPIs**
Efficiency	Production costs	√	√	Waste reduction
	Transaction costs	X	X	
	Return on investment	√	√	
	Inventory	√	√	
	Profit	√	√	
Flexibility	Customer satisfaction	√	√	Product flexibility
	Volume flexibility	√	√	
	Delivery flexibility	√	√	
	Backorders	X	X	
	Lost sales	X	X	
Responsiveness	Fill rate	X	X	
	Product lateness	X	X	
	Customer response time	X	X	
	Lead time	√	√	
	Shipping errors	X	X	
	Customer complaints	√	√	
Product quality	Appearance	√	√	Packing
	Taste	√	√	
	Shelf life	√	√	Satisfaction with quality standards
	Salubrity	X	X	
	Safety	X	X	
	Product reliability	X	X	FS-MRLs pesticide compliance
	Convenience	√	√	
Process quality	Traceability	√	√	Water quality
	Storage and transportation	√	√	
	Working conditions	√	√	
	Energy use	√	√	
	Water use	√	√	
	Pesticide use	√	√	
	Reuse	X	X	
	Client services	X	X	

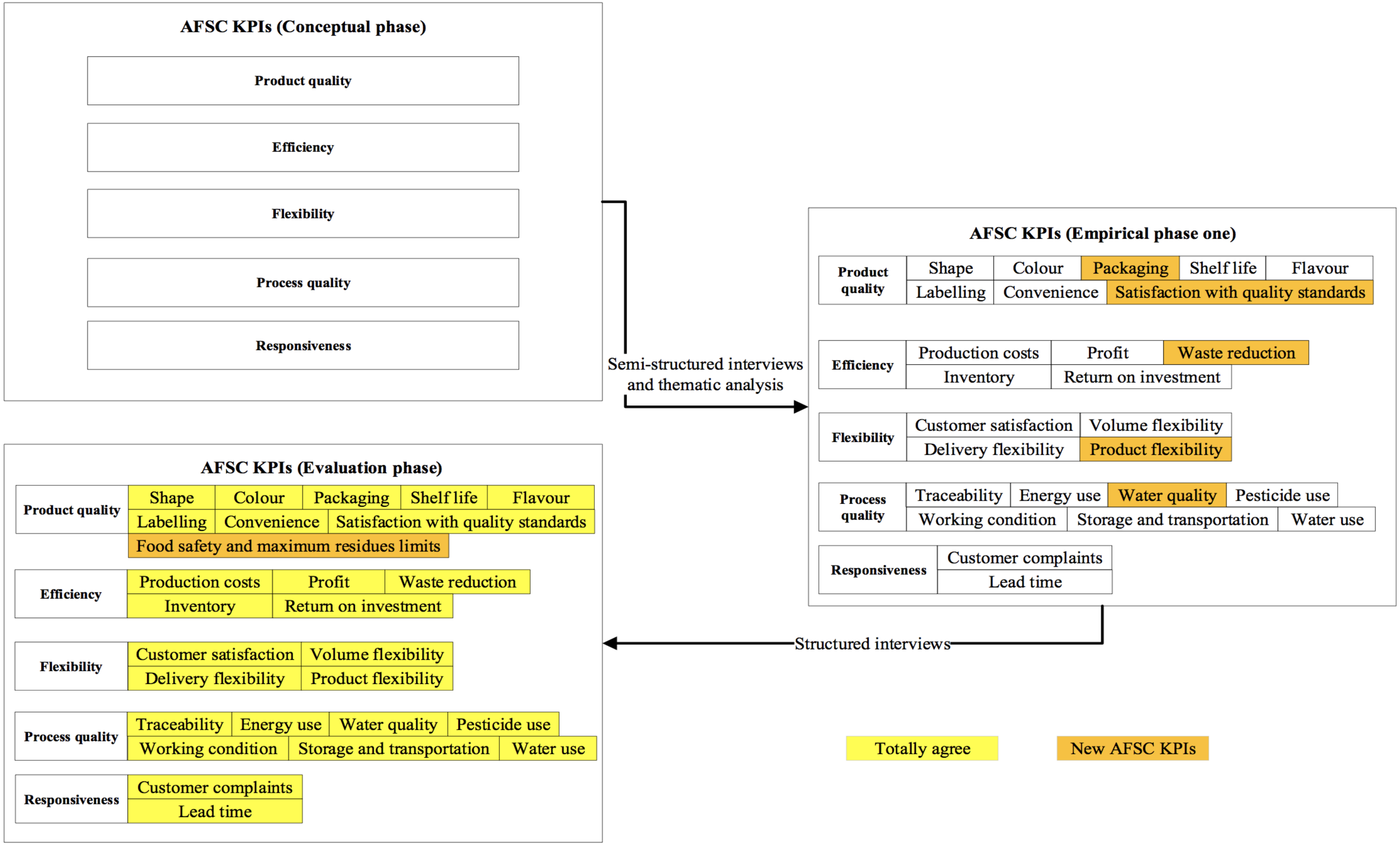


Figure 7.4 Evolution of AFSC KPIs across the different research phases

7.6 Evolution of the relationships among knowledge governance mechanisms, AFSC resilience capabilities, AFSC risks, and AFSC key performance indicators

The conceptual work was built based on the comprehensive literature review on KGMs, AFSC resilience, AFSC risks, and AFSC performance. Thus, the relationships among different constructs in the KRRP conceptual framework were formulated based on the work of scholars (see Figure 7.5). For example, little research has been conducted to explore the influence of KGMs on AFSC performance (Marra et al. 2012; Zhao et al. 2020). Previous literatures (e.g., Shaw et al. 2003; Hult et al. 2004; Raisinghani and Meade. 2005; Sangari et al. 2015) on supply chain KM indicates that knowledge acquisition, knowledge sharing, knowledge transfer, and knowledge application can have an impact on supply chain performance. However, it is unclear whether a relationship exist between KGMs and AFSC performance (Marra et al. 2012). Thus, the relationship between KGMs and AFSC KPIs was formulated as KGMs had an impact on AFSC KPIs in the left part of Figure 7.5. Impact means effect or influence, it is unclear the effect or influence is positive or negative.

The research on supply chain resilience concentrates on four principles for building supply chain resilience, includes supply chain collaboration, supply chain reengineering, agility, and SCRM culture. Based on the author's knowledge, little research has been conducted to explore how to improve supply chain resilience from the KM perspective (Tukamuhabwa et al. 2015; Kamalahmadi and Parast. 2016; Li et al. 2020). Thus, the relationship between KGMs and AFSC resilience was formulated as KGMs have an impact on AFSC resilience in the left part of Figure 7.5. Many scholars (e.g., Colicchia et al. 2010; Leat and Revoredo-Giha. 2013; Ambulkar et al. 2015; Macdonald et al. 2018; Singh and Singh. 2019) have suggested that AFSC resilience capabilities have positive effects in reducing the risks of AFSCs. Thus, the relationship was formulated as AFSC resilience could reduce AFSC risks in the left part of Figure 7.5. It is increasingly accepted among academics and practitioners that AFSC risks can deteriorate the performance of AFSCs (Ritchie and Brindley. 2007; Wagner and Bode. 2008; Zhao et al. 2013; Jajja et al. 2018). Thus, the relationship between AFSC risks and AFSC KPIs was formulated as AFSC risks could deteriorate the performance of AFSC in the left part of Figure 7.5.

Through conducting empirical study on AFSCs across five different countries, this study empirically identified that KGMs could help to improve AFSC performance (Zhao et al. 2020) (refer to Figure 4.4). This contributes to achieve the research objective five – To investigate the direct impact of KGMs on AFSC performance. For example, reciprocity-based KGM helps AFSC partners to acquire distinctive knowledge and resources through building reciprocal relationships. Trust-based KGM helps to transfer knowledge among different AFSC partners to reduce food waste, production cost, and increase profits. Contract-based KGM provides guidance for AFSC partners' behaviour, thinking, and judgement making through signing a contract with partners. Through deploying these KGMs, AFSC's efficiency, process quality, product quality, flexibility, and responsiveness can be improved.

Furthermore, this study also empirically identifies that KGMs help to build AFSC resilience, as KGMs facilitate knowledge transfer across the whole AFSC (refer to Figure 4.6). Different resilience capabilities (e.g., development and innovation, supply chain collaboration, flexibility, redundancy, and visibility) for reducing AFSC risks were summarised in Table 4.10. For example, development and innovation helps to reduce different AFSC risks (e.g., oral contract and agreement, tax evasion, and skill shortage) through applying different resilience capability factors such as training and development and leadership. Supply chain collaboration has positive effects in reducing the risks of poor planning, lack information sharing among partners, supply and demand imbalance, market price fluctuations, and political and economic instability. Finally, the relationship between AFSC risks and AFSC KPIs was also empirical identified (see Appendix B). For example, management and operational risks have negative effects in reducing product quality and process quality. Political and macroeconomic risks have negative effects in process quality, efficiency, flexibility, and responsiveness. Investigating the relationships between KGMs and AFSC resilience, the relationships between AFSC resilience and AFSC risks, and the relationships between AFSC risks and AFSC performance, this contributes to achieve the research objective six – To investigate the indirect impact of KGMs on AFSC performance through AFSC resilience capabilities and AFSC risks.

Finally, this study builds a KRRP framework (refer to Figure 5.5), links to different terms (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs) together, and depicts different factors that can be used for building each term. Therefore, it helps to achieve the research objective seven – To construct a KRRP model of the agri-food industry and research objective eight – To validate the KRRP model in different countries across Europe and South America.

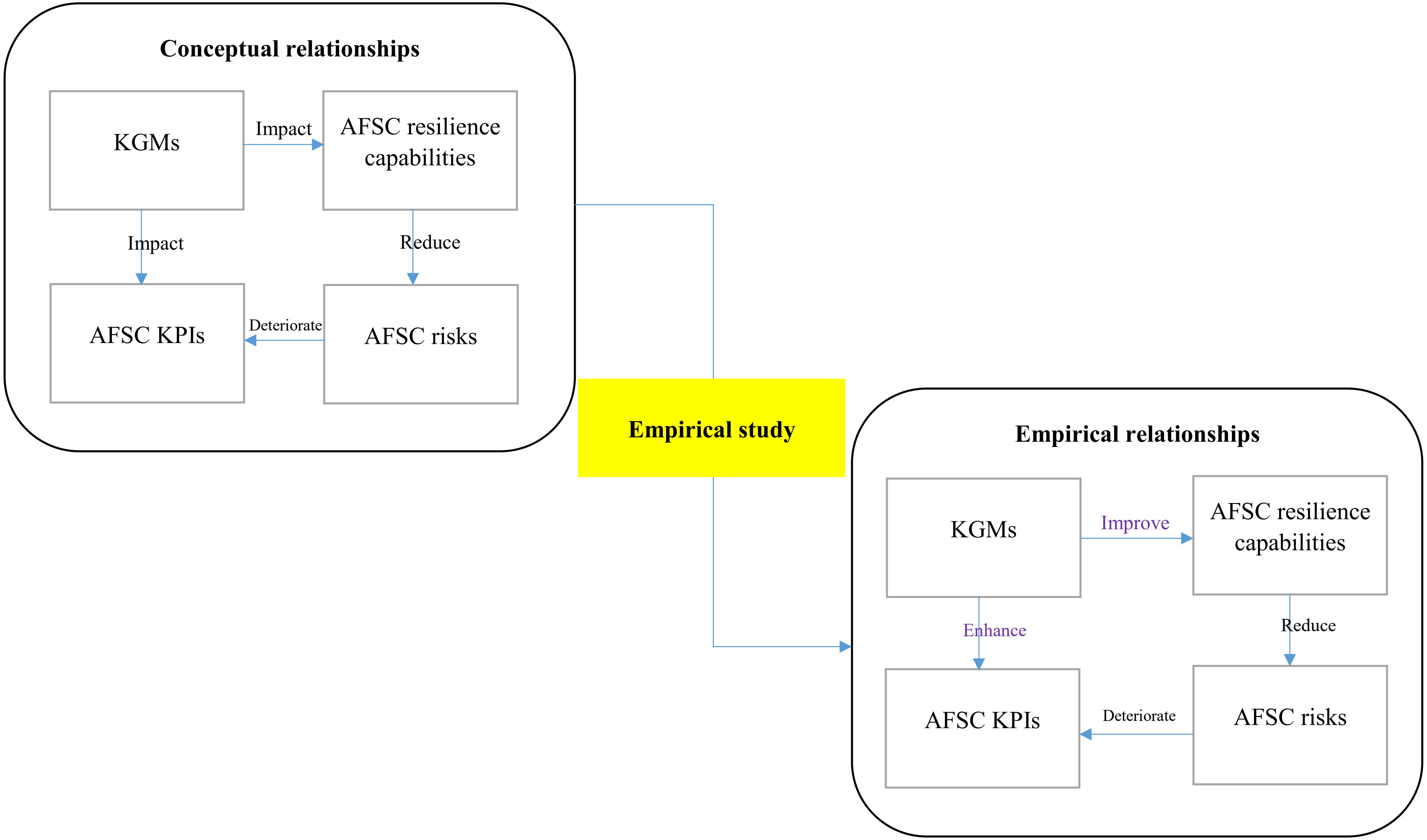


Figure 7.5 Evolution of the relationships among KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs

7.7 Summary

This chapter demonstrates how the conceptual framework is transformed across different research phases, including the conceptual phase, empirical phase one, empirical phase two, and the evaluation phase. First, the evolution of KGMs across the different research phases has been conducted (see Figure 7.1). Different factors for building KGMs are summarised and compared in each research phases. Second, the evolution of AFSC resilience capabilities across the different research phases has been conducted (see Figure 7.2). Different AFSC resilience capability factors have been identified and prioritisation of resilience capability factors has been built. Increasingly volatile business environment and more strict standards on agri-food products both requires AFSC practitioners to build resilience capabilities to prepare, resist, response, and recover from supply chain disruptions in an efficient and effective way. Third, the evolution of AFSC risks across the different research phases have been conducted (see Figure 7.3). Different AFSC risk factors have been identified and prioritised. Risk identification, categorisation, and analysis are extremely important for an AFSC practitioner's survival and development, as most of AFSC practitioners do not have unlimited resources. This study provides AFSC stakeholders' opportunity to target the key risks initially. Fourth, AFSC KPIs have been identified (see Figure 7.4), which provides a standard for AFSC practitioners to measure the performance of AFSC. Fifth, new links among different constructs have been identified, which can be considered as a novel contribution of this study. Furthermore, this chapter compared the empirical findings with that in the literature to provide a solid foundation for discussing the theoretical and managerial contributions in the next chapter (see Table 7.3).

Table 7.3 Comparison among the KRRP conceptual framework, the refined KRRP framework (1), the refined KRRP framework (2), and the main feedback from evaluation

Point of comparison	The KRRP conceptual framework	The refined KRRP framework (1)	The refined KRRP framework (2)	Main feedback from the evaluation
Research phase	Theoretical phase	Empirical phase one	Empirical phase two	Evaluation phase
Qualitative/ Quantitative phase	Qualitative phase	Qualitative phase	Qualitative phase	Qualitative phase
Research methods adopted	Literature review	(1) Semi-structured interview; (2) Thematic analysis; (3) TISM;	(1) TISM; (2) Fuzzy MICMAC analysis;	(1) Structured interviews;
Sample		22 experienced AFSC experts	8 experienced AFSC experts	5 experienced AFSC experts
Research questions	RQ1: What are the KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs that exist in the AFSCs? RQ2: What is the model that can be used to describe the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks? RQ3: What are the key AFSC risk factors and key AFSC resilience capability factors?	Empirical phase one answers research question one and research question two	Empirical phase two answers research question three	
Research objectives	RO1: To investigate different KGMs that can be used by AFSC practitioners for managing knowledge; RO2:To investigate AFSC resilience capabilities and corresponding resilience capability factors that can be used by AFSC practitioners for building AFSC resilience; RO3: To investigate AFSC risk types and corresponding risk factors that can cause vulnerabilities to the AFSCs; RO4: To investigate KPIs that can be used by AFSC practitioners to measure the performance of AFSC;	Research methods designed to solve research objectives 1, 2, 3, 4, 5, 6, 7, 8	Research methods designed to solve research objective 9	Research methods designed to evaluate the research results

	RO5: To investigate the direct impact of KGMs on AFSC performance; RO6: To investigate the indirect impact of KGMs on AFSC performance through AFSC resilience capabilities and AFSC risks; RO7: To construct a knowledge, resilience, risk, and performance (KRRP) model of the agri-food industry; RO8: To validate the KRRP model in different countries across Europe and South America; RO9: To investigate key AFSC resilience capability factors and key AFSC risk factors			
Research gaps	(1) Little research has been conducted to explore the influence of KGMs on AFSC performance; (2) Studies defining the correlations among different AFSC risk factors remain lacking; (3) Little research has been conducted to explore the influence of KGMs on AFSC resilience; (4) Fewer studies have explored the KGMs in the agri-food industry; (5) Scant of studies has explored the interrelationships among different AFSC resilience capability factors.	Research methods designed to solve research gaps (1), (3), and (4).	Research methods designed to solve research gaps (2) and (5).	Research methods designed to evaluate the research results
KGMs	(1) Trust-based KGM; (2) Reciprocity-based KGM; (3) Market-based KGM; (4) Contract-based KGM.	(1) Four KGMs are consistent with the literature; (2) Four new factors are identified: building an equal relationship, constructive feedback, building a project partnership, and personal ties.		(1) New factor is identified: collaboration with the leading company. (2) Factors for building KGMs are evaluated as appropriate.
AFSC resilience capabilities	(1) Increasing flexibility; (2) Creating redundancy; (3) Supply chain collaboration;	(1) Five AFSC resilience capabilities are identified: development and innovation,	(1) Interrelationships among AFSC resilience capability factors are built;	(1) New resilience capability factor under the category of development and innovation

	(4) Building visibility	increasing flexibility, creating redundancy, supply chain collaboration, and building visibility; (2) New resilience capability factors are identified: building a project partnership, working team stability, organisational ethos, and insurance;	(2) AFSC resilience factors are categorised into four categories: independent, dependent, autonomous, and linkage variables; (3) Key resilience capability factor is identified – leadership;	is identified: risk management; (2) Interrelationships among different resilience capability factors are evaluated as appropriate; (3) AFSC resilience categories are evaluated as appropriate;
AFSC risks	(1) Supply risks; (2) Demand risks; (3) Biological and environmental-related risks; (4) Weather-related risks; (5) Logistical and infrastructure risks; (6) Political and macroeconomic risks; (7) Financial risks; (8) Management and operational risks; (9) Policy and regulatory risks.	(1) Eight categories AFSC risks are identified, except policy and regulatory risks; (2) Five new AFSC risk factors are identified: rapid technological development, oral contract or agreement with partners, tax evasion, lack of investment in promoting agri-food products, and skill shortage.	(1) Interrelationships among AFSC risk factors are built; (2) AFSC risks are categorised into four categories: independent, dependent, autonomous, and linkage variables; (2) Key risk factors are identified: extreme weather conditions and political and economic instability;	(1) New AFSC risk factor is identified: social ethos; (2) Interrelationships among different AFSC risks are evaluated as appropriate; (3) AFSC risk categories are evaluated as appropriate;
AFSC KPIs	(1) Product quality; (2) Efficiency; (3) Flexibility; (4) Process quality; (5) Responsiveness.	(1) Five KGMs are consistent with the literature; (2) Five new AFSC KPIs are identified: packaging, waste reduction, water quality, product flexibility, and satisfaction with quality standards.		(1) New AFSC KPI is identified: FS-MRLs pesticide compliance.
Findings	(1) KGMs have positive effects in improving AFSC performance; (2) Interrelationships among different AFSC risk factors have been built; (3) Interrelationships among different AFSC resilience capability factors have been built; (4) Key AFSC risk factors and AFSC resilience capability factors have been identified, respectively; (5) KGMs have positive effects for facilitating AFSC resilience building.			

Chapter eight: Conclusions

8.1 Introduction

The research aim of this study is to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks. This was achieved by investigating different factors of KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs, as well as the relationships among KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. Furthermore, prioritisation of resilience capability factors and risk factors has been conducted to identify key AFSC resilience capability factors and key AFSC risk factors, respectively.

This chapter provides an overview of conclusions across all research phases in this project. In other words, it shows how research questions were answered through conducting empirical research phase one, empirical research phase two, evaluation phase, and how the research gaps were filled with meticulously designed research methodology. Furthermore, the theoretical and managerial contributions of the research findings were discussed, and limitations and future research directions were highlighted that open avenues for future research.

8.2 Conclusions across all research phases of the research

It is important to have a whole picture to demonstrate how the research questions are answered and how the research gaps are filled through conducting different research activities. Figure 8.1 illustrates conclusions across all research phases by visualising key research activities.

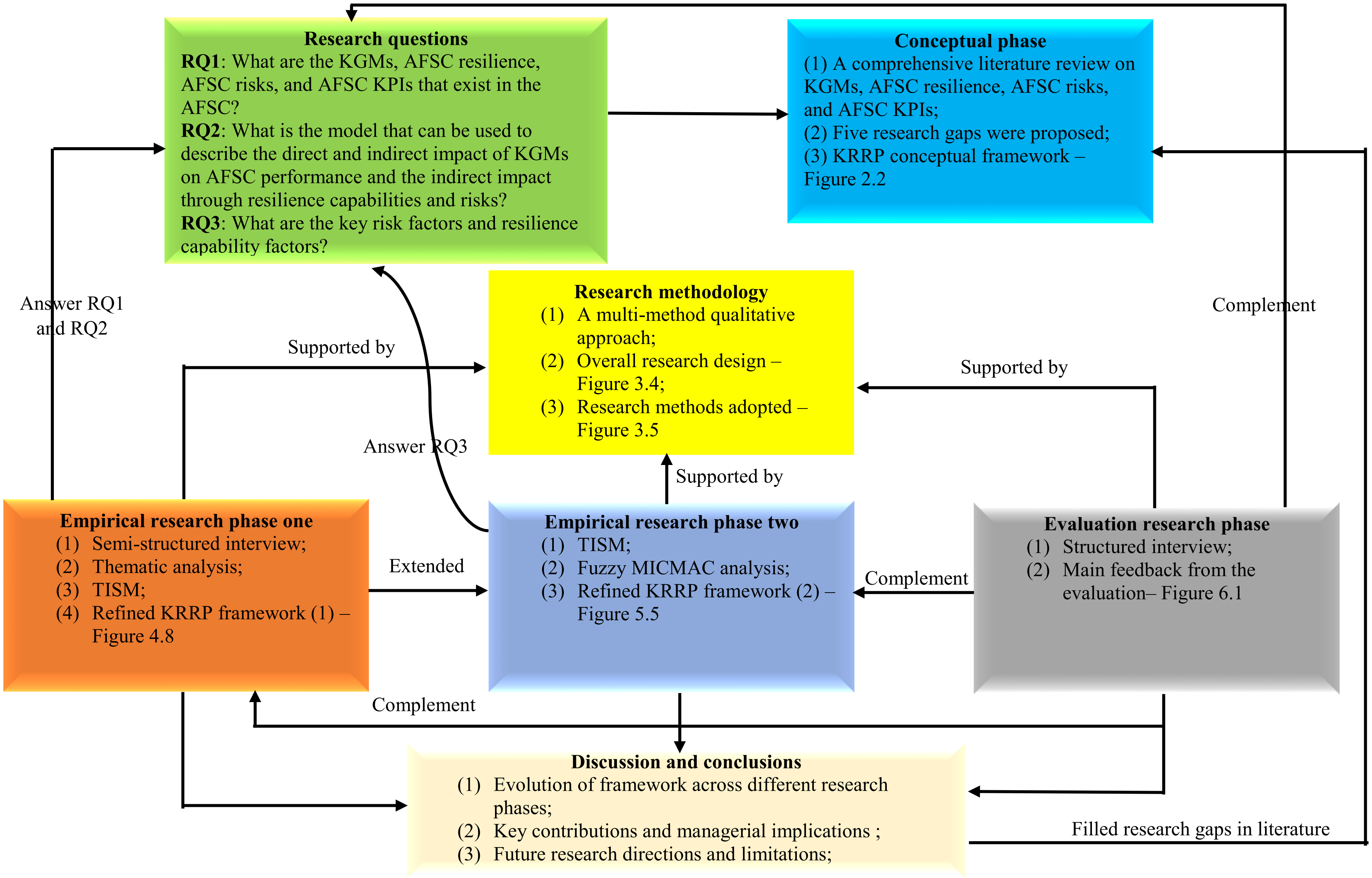


Figure 8.1 Conclusions across all research phases of this project

This study has three research questions, as presented in the introduction chapter, they are:

RQ1: What are the KGMs, AFSC resilience, AFSC risks, and AFSC KPIs that exist in the AFSC?

RQ2: What is the model that can be used to describe the direct and indirect impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks?

RQ3: What are the key risk factors and key resilience capability factors?

At the start of the project, the KRRP conceptual framework (see Figure 2.2) was built based on the comprehensive literature review on KGMs, AFSC resilience, AFSC risks, and AFSC KPIs. Additionally, five research gaps were proposed that related to KGMs, AFSC resilience, AFSC risks, as well as the relationships among KGMs, AFSC performance and AFSC resilience. A multi-method qualitative approach was adopted to answer the research questions, fill the research gaps, and evaluate the conceptual framework. Empirical studies were supported by the overall research design (see Figure 3.4) and research methods (see Figure 3.5) that discussed in the research methodology chapter.

Phase one of the empirical study aimed at answering the research questions one and two by exploring four constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs) in the KRRP conceptual framework and its relationships. Thus, semi-structured interviews were conducted with experienced AFSC experts and thematic analysis was used to analyse the data. Based on the data analysis results, different factors and their categorisations for building KGMs (see Table 4.3), AFSC resilience capabilities (see Table 4.4), AFSC risks (see Table 4.5), and AFSC KPIs (see Table 4.6) were identified. This is how research question one was answered through the study. Then, TISM was adopted to build relationships among different constructs. It is important to note that KGMs were empirically identified as having positive effects in enhancing AFSC resilience capabilities and improving AFSC performance. Furthermore, AFSC resilience capabilities were empirically identified have positive effects in reducing AFSC risks. Additionally, AFSC risks could deteriorate the performance of AFSC after analysing data collected from 22 experienced AFSC practitioners. This is how research question two was answered through the study. The main outcome of phase one of the empirical study is the refined KRRP framework (1) (see Figure 4.8) that integrates four constructs and its relationships, as well as the factors for building each construct in order to have a comprehensive understanding of the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks.

Phase two of the empirical study aimed at answering research question three by investigating the key AFSC resilience capability factors and key AFSC risk factors, respectively. TISM was used to build a hierarchy framework among different AFSC resilience capability factors (see Figure 5.1) and among different AFSC risk factors (see Figure 5.2), respectively. Fuzzy MICMAC analysis was adopted to classify different factors into different categories. The research results indicate that leadership is a critical resilience capability factor for building AFSC resilience, and extreme weather conditions and political and economic instability are key AFSC risk factors that may cause severe effects on the AFSC. Based on the empirical findings, the refined KRRP framework (2) (see Figure 5.5) was built that integrates key resilience capability factors and key risk factors, as well as the categorisations of AFSC resilience capability factors and AFSC risk factors. In this way, phase two of the empirical study helps to answer research question three.

The evaluation research phase aimed at evaluating the research findings generated through phase one and phase two of the empirical study. It can be seen as a complement for phase one and phase two of the empirical study. Thus, structured interviews were conducted in Chile with experienced AFSC experts to evaluate the factors, categorisations, and interrelationships among the factors. The evaluation process is relatively positive, as all five respondents hold strongly agree, agree, and neutral on the factors, categorisations, and interrelationships among the factors. Furthermore, contradictions with previous two empirical studies were fully explained. Based on the research results, the main feedback from the evaluation (see Figure 6.1) was developed that integrates new factors for building different constructs.

Overall, this study contributes to the understanding of the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks. Through identifying factors for building the four constructs (e.g., KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs), investigating relationships among the four constructs, and prioritising resilience capability factors and risk factors, a comprehensive and deep understanding on the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks.

8.3 Contributions

The theoretical contributions and managerial implications are described separately in the following sub-sections.

8.3.1 Theoretical contributions

This study investigates the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks. A combination of multiple qualitative research methods were adopted in this research, including semi-structured interviews, structured interviews, thematic analysis, TISM, and fuzzy MICMAC analysis. The key findings of this study contribute to the existing body of knowledge significantly, listed as follows.

- First, this study provides empirical evidence on identifying factors for building KGMs, AFSC resilience capabilities, AFSC risks, and AFSC performance. Among the factors identified through empirical findings and shown in the refined KRRP frameworks, several factors are considered as new factors for building KGMs, AFSC resilience capabilities, AFSC risks, and AFSC KPIs. For example, five factors (e.g., building a project partnership, personal ties, building an equal relationship, collaboration with the leading company, and constructive feedback) are new factors for building KGMs. Previous studies on KGMs (e.g., Kwon and Suh. 2004; Cai et al. 2010; Wang et al. 2014; Wang et al. 2019) identified managerial ties, information sharing, shared value, information availability were effective for building different KGMs in the context of the high technology industry, the manufacturing industry, the automotive industry, and the rail infrastructure industry. This study confirms that these factors are useful for building different KGMs in the agri-food industry. Four resilience capability factors are identified as new factors for building AFSC resilience capabilities, including working team stability, building a project partnership, organisational ethos, and insurance. Furthermore, it is important to note that a new resilience capability - development and innovation was identified to have positive effects for building AFSC resilience. Recent literature review papers on supply chain resilience (e.g., Kamalahmadi and Parast. 2016; Ali et al. 2017; Kochan and Nowicki. 2018; Ali and Golgeci. 2019) only indicated that flexibility, redundancy, trust, information sharing, visibility, and leadership are effective for building supply chain resilience. This study enriches the knowledge of supply chain resilience building. Although many studies (e.g., Wagner and Bode. 2006; Tang and Tomlin. 2008; Esteso et al. 2018) had analysed the risk factors in the supply chain context from an empirical perspective, this study identified six new AFSC risk factors: rapid technological development, oral contract or agreement with partners, tax evasion, lack of investment in promoting agri-food products, social ethos, and skill shortage (Zhao et al. 2020). It extends existing studies that primarily focus on supply chain risk identification. Finally, six AFSC KPIs (e.g., packaging, satisfaction with quality standards, waste reduction, product flexibility, water quality, and food safety and maximum residues limits) are identified as new for evaluating the performance of AFSC. Aramyan et al. (2007) highlighted that cost, profit, return on investment, lead-time, customer complaints, mix flexibility, volume flexibility, appearance, and product safety could be used to evaluate the performance of AFSC. This study confirms the aforementioned new KPIs can be used for evaluating AFSC performance.

- Second, this study shows that different KGMs help to improve AFSC resilience capabilities. This finding extends previous studies done at supply chain resilience, focusing on four principles to enhance supply chain resilience, namely, supply chain reengineering, collaboration, agility, and SCRM culture (Lummus et al. 2005; Hohenstein et al. 2015; Kamalahmadi and Parast. 2016; Ruiz-Benitez et al. 2018). This study confirms that KGMs are also effective for building supply chain resilience.
- Third, to the best of the author's knowledge, this is the first work to explore the impact of KGMs on AFSC performance. Previous studies (e.g., Marra et al. 2012; Cerchione and Esposito. 2016) on supply chain KM concentrated on six areas, including factors affecting KM adoption, factors affecting KM development, KM systems to support KM adoption, KM systems to support KM development, barriers to the adoption of KM, and KM development and performance. In this study, market-based KGM should be given critical focus, as it acts as a key driving force behind achieving higher levels of AFSC performance (Zhao et al. 2020).
- Fourth, this study develops a TISM hierarchy model of AFSC resilience capability factors, which explains the dynamics among the considered nineteen AFSC resilience capability factors. Previous studies on supply chain resilience are focusing on defining supply chain resilience, identifying enablers for building supply chain resilience, and exploring supply chain resilience strategies (Pettit et al. 2010; Brandon-Jones et al. 2014; Kamalahmadi and Parast. 2016; Dubey et al. 2019). Although there are few studies to formulate the supply chain resilience model (Ponomarov Holcomb. 2009;

Jain et al. 2017; Zhao et al. 2018), these models in the literature are inadequate, which confirms the emerging necessity of such research.

- Fifth, this study identifies key resilience capability factors for building AFSC resilience using fuzzy MICMAC analysis. It adds knowledge to supply chain resilience modelling in terms of using modelling methods to measure supply chain resilience.
- Sixth, it develops a TISM hierarchy model of AFSC risk factors, which can help researchers to understand the interrelationships among different AFSC risk factors. The interdependencies and interrelationships among various risk types in literature are currently inadequate (Ho et al. 2015), which confirms the emerging need for this research. Previous studies (Pfohl et al. 2011; Diabat et al. 2012; Bier et al. 2019) only used ISM to identify interrelationships among different risk factors in the supply chain context, with no study using the TISM method to develop a TISM hierarchy model that considers the interrelationships among different AFSC risk factors. To the best of the author's knowledge, this is the first study to define the interrelationships among different AFSC risk factors using TISM. Furthermore, the proposed TISM hierarchy model identified sixteen risk factors at different layers and highlighted their specific roles (Zhao et al. 2020).
- Seventh, this study identifies the key risk factors in AFSC using fuzzy MICMAC analysis. By categorising various risks into different categories based on experts' opinions in a structured and systematic way, key AFSC risk factors that drive the system are identified. This answers the call to strengthen the research in the supply chain risk classification as research on this topic is still in its infancy (Sodhi et al. 2012; Rangel et al. 2015).

8.3.2 Managerial implications

Besides the contribution to theory, this study also has a number of contributions to managerial practices.

- First, this study provides a guidance for AFSC managers to facilitate knowledge transfer among AFSC partners through deploying trust-based, reciprocity-based, market-based, and contract-based KGMs. Thus, AFSC managers need to make effective strategies for strengthening knowledge transfer, such as facilitate consistent communications among AFSC partners, participate in different projects, create rewards for their employees, and reduce intermediaries.
- Second, this study may help AFSC managers to make effective strategies for building AFSC resilience, as this study identifies five resilience capabilities and nineteen resilience capability factors. Currently, forming resilience capabilities are critical for AFSCs to cope with unexpected challenges, to survive from volatile business environment, and to take advantages of changes as opportunities (Ponis. 2012). Thus, AFSC managers need to build shared understanding among supply chain partners, develop multiple suppliers, and reserve raw material stock before peak season, and apply technology for improving traceability.
- Third, this study may help AFSC managers to raise risk awareness and make them more easily recognise the risks to which the supply chains are exposed, as this study identifies eight category of risks and sixteen AFSC risk factors.
- Fourth, a significant insight from this study is that AFSC stakeholders should focus on improving AFSC performance from different perspectives, including product quality, efficiency, flexibility, process quality, and responsiveness. The study reveals that 27 AFSC KPIs can be used for evaluating AFSC performance (e.g., packaging, product shape, pesticide use, waste reduction, and lead-time), which provides a guidance for

supply chain managers for enhancing their supply chain performance. For example, waste is a serious problem in countries where empirical studies have been conducted. Therefore, AFSC practitioners need to seek methods to reduce waste to increase their performance. Feasible methods include selling imperfect vegetables to the secondary market or donating the vegetables to poor people or charity organisations.

- Fifth, the findings reveal that AFSC stakeholders have priorities for building KGMs and improving AFSC performance. That is, they should focus on market-based KGM to facilitate knowledge transfer and efficiency for improving AFSC performance. Therefore, set rewards for their staff should be applied in their organisation if they make a breakthrough in knowledge or technology. AFSC managers can strengthen efficiency of AFSC performance by reducing production costs and increasing profits through applying different technologies, building relationships with the leading company in their field to improve return on investment (Zhao et al. 2020).
- Sixth, it investigates interrelationships among different AFSC risk factors. Investigating the joint impact of various risk factors can lead to better management of AFSC than tackling each risk factor in isolation (Ho et al. 2015). A more comprehensive understanding of the AFSC risks and their interrelationships, through a logical structure, will enable AFSC managers to prioritise and allocate the resources in an effective way. Thus, AFSC managers can focus on the key risks (extreme weather conditions and political and economic instability) that cause vulnerabilities within the AFSC. This will reduce the time and effort required to mitigate the effects of risks if the key risks is targeted initially (Zhao et al. 2020).
- Seventh, it classifies different risk factors into different categories such as linkage variables, independent variables, dependent variables, and autonomous variables. This classification also helps AFSC managers differentiate between risk factors and their

mutual relationships and formulate strategies to mitigate the effects of independent risks while developing contingency plans for linkage risks, and to monitor the dependent risks (Zhao et al. 2020). However, alleviating the effects of dependent risks will not help mitigate any of other risks because dependent risks are at the top of the TISM hierarchy model. Furthermore, the classification can be used to explain, communicate, and transfer risk knowledge between different departments of the company, as well as between various partners within the AFSC, thus enabling an effective management that deals with the various risks types from both the company and overall supply chain perspectives (Zhao et al. 2020).

❖ Finally, this study explores the interrelationships among different AFSC resilience capability factors. It is important to note that many of the supply chain resilience capability factors are interrelated and have the competences to influence the other (Rajesh. 2017). This study makes AFSC managers aware of the importance for building AFSC resilience and the most influential resilience capability factor (leadership) for which managers can give the critical attention.

8.4 Limitations and recommendations for further research

The author recognises that the study has a few limitations. First, the interviewees covered all the main actors in the AFSC, such as farmers, manufacturers, wholesalers, there was no interviewees from packaging companies, field test companies, and regional agriculture department/agencies.

Second, given that the research results were evaluated in Chile, and the evaluation results show that the factors of AFSC KPIs are only suitable for Chilean exportation AFSC. Thus, caution is needed when generalising the results.

Third, AFSCs are evolving throughout the time, as superior technological and innovations are deployed to the AFSCs, particularly in the era of digitalisation of AFSCs. With the development of the AFSCs, some KGMs, resilience capabilities, AFSC KPIs, and AFSC risks may not be applicable/exist to the AFSCs, some maybe influential. The changing situation may pose a limitation to this research.

Fourth, this study did not provide a specific agri-food product category due to the fragment nature of AFSCs. For the investigated company in the AFSCs, each company operated/cultivated different agri-food products. This may pose a limitation to the KRRP framework's application, as different agri-food products have different characteristics and may need different specific KGMs/resilience capabilities/AFSC KPIs to be managed/assessed.

Fifth, this study prioritised resilience capability factors and risk factors, respectively. However, this study have not prioritised the factors for building KGMs and AFSC KPIs for evaluating AFSC performance. This may pose a limitation for this study, as so many factors can be used for building KGMs and so many KPIs can be used for evaluating AFSC performance.

Sixth, this study investigates the direct impact of KGMs on AFSC performance and the direct impact of KGMs on AFSC resilience capabilities. However, this study have not investigated the direct impact of KGMs on AFSC risks, this may pose a limitation of this study.

Seventh, the data collection activities were conducted in different countries across Europe (e.g., France, Italy, and Spain) and South America (e.g., Argentina and Chile). In France, Italy, and Spain, all the interviewees could speak English. Thus, I could understand what they said. However, Argentina and Chile are Spanish speaking countries, this cause a limitation in understanding what the interviewees' said as I cannot speak Spanish. Although a translator associated with me did the data collection activities in these two countries, it was difficult for the translator did a timely, effectively, and appropriately translation. This causes a limitation to this research.

Based on the aforementioned discussions on the limitations of this paper, seven corresponding research directions are proposed:

- AFSC is a complex system that involves various AFSC practitioners. The interviewees from packaging companies, field test companies and regional agriculture department/agencies should be considered in the future research, as each AFSC practitioners has its unique position in the AFSC and can provide opinions/feedbacks from their research angles. Thus, a more comprehensive understanding and a deeper insight on KGMs, AFSC resilience, AFSC risks, and AFSC KPIs can be achieved.
- To test the generalisability of the research results, it is suggested that other countries such as China and Brazil are included in further research to evaluate the AFSC performance from the perspectives of domestic AFSC and exportation AFSC. Brazil is suggested as it is the largest country in South America and a leading exporter of a wide range of crops (e.g., oranges, soybeans, coffee, and cassava) (Brazil. 2010). China is suggested as the agriculture industry plays a vital role in China, employing over 300 million farmers (Food and Agriculture Organization of the United Nations. 2019).
- A longitudinal study is suggested to investigate the direct impact of KGMs on AFSC performance and the indirect impact through resilience capabilities and risks because of two reasons. First, a longitudinal study is effective for determining variables across time. Second, a longitudinal study is effective on doing research in developmental trends (Shropshire and Hillman. 2007). Thus, it would help to determine which KGMs/resilience capabilities/AFSC KPIs is useful for AFSCs across time.
- A specific agri-food product type should be investigated in the future AFSC investigation. Thus, AFSC risks can be specified in the specific AFSC, specific resilience capabilities/strategies can be designed based on the AFSC risks, KGMs/AFSC KPIs also can be designed/identified based on the characteristics of the agri-food products.

- Most of AFSC companies are SMEs and do not have unlimited resources for deploying KGMs for facilitating knowledge transfer and for improving AFSC performance. It suggests to use TISM and fuzzy MICMAC analysis to prioritise the factors for building KGMs and the KPIs for evaluating AFSC performance, respectively. Thus, key factors for building KGMs can be identified and key KPIs for evaluating AFSC performance also can be identified. A combination of TISM and fuzzy MICMAC analysis is suggested as it has been implemented successfully in this study and is effectively in determining the key factors for the whole system.
- Investigation the direct impact of KGMs on AFSC risks is essential for future research, as this study identifies that KGMs have an indirect impact on AFSC risks through resilience capabilities. For investigating the direct impact of KGMs on AFSC risks, there are several methods available for building relationships such as fsQCA, SEM, ISM, and TISM.
- It is better for me to study Spanish in the future. Thus, I can conduct a better data collection activity in Argentina and Chile.

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Appendices

Appendix A. Interview guide

(A) Introductory questions

(I) Interviewee Information

a. What is your current designation?
b. Can you give me a brief overview of your job within the company operations?
c. How many years have you been working in this company?
d. How many years of your working experience in the same job role in total?

(II) Company information

e. Can you give me a brief overview of the company structure, parent company, and its operations?
f. What is the industry sector in which the organisation operates?
g. How many employees are working for the company?

(B) Knowledge governance mechanisms

a. How would you describe the trust-based knowledge governance mechanism that affect your company to obtain and share knowledge?
b. How would you describe reciprocity-based knowledge governance mechanisms that affect your company to obtain and share knowledge?
c. How would you describe market-based knowledge governance mechanism that affect your company to obtain and share knowledge?
d. How would you describe contract-based knowledge governance mechanism that affect your company to obtain and share knowledge?

(C) AFSC risks

a. How would you describe the sources of risks that affect your company?
b. How would you describe the biggest risk that you faced in your company?
c. How would you describe the sources of risks that affect the whole AFSC?

- Supply risks
- Demand risks
- Biological and environmental risks
- Political related risks
- Weather related risks
- Logistical and infrastructure related risks
- Policy and regulatory related risks
- Management and operational risks
- Financial related risks

d. How would you describe what the greatest risk for the AFSC is?

(D) AFSC resilience

a. How would you describe any supply chain collaborations used for dealing with risks?
b. How would you describe any flexibilities used for dealing with risks?
c. How would you describe any redundancies used for dealing with risks?
d. How would you describe any visibilities used for dealing with risks?
e. How would you describe any innovations used for dealing with risks?

(E) AFSC KPIs

a. How would you describe the KPIs that you used for evaluating AFSC?

- Product quality
- Efficiency

- Flexibility
- Process quality
- Responsiveness

Appendix B. Relationships between AFSC risks and AFSC KPIs

AFSC risks/AFSC KPIs	Product quality								Responsiveness			Efficiency			
	Shape	Colour	Flavour	Shelf life	Packaging	Labelling	Convenience	Satisfaction of quality standards	Customer complaints	Lead time	Production costs	Profits	Waste reduction	Return on investment	Inventory
Oral contract or agreement with partners												√		√	
Tax evasion												√		√	
Lack of investment in promoting agri-food products												√	√	√	√
Skill shortage	√	√	√	√				√			√	√	√		
Lack of information sharing among partners	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Poor planning	√	√	√	√				√				√			
Pests and diseases' risks	√	√	√	√				√			√	√		√	
Extreme weather conditions	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Political and economic instability										√	√	√		√	√
Bad debts												√			
Delay in payment														√	
Market price fluctuations									√		√	√		√	√
Supply and demand imbalance												√		√	√
High energy costs											√	√		√	
Poor agricultural infrastructure				√						√					√

Rapid technological development	√	√

(**Note:** purple represents management and operational risks, yellow represents supply risks, brown represents biological and environmental risks, light blue represents weather-related risks, light green represents political and macroeconomic risks, grey represents financial risks, green represents demand risks and orange represents logistical and infrastructure risks)

(Continued…)

AFSC risks/AFSC KPIs	**Flexibility**				**Process quality**						
	Customer satisfaction	Volume flexibility	Delivery flexibility	Product flexibility	Traceability	Pesticide use	Storage and transportation	Working condition	Energy use	Water use	Water quality
Oral contract or agreement with partners											
Tax evasion											
Lack of investment in promoting agri-food products				√							
Skill shortage					√	√					
Lack of information sharing among partners	√										
Poor planning	√										
Pests and diseases' risks	√	√				√			√	√	
Extreme weather conditions	√	√	√	√			√	√	√	√	
Political and economic instability	√		√				√				
Bad debts			√	√	√						
Delay in payment											
Market price fluctuations				√							
Supply and demand imbalance				√							
High energy costs							√		√	√	
Poor agricultural infrastructure		√	√		√		√	√			
Rapid technological development									√		

(**Note:** purple represents management and operational risks, yellow represents supply risks, brown represents biological and environmental risks, light blue represents weather-related risks, light green represents political and macroeconomic risks, grey represents financial risks and green represents demand risks)

Appendix C. Partitioning the reachability matrix into different levels (resilience capability factors)

Variable	Reachability Set (RS)	Antecedent Set (AS)	RS∩AS	Level
Iteration 1				
F1	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,19	1,2,5,9	1,2,9	
F2	1,2,3,4,6,7,8,9,12,14,15,16,18	1,2,3,4,5,6,7,8,9,10,14,17,18,19	1,2,3,4,6,7,8,9,14,18	
F3	2,3,4,6,7,8,9,10,13,15,16,18	1,2,3,5,9	2,3,9	
F4	2,4,6,7,8,9,10,13,15,16,18	1,2,3,4,5,6,7,8,9,10,19	2,4,6,7,8,9,10	
F5	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19	5	5	
F6	2,4,6,7,9,11,12,13,15,16,18	1,2,3,4,5,6,7,8,9,10,14,17,18,19	2,4,6,7,9,18	
F7	2,4,6,7,8,9,13,15,16,18	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,8,9	
F8	2,4,6,7,8,9,13,15,16,18	1,2,3,4,5,7,8,9,10,14,17,18,19	2,4,7,8,9,18	
F9	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,19	1,2,3,4,5,6,7,8,9,19	1,2,3,4,5,6,7,8,9,19	
F10	2,4,6,7,8,10,18	1,3,4,5,9,10,14,17,19	4,10	
F11	11	1,5,6,9,11,12,13,14,15	11	**I**
F12	11,12	1,2,5,6,9,12,13,14,15	12	
F13	11,12,13	1,3,4,5,6,7,8,9,13,14,19	13	
F14	2,6,7,8,10,11,12,13,14,15,17,18,19	1,2,5,9,14	2,14	
F15	11,12,15	1,2,3,4,5,6,7,8,9,14,15,19	15	
F16	16	1,2,3,4,5,6,7,8,9,16,19	16	**I**
F17	2,6,7,8,10,17,19	1,5,9,14,17	17	
F18	2,6,8,18	1,2,3,4,5,6,7,8,9,10,14,18,19	2,6,8,18	**I**
F19	2,4,6,7,8,9,10,13,15,16,18,19	1,5,9,14,17,19	9,19	
Iteration 2				
F1	1,2,3,4,6,7,8,9,10,12,13,14,15,17,19	1,2,5,9	1,2,9	
F2	1,2,3,4,6,7,8,9,12,14,15,	1,2,3,4,5,6,7,8,9,10,14,17,19	1,2,3,4,6,7,8,9,14	
F3	2,3,4,6,7,8,9,10,13,15	1,2,3,5,9	2,3,9	
F4	2,4,6,7,8,9,10,13,15	1,2,3,4,5,6,7,8,9,10,19	2,4,6,7,8,9,10	
F5	1,2,3,4,5,6,7,8,9,10,12,13,14,15,17,19	5	5	
F6	2,4,6,7,9,12,13,15	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,9	
F7	2,4,6,7,8,9,13,15	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,8,9	
F8	2,4,6,7,8,9,13,15	1,2,3,4,5,7,8,9,10,14,17,19	2,4,7,8,9	
F9	1,2,3,4,6,7,8,9,10,12,13,14,15,17,19	1,2,3,4,5,6,7,8,9,19	1,2,3,4,5,6,7,8,9,19	
F10	2,4,6,7,8,10	1,3,4,5,9,10,14,17,19	4,10	
F12	12	1,2,5,6,9,12,13,14,15	12	**II**
F13	12,13	1,3,4,5,6,7,8,9,13,14,19	13	
F14	2,6,7,8,10,12,13,14,15,17,19	1,2,5,9,14	2,14	
F15	12,15	1,2,3,4,5,6,7,8,9,14,15,19	15	
F17	2,6,7,8,10,17,19	1,5,9,14,17	17	
F19	2,4,6,7,8,9,10,13,15,19	1,5,9,14,17,19	9,19	
Iteration 3				
F1	1,2,3,4,6,7,8,9,10,13,14,15,17,19	1,2,5,9	1,2,9	
F2	1,2,3,4,6,7,8,9,14,15,	1,2,3,4,5,6,7,8,9,10,14,17,19	1,2,3,4,6,7,8,9,14	
F3	2,3,4,6,7,8,9,10,13,15	1,2,3,5,9	2,3,9	
F4	2,4,6,7,8,9,10,13,15	1,2,3,4,5,6,7,8,9,10,19	2,4,6,7,8,9,10	
F5	1,2,3,4,5,6,7,8,9,10,13,14,15,17,19	5	5	
F6	2,4,6,7,9,13,15	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,9	
F7	2,4,6,7,8,9,13,15	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,8,9	
F8	2,4,6,7,8,9,13,15	1,2,3,4,5,7,8,9,10,14,17,19	2,4,7,8,9	
F9	1,2,3,4,6,7,8,9,10,13,14,15,17,19	1,2,3,4,5,6,7,8,9,19	1,2,3,4,5,6,7,8,9,19	
F10	2,4,6,7,8,10	1,3,4,5,9,10,14,17,19	4,10	
F13	13	1,3,4,5,6,7,8,9,13,14,19	13	**III**
F14	2,6,7,8,10,13,14,15,17,19	1,2,5,9,14	2,14	
F15	15	1,2,3,4,5,6,7,8,9,14,15,19	15	**III**
F17	2,6,7,8,10,17,19	1,5,9,14,17	17	
F19	2,4,6,7,8,9,10,13,15,19	1,5,9,14,17,19	9,19	
Iteration 4				
F1	1,2,3,4,6,7,8,9,10,14,17,19	1,2,5,9	1,2,9	
F2	1,2,3,4,6,7,8,9,14	1,2,3,4,5,6,7,8,9,10,14,17,19	1,2,3,4,6,7,8,9,14	**IV**
F3	2,3,4,6,7,8,9,10	1,2,3,5,9	2,3,9	
F4	2,4,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10,19	2,4,6,7,8,9,10	**IV**
F5	1,2,3,4,5,6,7,8,9,10,14,17,19	5	5	
F6	2,4,6,7,9	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,9	**IV**
F7	2,4,6,7,8,9	1,2,3,4,5,6,7,8,9,10,14,17,19	2,4,6,7,8,9	**IV**
F8	2,4,6,7,8,9	1,2,3,4,5,7,8,9,10,14,17,19	2,4,7,8,9	
F9	1,2,3,4,6,7,8,9,10,14,17,19	1,2,3,4,5,6,7,8,9,19	1,2,3,4,6,7,8,9,19	
F10	2,4,6,7,8,10	1,3,4,5,9,10,14,17,19	4,10	

F14	2,6,7,8,10,14,17,19	1,2,5,9,14	2,14	
F17	2,6,7,8,10,17,19	1,5,9,14,17	17	
F19	2,4,6,7,8,9,10,19	1,5,9,14,17,19	9,19	
Iteration 5				
F1	1,3,8,9,10,14,17,19	1,5,9	1,9	
F3	3,8,9,10	1,3,5,9	3,9	
F5	1,3,5,8,9,10,14,17,19	5	5	
F8	8,9	1,3,5,8,9,10,14,17,19	8,9	**V**
F9	1,3,8,9,10,14,17,19	1,3,5,8,9,19	1,3,8,9,19	
F10	8,10	1,3,5,9,10,14,17,19	10	
F14	8,10,14,17,19	1,5,9,14	14	
F17	8,10,17,19	1,5,9,14,17	17	
F19	8,9,10,19	1,5,9,14,17,19	9,19	
Iteration 6				
F1	1,3,9,10,14,17,19	1,5,9	1,9	
F3	3,9,10	1,3,5,9	3,9	
F5	1,3,5,9,10,14,17,19	5	5	
F9	1,3,9,10,14,17,19	1,3,5,9,19	1,3,9,19	
F10	10	1,3,4,5,9,10,14,17,19	10	**VI**
F14	10,14,17,19	1,5,9,14	14	
F17	10,17,19	1,5,9,14,17	17	
F19	9,10,19	1,5,9,14,17,19	9,19	
Iteration 7				
F1	1,3,9,14,17,19	1,5,9	1,9	
F3	3,9	1,3,5,9	3,9	**VII**
F5	1,3,5,9,14,17,19	5	5	
F9	1,3,9,14,17,19	1,3,5,9,19	1,3,9,19	
F14	14,17,19	1,5,9,14	14	
F17	17,19	1,5,9,14,17	17	
F19	9,19	1,5,9,14,17,19	9,19	**VII**
Iteration 8				
F1	1,9,14,17	1,5,9	1,9	
F5	1,5,9,14,17	5	5	
F9	1,9,14,17	1,5,9	1,9	
F14	14,17	1,5,9,14	14	
F17	17	1,5,9,14,17	17	**VIII**
Iteration 9				
F1	1,9,14	1,5,9	1,9	
F5	1,5,9,14	5	5	
F9	1,9,14	1,5,9	1,9	
F14	14	1,5,9,14	14	**IX**
Iteration 10				
F1	1,9	1,5,9	1,9	**X**
F5	1,5,9	5	5	
F9	1,9	1,5,9	1,9	**X**
Iteration 11				
F5	5	5	5	**XI**

Appendix D. Partitioning the reachability matrix into different levels (AFSC risk factors)

Variable	Reachability Set (RS)	Antecedent Set (AS)	RS∩AS	Level
Iteration 1				
E1	1,2,3,4,5,7	1,2,6,9,10,12,13,14,15	1,2	
E2	1,2,3,4,5,7	1,2,6,9,10,12,13,14,15	1,2	
E3	3	1,2,3,6,9,10,12,13,14,15,16	3	**I**
E4	4	1,2,4,6,7,8,9,10,12,13,14,15,16	4	**I**
E5	5	1,2,5,6,9,10,12,13,14,15	5	**I**
E6	1,2,3,4,5,6,7,8,10,11,16	6,9,13,14,15,16	6,16	
E7	4,7	1,2,6,7,9,10,12,13,14,15	7	
E8	4,8	6,8,9,13,14,15,16	8	
E9	1,2,3,4,5,6,7,8,9,10,11,16	9,13,15	9	
E10	1,2,3,4,5,7,10	6,9,10,12,13,14,15	10	
E11	11	6,9,11,13,14,15,16	11	**I**
E12	1,2,3,4,5,7,10,12,13	12,14,15	12	
E13	1,2,3,4,5,6,7,8,9,10,11,13,16	12,13,14,15	13	
E14	1,2,3,4,5,6,7,8,10,11,12,13,14,16	14	14	
E15	1,2,3,4,5,6,7,8,9,10,11,12,13,15,16	15	15	
E16	3,4,8,11,16	6,9,13,14,15,16	16	
Iteration 2				
E1	1,2,7	1,2,6,9,10,12,13,14,15	1,2	
E2	1,2,7	1,2,6,9,10,12,13,14,15	1,2	
E6	1,2,6,7,8,10,16	6,9,13,14,15,16	6,16	
E7	7	1,2,6,7,9,10,12,13,14,15	7	**II**
E8	8	6,8,9,13,14,15,16	8	**II**
E9	1,2,6,7,8,9,10,16	9,13,15	9	
E10	1,2,7,10	6,9,10,12,13,14,15	10	
E12	1,2,7,10,12,13	12,14,15	12	
E13	1,2,6,7,8,9,10,13,16	12,13,14,15	13	
E14	1,2,6,7,8,10,12,13,14,16	14	14	
E15	1,2,6,7,8,9,10,12,13,15,16	15	15	
E16	8,16	6,9,13,14,15,16	16	
Iteration 3				
E1	1,2	1,2,6,9,10,12,13,14,15	1,2	**III**
E2	1,2	1,2,6,9,10,12,13,14,15	1,2	**III**
E6	1,2,6,10,16	6,9,13,14,15,16	6,16	
E9	1,2,6,9,10,16	9,13,15	9	
E10	1,2,10	6,9,10,12,13,14,15	10	
E12	1,2,10,12,13	12,14,15	12	
E13	1,2,6,9,10,13,16	12,13,14,15	13	
E14	1,2,6,10,12,13,14,16	14	14	
E15	1,2,6,9,10,12,13,15,16	15	15	
E16	16	6,9,13,14,15,16	16	**III**
Iteration 4				
E6	6,10	6,9,13,14,15	6	
E9	6,9,10	9,13,15	9	
E10	10	6,9,10,12,13,14,15	10	**IV**
E12	10,12,13	12,14,15	12	
E13	6,9,10,13	12,13,14,15	13	
E14	6,10,12,13,14	14	14	
E15	6,9,10,12,13,15	15	15	
Iteration 5				
E6	6	6,9,13,14,15	6	**V**
E9	6,9	9,13,15	9	
E12	12,13	12,14,15	12	
E13	6,9,13	12,13,14,15	13	
E14	6,12,13,14	14	14	
E15	6,9,12,13,15	15	15	
Iteration 6				
E9	9	9,13,15	9	**VI**
E12	12,13	12,14,15	12	
E13	9,13	12,13,14,15	13	
E14	12,13,14	14	14	
E15	9,12,13,15	15	15	
Iteration 7				
E12	12,13	12,14,15	12	
E13	13	12,13,14,15	13	**VII**
E14	12,13,14	14	14	
E15	12,13,15	15	15	
Iteration 8				
E12	12	12,14,15	12	**VIII**
E14	12,14	14	14	
E15	12,15	15	15	
Iteration 9				
E14	14	14	14	**IX**
E15	15	15	15	**IX**

Appendix E. Interview template about research results evaluation

Part A Evaluate knowledge governance mechanisms
1. How do you think the following elements for building different knowledge governance mechanisms? Please tick (√) in the following table.

Knowledge governance mechanisms	Elements for building knowledge governance mechanisms	Descriptor				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Trust-based knowledge governance mechanism	Facilitate consistent communications					
	Building a project partnership					
	Joint decision-making					
	Long-term relationship					
	Building shared understanding					
	Personal ties					
	ICT applications					
Any other elements?						
Market-based knowledge governance mechanism	Rewards					
	Legislation and rules application					
Any other elements?						
Reciprocity-based knowledge governance mechanism	Increasing involvement					
	Building an equal relationship					
	Constructive feedback					
Any other elements?						
Contract-based knowledge governance mechanism	Sign a contract or agreement					
	Role clarity					
	Fewer intermediaries					
Any other elements?						

2. If you disagree or strongly disagree the above elements for building different KGMs, please tell me **why**.

Part B Evaluate AFSC resilience framework
B1 Evaluate AFSC resilience capability factors
1. How do you think the following resilience capability factors that exist in the agri-food supply chains of Chile? Please tick (√) in the following table.

AFSC resilience capabilities	AFSC resilience capability factors	Descriptor				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Development and innovation	Training and development					
	Building shared understanding					
	Building a project partnership					
	Working team stability					
	Leadership					
Any other factors?						
Supply chain collaboration	Information sharing					
	Trust					
	Joint decision making					
	Organisational ethos					
	Regularly meetings					
Any other factors?						
Flexibility	Labour contract flexibility					
	Frequent quality checks					
	Product differentiation					
Any other factors?						
Redundancy	Multiple suppliers					
	Reserve raw material stock					
	Insurance					
Any other factors?						
Visibility	Traceability					
	Role clarity					
	ICT application					
Any other factors?						

2. If you disagree or strongly disagree the above resilience capability factors that exist in the agri-food supply chains of Chile, please tell me **why**.

B2 Evaluate interactions among the identified resilience capability factors
1. Interrelationships between and among different resilience capability factors have been built through total interpretive structural modelling. How do you think the interrelationships among different resilience factors? Please tick (√) in the following table.

Interrelationships between different resilience capability factors	Descriptor				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Leadership will facilitate training and development, organisational ethos and multiple suppliers					
Training and development will facilitate organisational ethos, multiple suppliers and building a project partnership					
Organisational ethos will facilitate training and development and multiple suppliers					
Multiple suppliers will facilitate traceability					
Traceability will facilitate ICT application					
ICT application will facilitate regularly meetings					
Regularly meetings will facilitate joint decision making					
Building a project partnership will facilitate regularly meetings, joint decision making and trust					
Trust will facilitate joint decision making					
Joint decision making will facilitate build a shared understanding and information sharing					
Building shared understanding will facilitate joint decision making					
Working team stability will facilitate trust and information sharing					
Information sharing will facilitate building shared understanding, reserve raw material stock and product differentiation					
Reserve raw material stock will facilitate frequent quality checks					
Production differentiation will facilitate frequent quality checks					
Frequently quality checks will facilitate labour contract flexibility					

2. If you disagree or strongly disagree the interrelationships between and among different resilience capability factors, please tell me **why**.

B3 Evaluate resilience categories

1. Various resilience capability factors have been divided into different groups based on their influence on the agri-food supply chains. How do you think each resilience capability factors have been divided into suitable groups? Please tick (√) in the following table.

Different groups	Resilience capability factors	Descriptor				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Independent variables	Training and development					
	Leadership					
	Organisational ethos					
	Multiple suppliers					
	Traceability					
Linkage variables	Building a project partnership					
	Working team stability					
	Joint decision making					
	Regularly meetings					
	ICT application					
Dependent variables	Build shared understanding					
	Information sharing					
	Trust					
	Labour contract flexibility					
	Frequently quality checks					
	Reserve raw material stock					
	Insurance					
	Role clarity					
	Product differentiation					

2. If you disagree or strongly disagree each resilience factors have been divided into suitable groups, please tell me **why**.

Part C Evaluate AFSC risk framework

C1 Evaluate AFSC risk factors

1. How do you think the following risk factors that exist in the agri-food supply chains of Chile? Please tick (√) in the following table.

Risk categories	Risk factors	Descriptor				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Supply risks	Lack of information sharing among partners					
	Poor planning					
Any other elements?						
Demand risks	Supply and demand imbalance					
	Market price fluctuations					
Any other elements?						
Management and operational risks	Lack of investment in promoting agri-food products					
	Skill shortage					
	Tax evasion					
	Oral contract or agreement with partners					
Any other elements?						
Financial risks	Delay in payment					
	Bad debts					
Any other elements?						
Political and macroeconomic risks	Political and economic instability					
Any other elements?						
Logistical and infrastructure risks	High energy costs					
	Poor agricultural infrastructure					
	Rapid technological development					
Any other elements?						
Biological and environmental related risks	Risk from pests and diseases					
Any other elements?						
Weather-related risks	Extreme weather conditions					
Any other elements?						

2. If you disagree or strongly disagree the above risk factors that exist in the agri-food supply chains of Chile, please tell me **why**.

C2 Evaluate interactions among the identified risk factors

1. Interrelationships between and among different risk factors have been built through total interpretive structural modelling. How do you think the interrelationships among different risk factors? Please tick (√) in the following table.

Interrelationships between different risk factors	Descriptor				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Extreme weather conditions and political and economic instability will cause poor agricultural infrastructure					
Poor agricultural infrastructure will cause lack of information sharing among partners					
Lack of information sharing among partner will cause poor planning					
Poor planning will cause risk from pests and diseases					
Risk from pests and diseases will cause supply and demand imbalance					
Risk from pests and diseases will cause rapid technological development					
Supply and demand imbalance will cause bad debts and delay in payment					
Delay in payment and bad debts will cause lack of investment in promoting agri-food products					
Bad debts will cause skill shortage and tax evasion					
Lack of investment in promoting agri-food products will cause market price fluctuations					
Rapid evolution in technology will cause high energy costs and oral contract or agreement with partners					
High energy costs will cause market price fluctuations					

2. If you disagree or strongly disagree the interrelationships between and among different risk factors, please tell me **why**.

C3 Evaluate risk categories

1. Various risk factors have been divided into different groups based on their influence on the agri-food supply chains. How do you think each risk factors have been divided into suitable groups? Please tick (√) in the following table.

Different groups	**Risk factors**	**Descriptor**				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Independent variables	Risk from pests and diseases					
	Poor planning					
	Supply and demand imbalance					
	Poor agricultural infrastructure					
	Lack information sharing among partners					
	Extreme weather conditions					
	Political and economic instability					
Linkage variables	Bad debts					
Autonomous variables	Rapid technological development					
Dependent variables	Delay in payment					
	Skill shortage					
	Market price fluctuations					
	Tax evasion					
	Lack of investment in promoting agri-food products					
	Oral contract or agreement with partners					
	High energy costs					

2. If you disagree or strongly disagree each risk factors have been divided into suitable groups, please tell me **why**.

Part D Evaluate AFSC key performance indicators

1. How do think following elements for building AFSC performance measurement systems? Please tick (√) in the following table.

AFSC performance categories	**AFSC key performance indicators**	Descriptor				
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Product quality	Shape					
	Colour					
	Flavour					
	Shelf life					
	Packaging					
	Labelling					
	Convenience					
	Satisfaction of quality standards					
Any other elements?						
Efficiency	Production costs					
	Profit					
	Waste reduction					
	Return on investment					
	Inventory					
Any other elements?						
Flexibility	Customer satisfaction					
	Volume flexibility					
	Delivery flexibility					
	Product flexibility					
Any other elements?						
Process quality	Traceability					
	Pesticide use					
	Storage and transportation					
	Working condition					
	Energy use					
	Water use					
	Water quality					
Any other elements?						
Responsiveness	Customer complaints					
	Lead time					
Any other elements?						

2. If you disagree or strongly disagree the above AFSC key performance indicators, please tell me **why**.