# Links Between Risk Source Identification and Resilience Capability Building in Agri-Food Supply Chains: A Comprehensive Analysis

Guoqing Zhao, Femi Olan, Shaofeng Liu, Jorge Hernandez Hormazabal, Carmen Lopez, Nasiru Zubairu, Jinhua Zhang, and Xiaoning Chen

***Abstract*—Agri-food supply chain (AFSC) resilience is receiving increasing attention as AFSC stakeholders perceive its benefits in recovering from unexpected disruptions. However, which resilience capabilities are more effective in mitigating AFSC risks remains unclear. To address this gap, this article presents a novel AFSC risk and resilience analysis based on a systematic literature review (SLR). In total, 95 journal articles on AFSC risk and resilience management published between 2004 and 2020 are analyzed to identify key risks and resilience capabilities in AFSCs, the relationships, correlations and causalities between them, and research gaps and future research directions in the field. Our SLR reveals eight types of AFSC risk and seven types of AFSC resilience capability, and enables us to develop a one-to-one resilience-risk correspondence model. Suggestions for future research include: cross-country comparative analysis to gain a deeper understanding of risk and resilience management; identification of risk and resilience strengthening strategies through a multi-sectoral approach; longitudinal studies to determine the long-term effects of resilience capabilities; research to understand resilience from the perspectives of supply-chain collaboration, traceability, redundancy, knowledge management, innovation, leadership, and flexibility; investigations of the positive effects of AFSC risks in triggering resilience capabilities; and cross-disciplinary research to understand the relationships between resilience and other disciplines.**

***Index Terms*—Agri-food supply chain, relationships between risk and resilience, supply chain resilience, supply chain risks, systematic literature review.**

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## I. Introduction

THE world's current population of 7.8 billion is expected to increase significantly to 8.5 billion by 2030 and to 9.7 billion by 2050 [1]. This drastic growth, coupled with accelerating urbanization, will place enormous pressure on agri-food supply systems, as more affluent and urbanized populations demand more nutritious, affordable, sufficient, high-protein, and safe agri-food products [2]. Furthermore, globalization, increasing competition, uncertain business environments, rapid and dynamic customer demand behavior, and the perishability of agri-food products are naturally driving agri-food supply chain (AFSC) practitioners to build connections between key agri-food players in order to capture the latest agricultural technologies, knowledge, and high-quality agri-food products, as well as reducing operational costs [3], [4]. AFSCs have become longer, more complex and more prone to various risks [5], [6]. In addition, understanding and analyzing AFSCs has become increasingly complex owing to unexpected risks linked with emerging disruptions and vulnerabilities that affect food systems.

AFSCs can be understood as moving agri-food products from production to final consumption literally, from "farm-to-fork" [7], [8]. In this process, agri-food products must be farmed, cleaned, tested, categorized, packaged, refrigerated, distributed, and marketed all of which, involve agri-food research institutes, farmers, manufacturers, logistics service providers, and wholesalers. This complexity leads to considerable interdependence amongst AFSC stakeholders, particularly in relation to product, information, and decision flows, which also increases vulnerability and risk. Risk can be viewed from various perspectives, including *environmental* risks from droughts, floods, forest fires, and earthquakes, *supply* risks relating to supplier reliability, information and communication technology (ICT) infrastructure, supply quality and supplier capability, *demand* risks arising from data errors, customer preferences and forecasting errors, and process risks from technological changes and production and transportation issues [8]. However, beyond these traditional sources, further risks relating to perishability, product contamination, storage and transportation, and climate conditions must also be considered [9]. These are likely to disrupt information, material, technology, and knowledge flows in AFSCs, causing discontinuity and reduced profitability [10]. Therefore, research domains, such as supply chain risk management (SCRM) are seeking to provide better understandings and analyses of the implications of these risks, particularly in terms of their identification, assessment, mitigation, and monitoring [11], [12], [13]. AFSC-related risks affect a large proportion of the

agri-food sector, and their wide variety and effects on AFSC performance mean that they must be both managed and anticipated, in order to enhance recovery from unexpected events and risks.

Resilience has been explored in various contexts, including engineering, ecology, psychology, economics, and management [14]. In the context of management, as external threats increase, two areas have attracted particular research interests: organizational resilience and supply chain resilience (SCRes) [15]. Resilience is generally seen as a desirable capability allowing supply chains, organizations and their members to prepare for, resist and recover from unpredictable disruptions [16]. Recent reviews of the literature on supply chain risks and resilience (e.g., [17], [18], [19], [20]) find that, although research has identified supply chain risks and SCRes in various industries, the agri-food industry seems have been neglected. In [17], literature review of SCRM, only six out of 90 papers focused on the agri-food industry, whereas in [20] review paper of SCRes, only eight out of 101 papers focused on the agri-food industry, indicating a clear gap in the literature. Besides, SCRes are generally considered as a heterogeneous and fragmented area, with very different elements, stages, issues, and research contexts involved. For example, these issues include resilience building using various strategies (e.g., supply chain collaboration and redundancy), application of old features (e.g., flexibility) in various industries (e.g., manufacturing, services, pharmaceuticals, and automotive), and investigation of new issues (e.g., robotics, blockchain technology, and artificial intelligence) and their effects on resilience. Taking this into consideration, a systematic literature review (SLR) is necessary to summarize existing findings, synthesize knowledge, and propose research directions to guide future research. Studies have addressed definitions, principles, strategies, elements, and phases of SCRes [21], [22], but few have established clear connections between supply chain risks and SCRes [23]. This research gap requires urgent attention through conducting a SLR.

Responding to current industry and research needs, we conducted a SLR of studies on AFSC risks and AFSC resilience. We sought to highlight risks that may have severe effects on AFSCs, identify resilience capabilities that can be used in an AFSC context, build connections between AFSC risks and AFSC resilience capabilities, and propose the most promising directions for future research. The aim was to gain a fuller understanding of the connections between risk and resilience by building a one-to-one resilience-risk correspondence model to reveal correlations and causalities. Four research objectives are formulated as follows.

1) To identify risks that may have severe effects on AFSCs.
2) To identify resilience capabilities that can help AFSCs to respond to and recover from disasters or disruptions.
3) To build connections between identified AFSC risks and resilience capabilities through extracting evidence from the literature.
4) To identify research gaps and propose future research directions.

This article makes several contributions to theory and managerial practices. As for the contributions to theory, *first*, a novel one-to-one resilience-risk correspondence model in terms of AFSCs was built through an exhaustive search and analysis of the relevant literature. Previous literature reviews on SCRes or SCRM tend to focus on summarizing their definitions [17], [24], framework development [25], SCRes principles and performance analysis [18], or modeling techniques [26], [27]. Very few studies give a clear overall picture of the relationship between risks and resilience capabilities. To the best of our knowledge, this is the first literature review that aims to build relationships between risks and resilience capabilities specifically for AFSCs. *Second*, this article identifies 20 valuable directions for future research from seven perspectives, such as the methodology adopted and AFSC risk identification and assessment. *Third*, we identified 50 AFSC resilience capability factors and 77 AFSC risks that exist in AFSCs. This article provides an overview of risks and resilience capabilities involved in the AFSCs. As for the managerial implications, this study helps AFSC managers to reduce the time and effort required to mitigate AFSC risks, as we build a one-to-one resilience-risk correspondence model. More than 70% agri-food companies are small-and medium-sized enterprises (SMEs), which indicates that they do not have unlimited resources to mitigate risks. This article provides clear guidance for them to mitigate or avoid risks using dedicated resilience capabilities. Furthermore, this article raises the risk and resilience awareness of AFSC practitioners through identifying various AFSC risks and resilience capabilities. *Finally*, this article sheds some light on which resilience capabilities should be used to mitigate risks, as we summarized their frequency of use from the literature. For example, information sharing, blockchain-based technology, and multiple sources are frequently mentioned by scholars.

The rest of this article is organized as follows. Section II describes the research methodology and Section III analyses the literature. In Section IV, we discuss the major findings and contributions of this article and propose future research directions. Finally, Section V concludes this article.

## II. Research Methodology

SLR was selected as the research methodology for this article for several reasons. *First*, the aim of this article was to identify risks associated with AFSCs and propose corresponding risk mitigation and avoidance strategies to help build AFSC resilience. Furthermore, because resilience has been explored in various fields, SCRes is a fragmented and somewhat inconsistent research field [19]. SLR provides an opportunity to overcome this fragmentation by conducting an exhaustive search for relevant studies in a systematic, replicable, scientific, and transparent manner [28]. *Second*, SLR helps to minimize bias and errors generated in the course of data collection and analysis [29], [30]. *Third*, SLR enhances the quality of the review and its outcomes, as quality control mechanisms are embedded in the process [31]. *Finally*, SLR has been successfully applied to a range of research topics, including omni-channel retailing [32], supply chain agility and flexibility [33], and human resource management [34], and is, thus, widely used in business and management. The SLR in this article involved three steps: 1) research question formulation, 2) study identification, selection, and evaluation, and 3) analysis and synthesis (see Fig. 1).

### A. Research Question Formulation

Managing risk in the supply chain is a key capability for the survival of supply chain stakeholders in an increasingly volatile and unpredictable business environment [35]. Therefore, SCRM is a key area of interest, encompassing risk identification, assessment, mitigation, and monitoring [36], [37]. The literature addresses issues, such as risk sources in supply chains, the

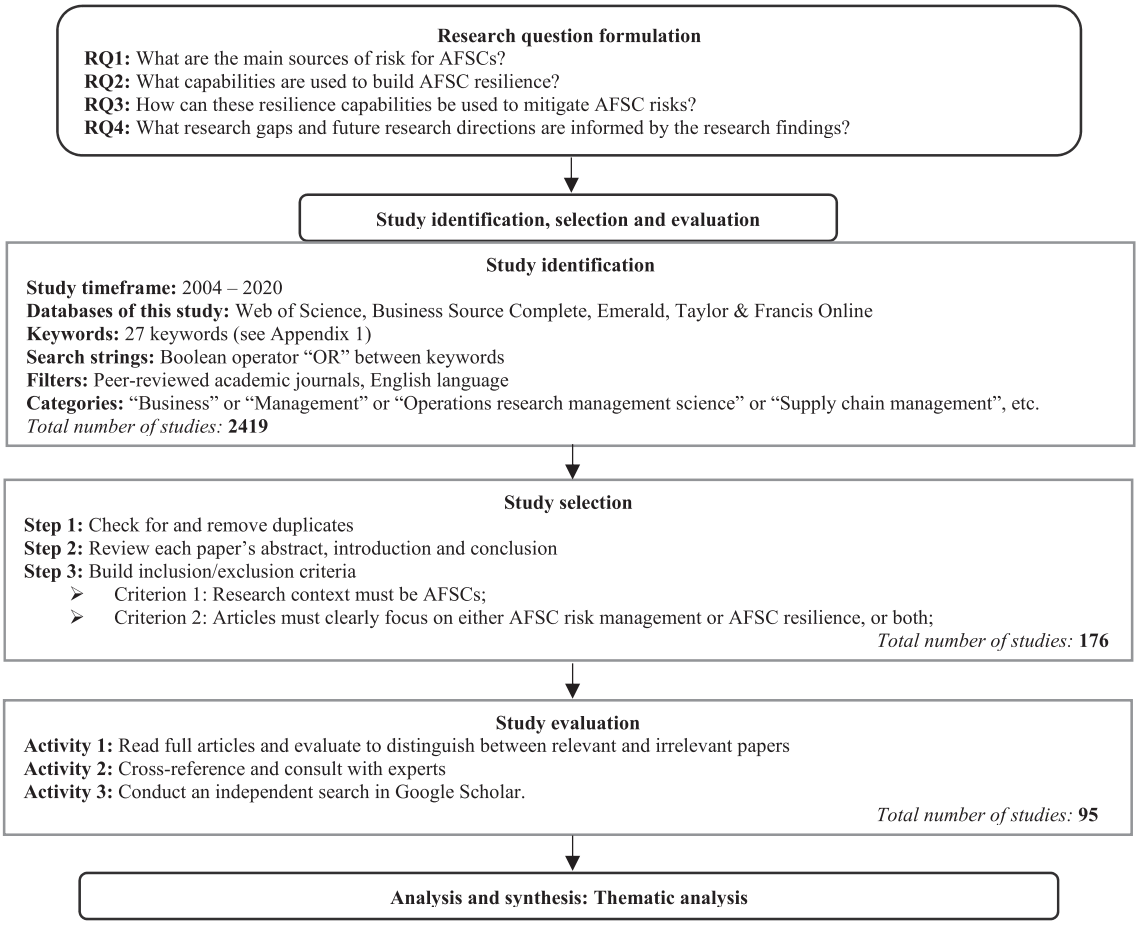


Fig. 1. Summary of the SLR process.

typology of supply chain risks, strategies to mitigate supply chain disruptions, and quantitative methods to assess supply chain risks [38]. Most studies focus on a particular industry such as automotive, electronics or aerospace, but the agri-food industry remains relatively unexplored [17], [20]. This is because the latter has evolved over time under the influence of various changing factors, such as population growth, dietary choices, technological progress, income distribution, and the state of natural resources, posing problems for investigation. The few studies that do concentrate on the agri-food industry focus either on the AFSC resilience [19] or specifically on AFSC sustainability [39]. No previous studies appear to have systematically identified both AFSC risks and AFSC resilience capabilities, nor built clear connections between the two. Therefore, in this SLR, we conducted an exhaustive search, identification, and categorization of relevant literature on both topics, aiming to build a unified framework that would provide insights into the relationships between AFSC risks and AFSC resilience, highlight AFSC risk factors, AFSC resilience capabilities and their corresponding relationships, summarize research gaps, and propose future research directions. Thus, the following four research questions were investigated as follows.

1) What are the main sources of risk for AFSCs?
2) What capabilities are used to build AFSC resilience?
3) How can these resilience capabilities be used to mitigate AFSC risks?
4) What research gaps and future research directions are informed by the research findings?

### B. Study Identification, Selection, and Evaluation

The main purpose of this step was to build a comprehensive database of studies on AFSC risk and resilience pertinent to the review questions. Four databases—Web of Science, Business Source Complete, Emerald, and Taylor & Francis Online—were selected to search for relevant studies as these include the world's major journals, conference proceedings, and book chapters, with a strong focus on business and management, and have been extensively used in literature reviews [40], [41]. Our timespan for relevant publications was set from 2004 to 2020 for several reasons. *First*, the concept of resilience can be traced back to [42] seminal work on "Resilience and stability of ecological systems," but was first applied to the context of supply chain management with [43] "Building the resilient supply chain." *Second*, risk sources in AFSCs and mitigation strategies used to build AFSC resilience are constantly evolving, and were heavily impacted by the COVID-19 pandemic in 2020. We assumed that this would prompt further research on AFSC resilience and, therefore, set our end date to 2020. Consistent with previous literature on supply chain risk and resilience [17], [18], [19], 27 keywords (e.g., disruptions, risk, vulnerability, and uncertainty) and search strings were employed to identify relevant

publications in English from their titles, keywords, and abstracts (see Appendix I). Since the focus of this article was on AFSC risk identification and resilience capability building, publications were limited to those pertinent to the areas of "business" or "management" or "operations research management science" or "supply chain management," based on the categorizations of the various databases. Furthermore, to ensure quality, only international peer-reviewed journal articles were included for further analysis, as such articles are evaluated by international peers through a rigorous review process [159]. Thus, other document types such as conference proceedings, book chapters, corrections, and meeting abstracts were excluded. The initial search resulted in 2419 journal papers.

The publications identified were then checked for duplicates. Their full records were imported into EndNote X8 bibliographic software. Using the command "Find Duplicates" embedded in EndNote X8, the number of papers was reduced from 2419 to 943. Next, each paper's abstract, introduction and conclusion were assessed to check whether the basic criteria for relevance were fulfilled [31], which resulted in 176 articles remaining. Articles included for further analysis must have specific characteristics. *First*, their research context must be AFSCs; thus, articles focusing on enterprise resilience, enterprise risk management, resilience in SMEs, and general SCRes or risk management were excluded. However, articles focusing on how to build AFSC resilience from a focal company perspective were included, as the unique power of focal firms may structurally influence the whole supply chain [24], [44], [45]. *Second*, the selected articles had to have a clear focus on either AFSC risk management or AFSC resilience, or both. Articles concentrating on AFSC risk management were included, because risks must first be identified to enable risk categorization, assessment, mitigation, and monitoring [46]. Articles focusing on AFSC resilience principles, AFSC resilience strategies, and AFSC resilience measurement were also included.

Next, the remaining 176 articles were read in full to distinguish between relevant and irrelevant papers, which narrowed the pool to 86 articles. By cross referencing and consulting with two professors in operations management and decision-making, a further nine articles were identified, leading to a final sample of 95 articles. Finally, we conducted an independent search in Google Scholar to ensure that all key articles were included in this article [30], [47]. The steps, in this analysis, are presented in Appendix II.

### C. Analysis and Synthesis

Thematic analysis was selected for analyzing the qualitative data for several reasons. *First*, thematic analysis is useful for summarizing the key features of a large data set [48]. As 95 articles required analysis, thematic analysis was the most appropriate method for this article. *Second*, thematic analysis allows high levels of flexibility, simplicity, and tangibility in the analytical process. Other qualitative data analysis methods, such as narrative analysis and discourse analysis, may provide a highly flexible theoretical framework, but may fall short of identifying broader structural influences or producing tangible answers to research questions making them inapplicable to this article. *Finally*, thematic analysis is able to highlight similarities and differences between different datasets, making it extremely useful for generating unanticipated insights [48]. Thus, thematic analysis was applied to analyze the qualitative data in this article.

We started by analyzing each study to identify descriptive elements (e.g., author(s), year of publication, methodology, geographical location, and type of AFSCs), and major findings. Each paper was classified according to the primary methodology used, including theoretical and conceptual papers, case studies/interviews, surveys, modeling papers, and literature reviews [49], [50]. Information on each study was recorded in a Microsoft Excel worksheet. In order to ensure credibility and reliability, two coders were involved in line-by-line coding of each study, resulting in an intercoder reliability of $k = 0.81$ [51]. NVivo 12 was used in the coding process, as this made it easy to identify, highlight, categorize, and link related AFSC risks and AFSC resilience capabilities [30]. Finally, we synthesized the thematic analysis results and identified avenues for further research.

## III. Literature Analysis

In the following, Section III-A presents the results of our descriptive analysis relating to the distribution of journals, the number of journal articles over the years, authors' country, types of AFSCs, and the research methodology adopted. Section III-B describes the results of our thematic analysis, summarizing the sources of risk to AFSCs, their resilience capabilities, and relationships between the two.

### A. Descriptive Analysis

Appendix III presents the distribution of articles on AFSC risks and/or AFSC resilience across 43 different journals. *Supply Chain Management: An International Journal* has the highest number of papers ($n = 12$, 12.63%) on these topics, as it aims to publish works that contribute to extending supply chain knowledge beyond a dyadic perspective and solving challenges posed by issues, such as globalization and disruption. A significant number of articles have also been published by *PP&C* ($n = 7$, 7.37%), *International Journal of Operations and Production Management* ($n = 6$, 6.32%), *International Journal of Pharmaceutical Research* ($n = 6$, 6.32%), *International Journal of Performability Engineering* ($n = 5$, 5.26%), *International Journal of Logistics Management* ($n = 5$, 5.26%), *European Journal of Operational Research* ($n = 4$, 4.21%), and *International Journal of Physical Distribution and Logistics Management* ($n = 4$, 4.21%). These journals aim to publish leading research on developing and implementing strategies, systems, processes, and practices in operations and supply chain management. We also note that journal articles relating to AFSC risks and resilience have been published in other subject areas, including marketing, information management, social sciences, sector studies, general management, ethics, and social responsibility. This is because new technologies and digitalization have gradually transformed traditional AFSC, requiring researchers to reconsider the associated risks and resilience [52]. Also, diverse AFSC risks must be tackled from different research angles, which may provide innovative approaches and new ideas to identify, categorize, analyze, monitor, and mitigate risks [53].

With regard to the number of journal articles over the years, although fluctuations are observed in 2007, 2011, 2013, 2016, and 2018, a growing trend for publications on AFSC risks and/or AFSC resilience is observed from 2004 to 2020, reaching a peak in 2020 ($n = 20$; see Fig. 2). This indicates that research relating to AFSC risks and/or AFSC resilience is consistently attracting

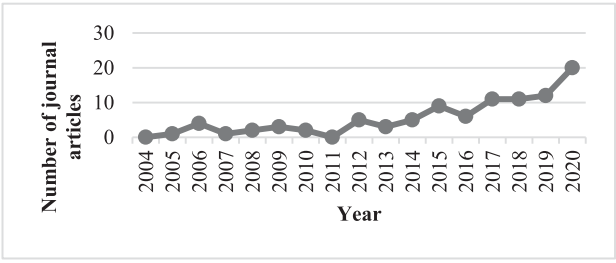


Fig. 2. Number of relevant journal articles published 2004–2020.

more attention as time passes, particularly as the COVID-19 pandemic caused severe AFSC disruptions globally from 2019 to 2020 [54]. We assumed that the number of publications on AFSC risks and/or AFSC resilience would continue to increase in the following several years for several reasons. *First*, COVID-19 vaccines are successful but it will take time to administer them globally. *Second*, greenhouse gas emissions will continue to worsen climate change until at least 2030, when they reach the peak set by the Paris Agreement in 2016. More uncertain impacts of climate change will further increase the production risks faced by the agricultural sector [55].

With regard to author's geographical locations, we find authors affiliated to institutions in 24 countries around the globe. The agricultural industry has received significant attention globally because agricultural growth raises the incomes of the poorest two to four times more effectively than other sectors. Most authors are affiliated to institutions in the United Kingdom ($n = 14$, 14.74%), USA ($n = 13$, 13.68%), China ($n = 11$, 11.58%), India ($n = 8$, 8.42%), Australia ($n = 7$, 7.37%), Brazil ($n = 7$, 7.37%), The Netherlands ($n = 6$, 6.32%), and New Zealand ($n = 5$, 5.26%). Interestingly, only one author was affiliated to Denmark, even though Denmark is a food and farming country that exports 24% of its agricultural product [56]. This may be because AFSC risks are less severe in Danish AFSCs, as farmers are well-educated, major enterprises are farmer-owned co-operatives, knowledge is transferred efficiently across AFSCs, and intensive agricultural research and innovation activities are conducted [56].

Regarding types of AFSCs (see Appendix IV), considerable academic attention has been devoted to the AFSCs' risk management and resilience building in general ($n = 51$, 53.68%), but only a limited amount to different types of AFSCs ($n = 44$, 46.32%). For example, among countries in Asia (China, India, Iran, and Pakistan) and Oceania (Australia and New Zealand), emphasis has been placed mainly on SCRM for dairy products, grain, citrus, and wine. Dairy products have been a particular focus for several reasons. *First*, widespread use of melamine in infant milk formula severely disrupted China's milk production and consumers' confidence and trust in dairy producers [57], thus attracting attention to risk management in Chinese dairy supply chains. *Second*, India has the highest level of milk production and consumption of all countries, but its dairy industry-related services are underdeveloped with a scarcity of fodder resources, lack of vaccinations for cows, and a shortage of access to credit, making quality control of its dairy supply chain a critical issue [6]. *Third*, Iran is 100% self-sufficient in milk and seeks to export its milk products to other countries [58], while New Zealand's dairy products are its most important export commodity. Therefore, appropriate risk management and resilience strategies throughout their dairy supply chains are critical for opening up foreign markets. European studies (Italy, United Kingdom, Germany, Denmark, The Netherlands, Switzerland, and Portugal) have devoted considerable attention to risk management relating to fresh vegetables and fruits (e.g., potatoes, strawberries, and mushrooms), processed foods (e.g., canned tomatoes, oils, tomato sauce, and beverage), and meat (e.g., pork, broilers, and horsemeat). Risk management of beverage supply chains has been a particular focus in the U.K. and Italy, as beverages are the U.K.'s largest manufacturing industry and beverage industry revenues in Italy are expected to grow dramatically from $317 million in 2017 to $1054 million in 2025 [59]. Risk management relating to meat products in Europe has also received attention, particularly in the U.K. following the horsemeat scandal in 2013. Interestingly, the widest variety of AFSCs (e.g., potatoes, strawberries, mushrooms, meat, and fast-moving consumer goods) investigated for resilience building among countries in Europe has been in The Netherlands. This is because The Netherlands has been ranked top for potato, strawberry and mushroom exports, and is the second-largest exporter of vegetables overall in terms of value. It also has highly intensive agricultural research and innovation activities [60]. In North America (Canada and the USA) considerable attention has been given to risk management of fruits, vegetables, eggs-and processed food, whereas in South America (Brazil), the focus has been on beef, sugarcane, mangoes, and oranges.

Regarding the research methodology adopted, case studies are frequently used ($n = 34$, 35.79%), including both single (21.05%) and multiple case studies (14.74%). We assumed that case studies would be the preferred research methodology in operations management because they are a powerful research technique for capturing the complexity of a single case and building a theory [61]. Modeling ($n = 23$, 24.21%), theoretical and conceptual approaches ($n = 12$, 14.74%), surveys ($n = 6$, 6.32%), and literature reviews ($n = 6$, 6.32%) are also popular research methodologies. Other papers adopt a mixed-methods approach, including modeling and case study ($n = 6$, 6.32%), survey and modeling ($n = 4$, 4.21%), case study and survey ($n = 3$, 3.16%), and literature review and case study ($n = 1$, 1.05%).

### A. Thematic Analysis

We analyzed the 95 papers through thematic analysis. *First*, we uploaded each paper into NVivo 12 to assist the analysis process. *Second*, we thoroughly read each paper and categorized them into four categories, such as risk identification ($n = 7$, 7.36%), assessment ($n = 16$, 16.84%), mitigation ($n = 71$, 74.75%), and monitoring ($n = 1$, 1.05%) (see Appendix V). In this process, some studies (e.g., [9], [62]) identified AFSC risks and also proposed risk mitigation measures, so we categorized them under risk mitigation. Other studies such as [8] and [63] conducted an analysis of different AFSC risks involved risk identification and assessment; thus, we categorized them under risk assessment. Studies related to resilience such as supply chain collaboration and traceability, are all related to mitigation measures. Accordingly, we categorized them under risk mitigation. *Third*, we coded each paper such as relevant sentences and paragraphs that described risks or mitigation measures, highlighted them, and aggregated them into different themes. In this article, we are focusing on identification AFSC risks and resilience capabilities, and establishment connections between

them. Thus, we extracted different risks from the literature and categorized them into eight categories (as shown in Appendix VI), as well as extracted different resilience capabilities from the literature and then categorized them into seven categories (as shown in Appendix VII). *Finally*, we generated a report related to various AFSC risks, AFSC resilience capabilities, and the linkages between AFSC risks and resilience capabilities.

*1) Sources of Risk for AFSCs:* In many studies, supply chain risk is defined vaguely and ambiguously, with few clear and concise definitions [64]. According to a recent literature review on SCRM, 82% of studies do not explicitly define supply chain risk [65]; instead, they either imply supply chain risk as a deviation from the expected objective, or provide no insight into the definition of risk [17]. In this article, we chose to use [65] (2015, p. 130) definition to identify AFSC risks, as it covers all core characteristics of supply chain risks: objective-driven risk, risk exposition, and risk attitude. This defines supply chain risk as "the potential loss for a supply chain in terms of its target value of efficiency and effectiveness evoked by uncertain developments of supply chain characteristics whose changes were caused by the occurrence of triggering events."

The literature presents many AFSC risk sources and risk categorizations [9], [66]. Early attempts to categorize AFSC risk adopted binary classifications, such as internal and external risks, risk arising from either intentional or unintentional causes, and macro- and microrisks [17], [67]. AFSCs are facing greater risks as the lean philosophy has been widely applied to production and logistics to increase the efficiency of the whole supply chain, and firms are increasingly going global [68]. Therefore, researchers and practitioners are aware of a need to continuously review AFSC risk sources and develop appropriate AFSC risk classification schemes [69]. For example, AFSC risks have been classified into three categories based on their level in the supply chain network: 1) risks from sources within the firm (process and control risk); 2) risks from sources external to the firm but internal to the supply chain network (supply and demand risk); 3) risks from sources external to the supply chain network (environmental risk) [66]. Pereira et al. [9] extend this to six categories with the inclusion of sustainability risk, based on the assumption that the source of environmental risk lies in the macroenvironment, whereas the source of sustainability risk lies in the organization and supply chain. In terms of the supply chain process, AFSC risks can be classified into five categories: 1) sourcing risk; 2) delivery risk; 3) manufacturing risk; 4) infrastructural risk, and 5) environmental risk [43]. These AFSC risk classification methods are similar, categorizing risks based on either supply chain network levels or supply chain processes. However, they do not reflect the characteristics of agri-food products. Therefore, in this article, we classify AFSC risks into eight categories: supply risk, demand risk, financial risk, biological and environmental risk, weather-related risk, management and operational risk, logistical and infrastructural risk, and policy and regulatory risk. This is because characteristics of agri-food products, such as perishability, make them extremely vulnerable to climate change, biological risk, and infrastructural problems [70], and because a majority of AFSC companies are SMEs, which are liable to be affected by financial and policy change problems [8] (see Appendix VI).

In the supply risk category, ten AFSC risks are identified. Five articles [8], [45], [62], [71], [72] mention that farmers' inability to supply is a critical risk for two reasons. *First*, most agri-food products are seasonal and farmers production is limited, so they cannot respond to this risk if there is an increase in demand. *Second*, farmers globally are struggling with excess supplies of their products, as their harvests cannot be transported to potential customers owing to the COVID-19 pandemic [9]. Interestingly, ethical issues, such as collusion amongst suppliers to ration supplies and increase prices, may cause uncertainty in supply chains, as observed in the Indonesian food industry [3].

In the demand risk category, seven AFSC risks were identified. For example, food safety incidents include the "Chinese milk scandal" which led to the hospitalization of 54000 babies [73], the "horsemeat scandal" that engulfed at least seven European countries and caused a dozen retail giants to recall beef products [74], and foodborne diseases that caused 127836 Americans to be hospitalized [75]. These food safety disruptions have not only permanently damaged consumers' confidence, but have also caused reputational risks and have compromised the performance of the entire AFSC [76]. Governments are, therefore, seeking to formulate more strict food safety standards, but this will impose great pressure on AFSC participants [13], [62]. Another stream of literature analyses the risk of power asymmetry/imbalance among AFSC partners. For example, Madichie and Yamoah [74] concluded that, in a single supplier-multiple buyer relationship, buyers may tolerate unethical decisions by the supplier. Simangunsong et al. [3] suggested that the Indonesian food industry is subject to abuses of power by large retailers at the expense of smaller competitors.

In the financial risk category, seven AFSC risks are identified. These would have severe effects on aspects of AFSCs such as production, market access, purchases agri-chemical products, and insurance. Zhao et al. [8], Nyamah et al. [62], Leat and Revoredo-Giha [66], and Gorton et al. [77] mentioned that delays in payment and even nonpayment are frequent in AFSCs, as most farmers have weak bargaining power in the supply chain. Most agricultural activities are season- and weather-dependent, and all processes and stages of the AFSC are closely interconnected [78]. Therefore, a slight delay or nonpayment may trigger a butterfly effect, resulting in a substantial loss in yield and outputs.

Biological and environmental risks are associated mainly with reduced yield and quality disrupting AFSCs' flows of food and services. In the biological and environmental risk category, 13 AFSC risks are identified. Risks from pests and diseases have received considerable attention [8], [22], [71], [79] for two reasons. *First*, with globalization and increased trade and travel, pests, and diseases are able to cross borders more easily and spread into new areas. *Second*, approximately 20–40% of global crop production is lost annually due to pests and diseases. In addition, skilled labor shortages, agro-terrorist attacks, political uncertainty, and economic downturns all receive relatively high attention. For example, skilled labor shortages are a serious, widely experienced problem in different countries. This is because, as skilled labor is more wage-oriented, agricultural automation and digitization are increasingly forcing existing labor out of the agri-food industry, and COVID-19 will reinforce antiglobalization and impede labor migration [80]. Weather-related risks have increased in recent years owing to rapid population growth and the influence of global warming. For example, extreme drought has been observed to affect Brazil's sugarcane supply chains [81] and Australia's perishable product supply chains [22]. In 2019, Australian bushfires burnt 14% of agricultural land.

In the category of management and operational risk, extremely high attention has been given to forecasting and planning errors and potential restrictions on waste disposal. The former occurs frequently in AFSCs due to stakeholders' opportunistic behavior in their quest for higher profit margins, the high perishability of agri-food products, difficulties in keeping safety stock, and heavily reliance on human judgements in planning [22], [62]. Food waste has various negative effects on AFSCs, reducing profit, labor productivity and wage, and increasing the emissions of greenhouse gases [63]. Most AFSC stakeholders are currently tackling agricultural waste through burning. However, stricter environmental standards will make this impossible in the future.

Finally, 22 AFSC risks are categorized as logistical and infrastructure risk, and policy and regulatory risk.

*2) AFSC Resilience Capabilities:* To identify capabilities that can be used to build AFSC resilience, we analyzed the collected papers to find common themes. As illustrated in Appendix VII, the contributions are heterogeneous. *First*, seven resilience capabilities are identified that may significantly build AFSC resilience: supply chain collaboration, traceability, innovation, knowledge management (KM), redundancy, leadership, and flexibility. Of these, supply chain collaboration has received the most attention [82], [83], [84], [85] and leadership the least [86], [87]. *Second*, an emerging trend is observed for scholars to adopt a KM perspective on building AFSC resilience. For example, knowledge sharing inversely moderates the adverse effect of operational risks [88], mutually created knowledge enables visibility, velocity, and flexibility [21], relational networking generates both industry and supply chain knowledge [89], and effective employee training enhances food safety knowledge [22], [90]. *Third*, to mitigate the effects of food safety disruptions and increase resilience, it is suggested that traceability should be embedded in AFSCs [91]. Traceability means the ability to track any food, feed, food-producing animal, or substance that will be used for consumption through all stages of production, processing, and distribution. Min [52], Stranieri et al. [92], Bumblauskas et al. [93], Iftekhar et al. [94], and Rogerson and Parry [95] proposed building traceability from a blockchain perspective. With regard to building redundancy, various measures are used, but insurance and multiple sources have received most attention [8], [66], [96], such as nonpayment of insurance to ensure that AFSC members are paid promptly [66], and contingent sourcing to help processors to recover quickly from disasters [96]. *Finally*, innovation is suggested as a capability for building AFSC resilience. Recent literature focuses on two perspectives on facilitating innovation: the application of new technologies (e.g., blockchain, Internet-of-Things (IoT), mobile technology, and detection technology) and organizations' soft environment building [12], [82], [97], [98].

*3) One-to-One Resilience-Risk Correspondence Model:* This section explores relationships between AFSC risks and AFSC resilience capabilities by building a one-to-one resilience-risk correspondence model (see Fig. 3). Our review results are heterogeneous. *First*, supply chain collaboration and traceability are both frequently identified as reducing AFSC risks, whereas other resilience capabilities have received less attention. *Second*, supply, demand, biological, environmental, and weather-related risks are significantly mitigated by applying various resilience capabilities, whereas other risks are seldom considered by scholars. *Third*, the benefits of maintaining a certain level of risk are completely neglected by scholars. In the following sections, we demonstrate how supply chain collaboration, blockchain-enabled traceability, innovation, KM, redundancy, leadership, and flexibility are used to reduce AFSC risks.

Supply chain collaboration has various benefits. For example, it facilitates access to new markets, provides sources of new knowledge, and increases innovation capacity, resource efficiency, and stakeholders' negotiating power in the collaborative network [99]. It plays a critical role in reducing several AFSC risks. For example, more collaborative communication between upstream suppliers and downstream buyers may reduce delivery delays [100]. Option contracts associated with stock-out penalties between farmers and retailers may force retailers to share market information with farmers and facilitate AFSC coordination, with the aim of mitigating the risk of uncertain demand [101]. Vertical and horizontal collaboration (e.g., information gathering and sharing, innovation, and lobbying) are effective in responses to constitutional change [102]. Sharing of available information (e.g., weather conditions, the number of agri-food products, and the available transportation methods) among different AFSC stakeholders may reduce the effects of dependence on a single model of transportation [9]. However, Cadilhon et al. [82] and Taylor and Fearne [103] state that information sharing among AFSC stakeholders is insufficient and must be accompanied by joint planning. Thus, some AFSC risks such as imbalance in offer and demand, opportunism, and weather-related risks, may be mitigated or avoided. Kangogo et al. [98] suggested a novel way to reduce weather-related risks through building farmers' entrepreneurship. Working in combination helps farmers to access greater financial, technological, knowledge, and network resources. Active engagement with consortia to accumulate social capital is also an effective method of helping AFSC stakeholders to recover from weather-related risks [104]. To achieve a win–win situation under the influence of adverse weather, it is suggested that a guaranteed price mechanism-based risk-reward contract should be signed between farmers and wholesalers [105], enabling extreme weather conditions to be hedged and farmers' profits to be guaranteed. To reduce the risk of uncertain exchange rates to an acceptable level, Nyamah et al. [62] suggested building collaborative relationships with financial companies and using a range of financial instruments, such as financial hedges and operational hedges. Interestingly, suppliers' accountability to consumers has positive effects in mitigating or avoiding collusion issues, such as food adulteration and collusion amongst suppliers to ration supplies and increase prices [3], [84]. Being accountable may force suppliers to question who is responsible and why these collusion issues occur, ultimately leading them to improve their behavior. Finally, low technology risk is considered to be a positive factor in building trusting relationships among AFSC stakeholders, as it increases pressure on AFSC companies and the likelihood of AFSC investing in vertical integration [13], [83].

Blockchain technology is an emergent digital technology with the four beneficial characteristics of being decentralized, immutable, consensual, and democratic [106]. It is playing an increasingly important role in enhancing AFSC resilience and reducing the risk of intermediaries' interventions [52]. Therefore, a combination of blockchain technology and the IoT has been extensively applied in AFSCs to enhance traceability, transparency, and visibility. However, increased transparency and availability of data on supply structure may cause substantial damage to AFSC stakeholders if data are leaked [79]. Therefore,

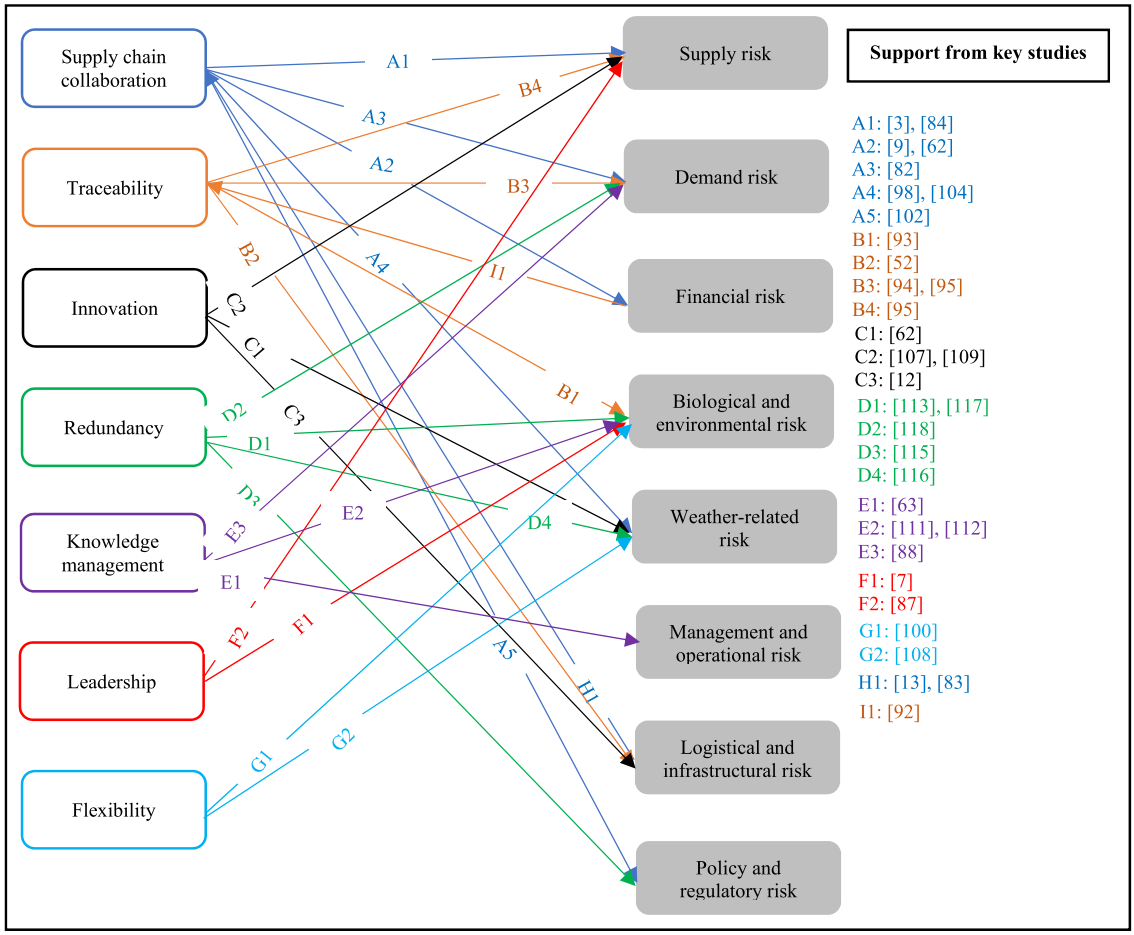


Fig. 3. One-to-one resilience-risk correspondence model.

a two-layer structure based on blockchain is suggested, one for AFSC stakeholders and the other one for the public [106]. Bumblauskas et al. [93] proposed a blockchain-based framework for monitoring the humidity, location, and temperature of eggs in the distribution process. Their research results indicate that blockchain-enabled traceability has positive effects in reducing food contamination, food fraud, and food loss. Rogerson and Parry [95] confirmed that, to enhance AFSCs' visibility and increase consumer trust, blockchain-enabled traceability should be placed as a priority, as its decentralized and fully digitalized characteristics enable customers to know "when," "where," and "how" products are processed. Finally, blockchain-based traceability may reduce the risk of collusion if stakeholders address the problem of how to govern their blockchain networks properly [95]. Although blockchain-based traceability allows agri-food products to be traced and tracked with high-precision, Resende-Filho and Hurley [76] state that high-precision traceability systems do not strengthen food safety, whereas intensive contingent payments may encourage more engagement in food safety. Regarding voluntary adoption of traceability standards, Stranieri et al. [92] proposed that to reduce exogenous risks, traceability standards must be sufficiently flexible to respond to unexpected changes in market dynamics whereas, to reduce internal transactional risks, complex traceability standards are required, as these foster effective management across the whole AFSC.

Innovation is increasingly important for tackling AFSC risks, particularly in the era of industry 4.0. Deploying smart systems releases human intelligence and, therefore, encourages people to generate and utilize knowledge in their working processes, with positive impacts on dynamic inventory management, skills development, quality improvement, new marketing ideas, and risk reduction [107]. For example, analyzing historical meteorological data using a combination of Big Data technology and IoT is an effective way to address weather-related risks [62]. To mitigate the effects of earthquakes, Forbes and Wilson [108] suggested migrating essential transactional IT systems and databases to cloud computing platforms that can be fully accessed from any location. Embedding IoT in the cyber-physical system to monitor the movements of logistics services, will reduce postharvest loss through automatic rerouting [12]; and to ensure the quality of red wine, logistics data can be continuously mined to support ongoing planning and monitoring of quality assurance practices in the supply chain network [109].

KM is essential to enable AFSC partners to gain sufficient knowledge through efficient knowledge sharing and knowledge flows [110]. Lack of professional knowledge and relevant expertise may cause bottlenecks in tackling AFSC risks [87]. To reduce food waste, knowledge of challenges to preventing and reducing waste must flow efficiently among AFSC partners [63]. Building reciprocal knowledge-sharing relationships with long-term AFSC partners to share data on production and distribution

would bring huge benefits in controlling supply demand mismatch [88]. Ali et al. [100] suggested that training and development opportunities to enable food organizations' employees to acquire knowledge play a critical role, as trained employees use resources more efficiently in response to disruptions. Scholten and Schilder [21] found that joint knowledge creation and sharing relates to indirectly to mitigating disruptions by providing a deeper understanding of each company's processes to increase supply chain visibility and velocity. Besides knowledge generated within the AFSC, informal relationships among individuals, such as unplanned and random exchanges of information, may also help to assure agri-food product safety [89]. All members of the public, and particularly the poorly educated, should be given some knowledge of food safety and the food chain as this will have positive effects in changing consumers' perceptions of food system vulnerability [111]. Furthermore, changing consumers' perceptions will lead to AFSC stakeholders taking more responsibility for monitoring and truth-telling when food scandals occur [112]. According to [87], knowledge of suppliers' quality management practices is effective in tackling poor-quality risk management.

Creating redundancy is an effective way to enhance resilience and reduce risks across supply chains [18]. To reduce food contamination, primary criteria, such as quality and food safety should be considered in the supplier selection process [113]. Critical attention should be given to suppliers that fulfil the requirements for business certification and accreditation schemes such as Hazard Analysis and Critical Point (HACCP), ISO22000, FASCAT and other food safe standards as they have lower rejection and return rates, and implement quality tests prior to each delivery [73], [100], [114]. HACCP suggests using radio frequency identification to avoid food recalls [90]. Furthermore, AFSC organizations must demonstrate corporate social responsibilities, for example with regard to animal welfare, sustainable supplies, responsible procurement, and fair trade. This will enable them to build their reputation and avoid negative criticism from society, as well as making them more able to respond to policy and regulatory risks [66], [115]. Reis [116] summarized the key issues for governments formulating food contingency plans, which include building a shared control and responsibility network among AFSC stakeholders, and involving more stakeholders in decision making. These measures may mitigate the effects of severe weather events. Government aid is another form of intervention that may help AFSC stakeholders to recover from natural disasters, although its use depends on the unit recovery cost compared with other methods, such as backup suppliers [96]. Yavari and Zaker [117] suggested that a two-layer electricity network may improve AFSCs' resilience and avoid power disruptions. Redundant electricity generation capacity is extremely important in the response and recovery phases, as it allows AFSC stakeholders to keep products refrigerated and access business systems and customer database [108]. To reduce the effects of volatile demand, a distributed localized manufacturing strategy is suggested. This enables the scale and location of manufacturing facilities to be modified [118], thus avoiding long-distance transportation of raw materials and quickly adjusting production volumes to customer requirements.

Leadership is an essential capability for building AFSC resilience. For example, Dani and Deep [7] analyzed three food safety incidents (salmonella poisoning in peanut butter, Wal-Mart's response during Hurricane Katrina and the Chinese milk scandal), concludes that, amongst the factors identified (e.g., communication, multipartner collaboration, resource allocation, escalation, and speed of response), leadership was the most important. Top management support is critical in rearranging resources to respond to disruptions, particularly involving multiple departments within a company [87]. At a supply chain level, only the leader of the supply chain (e.g., focal company) has the power to reconfigure resources to take control of a disruption. Thus, De Sa et al. [45] proposed that AFSC resilience should be built from the focal company perspective, rather than relying on each company in the AFSC to do so.

Flexibility is defined as the ability to adapt quickly to abnormal situations by adopting different measures [110]. To avoid the effects of weather-related risks, Ali et al. [100] proposed acquiring flexible transportation capabilities by building long-term, reliable relationships with logistics service providers. They also suggest that taking advantage of globalization is a flexible measure, as it will provide opportunities for local farmers to access global markets. All flexible measures require implementation by the workforces. Therefore, Forbes and Wilson [108] highlighted the importance of staff willingness to do whatever it takes to recover and adapt.

## IV. Discussion, Future Research Directions, and Contributions

In this section, we discuss research gaps in the extant literature, such as country coverage, agri-food products, methodologies, and content (see Appendix VIII), and propose future research directions. Thereafter, we discuss the contributions of this article.

### A. Directions for Future Research Development

To address country-related gaps, we propose two future research directions. *First*, there is a need to conduct AFSC risk and resilience studies in African and South American countries, as existing studies focus mainly on countries in Asia, Europe, North America, and Oceania. Studies of Africa are extremely important, since 70% of its population relies on agriculture for a living, and more than 100 million people on the African continent face acute hunger. *Second*, comparative, cross-country AFSC risk and resilience analyses are needed to gain a deeper, more sharply focused understanding that offers new perspectives. Using comparative methods to test theories in different settings and examine existing AFSC resilience and risk mitigation models across different contexts will improve the adoption and implementation of AFSC resilience measures. In particular, comparative analyses of European and African countries will provide valuable insights into how underexplored countries can build AFSC resilience.

To address gaps relating to AFSC risk identification and assessment, our findings reveal that existing research employs a range of methods for prioritizing risks and building interrelationships, such as interpretive structural modeling (ISM) and the fuzzy analytical hierarchy process (AHP) [5], [71], [119]. However, each study adopts only one multiple-criteria decision-making (MCDM) method of risk assessment. Practical application of these research results may be challenging, as each MCDM method has its own limitations. Future research might combine two or more MCDM methods to overcome these limitations. For instance, combining AHP and ISM to identify key AFSC risks may provide more robust and reliable results

for AFSC stakeholders. Comparison of the results of AHP and ISM may yield fruitful insights and deeper understanding. Furthermore, cross-case comparisons are necessary to understand product- and country-specific risk types, as current studies fail to provide comparative analyses of risk faced by various agri-food products. For example, both Iran and New Zealand have achieved 100% self-sufficiency in milk and export their milk products to other countries. However, our systematic literature search reveals that no comparative studies have analyzed the risks faced by these two countries' milk supply chains. Therefore, cross-case comparisons should be conducted to provide AFSC practitioners with a clear understanding of product- and country-specific risk types.

To address the gaps relating to AFSC resilience building, several future research directions are proposed. *First*, there is a need to clarify the relationship between the resilience of the focal firm and that of whole AFSC, as AFSC resilience does not require all organizations to become resilient, but rather relies on the focal company being able to reconfigure resources to control disruptions [45]. Research should seek to evaluate firms' positions in the AFSCs and their interfirm relationships to determine which firms are focal, how focal firms can activate resilience by deploying specific resources, structures, and processes, and what focal firms should do to leverage resilience across the whole AFSC. *Second*, future research should investigate what resilience capabilities are suitable for different AFSCs, as each agri-food product has different characteristics and infrastructure. For example, tropical fruits and infant food have differing expiry and perishability dates, requiring different resilience capabilities to respond to the same AFSC disruptions. *Third*, there is a need to understand how to evaluate AFSC resilience, because insufficient understanding of the level of AFSC resilience, makes it difficult to assess the effectiveness of resilience strategies implemented in the anticipation, resistance, recovery, and response phases [15], [18]. Existing studies consider how to assess SCRes associated with various disruptions such as natural disasters and uncertain demand [96], [120], but only a few studies provide a unified framework for evaluating AFSC resilience. Future research might investigate and summarize the different resilience assessment schemes used in discrete case examples to provide a unified framework that is more generalizable to different contexts and settings. *Fourth*, existing studies have investigated traceability from various perspectives [52], [92], [93], [94], including technology, planning, and conceptualization perspectives. However, no studies appear to have identified and prioritized the various resilience capability factors that have positive effects in building AFSC traceability. An empirical study might be conducted to identify, which factors are most beneficial for building AFSC traceability, using modeling methods such as AHP and ISM to priorities these factors, which will enable practical guidance to be provided to AFSC stakeholders on deploying traceability technology. *Fifth*, although industry 4.0 technologies such as blockchain, Big Data, robotics, and IoT have been found to be effective in developing new skills and enhancing human resource capabilities [107], their efficacy in building AFSC resilience has not been extensively explored. This maybe because industry 4.0 technologies are new, and their application needs time and presents challenges, including the need for standards, farmers' ability to modernize, and modernization of infrastructure. Thus, interviewing experienced AFSC stakeholders may help reveal which industry 4.0 technologies may be most beneficial for which dimensions of AFSC resilience (e.g., flexibility and redundancy). *Sixth*, there is a need to investigate the relationship between supply chain collaboration and other AFSC resilience capabilities, since existing research focuses on detailed collaborative activities such as information sharing, trust building, and contract application [13], [85], [98], [121], rather than considering supply chain collaboration as a whole. Future research might investigate interrelationships between different AFSC resilience capabilities to examine whether supply chain collaboration may help foster other resilience capabilities. *Seventh*, there is a need to understand what kinds of resources and capabilities—both tangible and intangible—should be built and configured to achieve optimal resilience. For example, it is vital to investigate the roles of knowledge, collaborative capacity, accountability, customer connectivity, and innovative spirit in building AFSC resilience, as these intangible resources are increasingly important in building sustainable and resilient AFSCs [122]. The *eighth* gap lies in the need to strengthen research on KM, as knowledge exchange hubs in Europe and North America reveal the important role of KM in building AFSC resilience. Thus, investigating cross-boundary knowledge mobilization is necessary. Future research might explore what kinds of knowledge (e.g., local, practice based, tacit, and explicit) are most beneficial for building AFSC resilience, what knowledge networks should be built to facilitate knowledge transfer, and how knowledge networks and trans-disciplinary knowledge can be combined to overcome knowledge boundaries to maximize effectiveness. Finally, there is a need to explore how to achieve AFSC resilience from the consumers' perspective. In fact, it is widely accepted that consumers' trust in manufacturers and third-party logistics fosters their confidence in food safety - for example in relation to milk products [73], and that consumers' sense of responsibility accelerates the process of food product recalls [84]. Further studies might investigate the role of consumers' trust and responsibility in fostering AFSC resilience, and identify the related mediators and drivers.

Concerning gaps relating to the relationship between AFSC resilience capabilities and AFSC risks, it is widely recognized that the former have positive effects in reducing the latter. However, existing studies fail to consider that a certain level of supply chain risk may help to elicit collaborative activities among AFSC stakeholders [13], [92] as researchers assume that risks always have adverse effects. Future research might: examine what risks may be intentionally tolerated by AFSCs to facilitate collaboration and coordination. Future studies might also investigate the positive effects of AFSC risks, to determine whether a certain level of risk may elicit collaborative activities and greater risk awareness among AFSC stakeholders, and further increase AFSC resilience. Extant research fails to clarify the relationship between AFSC resilience capabilities and AFSC risks, so empirical studies are required in different contexts and settings to build a one-to-one correspondence between AFSC resilience capabilities and AFSC risks and produce generalizable results.

Agriculture and food production are the main drivers toward achieving the United Nations goal of net-zero emissions no later than 2050. In this context, considerable research attention has been given to ways to achieve environmental sustainability and AFSC resilience simultaneously [53], [60], [63], [117], [118]. However, existing studies neglect to integrate the lean, agile, resilient, and sustainable (LARS) characteristics to achieve less waste, fewer emissions, and faster responses by AFSCs. This opens avenues for further research on how to equip employees

with new skills using existing digital technologies and to fulfil the core characteristics of industry 5.0. Resilience is a multidisciplinary concept that has been successfully applied in various disciplines, including ecology, psychology, economy, metallurgy, and engineering [123]. However, studies taking a holistic view on resilience from different disciplinary perspectives are lacking. Attempts to "borrow" concepts, resilience capabilities, and resilience capability factors from other disciplines should be encouraged, as this may reveal new dimensions and have a significant impact on AFSC resilience.

### B. Contributions to Theory and Managerial Practices

This article makes several important contributions to theory and managerial practices. As for the contributions to theory, *first*, the novelty of this article compared with existing SLRs is that it provides a one-to-one resilience-risk correspondence model. None of the recent literature reviews on SCRes and SCRM match risks with resilience capabilities in the context of AFSCs. For example, Bak et al. [20] conducted a SLR of SCRes in SMEs. Their research results concentrate on four focal areas for building resilience—collaboration and culture, SME's capabilities, information systems, and cost and financing. Phillips and Chao [124] discussed resilience definitions from the system theory perspective. Fan and Stevenson [36] presented SCRM definitions, theory used, and future research agenda, whereas Spieske and Birkel [125] investigated industry 4.0 and SCRes. Empirical studies either focus on SCRes assessment [126], [127], SCRes framework building [128], [129], or explore the relationships between SCRes and operational performance [123]. As a general consideration, a comprehensive analysis that links AFSC risks and resilience capabilities based on existing literature is scant. This article fills this gap through reviewing 95 articles and building a framework to link AFSC risks and resilience capabilities. *Second*, this article presents a clear picture of the recent developments of AFSC resilience and risks based on the relevant features, such as the methodology adopted, AFSC risk sources, agri-food products investigated, and others. We synthesized existing evidence from the literature, proposed research gaps, and generated corresponding future research directions. We proposed 20 future research directions based on the country, agri-food products, methodology adopted, AFSC risk identification and assessment, AFSC resilience capabilities, the relationships between AFSC risks and resilience capabilities, and the relationship between resilience and other disciplines. Because AFSC resilience is a fragmented and heterogeneous area, a SLR is critical for guiding future research. *Third*, we refreshed researchers' knowledge in terms of risks and resilience capabilities that exist in the context of AFSCs. For example, we identified 55 resilience capabilities that were used to mitigate AFSC risks, and 77 AFSC risks that exist in AFSCs.

This article also makes contributions to managerial practices. *First*, a critical question for most of AFSC practitioners is how to mitigate risks, particularly for those practitioners who lack knowledge in several areas, such as what approaches and techniques are available to use, and what strategies can be implemented and their effects. The situation is even worse for the low-educated practitioners living in rural areas, such as most of the farmers are running their family-business and have limited channels to receive knowledge. This article sets out clear guidance for AFSC managers and assists them in the decision-making process in how to use resilience capabilities to mitigate risks, as we linked each risk with resilience capabilities through extracting information from the existing literature. *Second*, we did not only summarize frequently mentioned AFSC risks (e.g., farmers' inability to supply and volatile customer demand) and resilience capabilities (e.g., insurance and blockchain-based technology); we also draw attention to the rarely mentioned ones. This article has the potential to increase the risk and resilience awareness of AFSC practitioners and update their knowledge related to SCRes and SCRM. *Third*, this article elicits how to embed resilience into AFSCs. That is, from the *supply chain collaboration* perspective, implement collaborative initiatives (e.g., collaborative communications, collective action, and public-private collaboration) and deploy ICTs such as cloud computing to deliver services through the internet; use IoT-based blockchain to monitor the logistic service; facilitate information sharing at the department, organizational and supply chain levels, and keep low technology risk to force AFSC partners to meet regularly and check their systems. From the *innovation and traceability* perspectives, we suggest that practitioners follow the latest academic developments to deploy industry 4.0 technologies (e.g., blockchain and IoTs), facilitate digital transformation, and nurture innovation culture at the organizational level. From the KM perspective, effective employee training to facilitate knowledge sharing is necessary (e.g., quality management and technology adoption), which can be achieved through forming university-industry collaboration or linking with knowledge hubs across the EU or other nonprofit agricultural organizations. From the *redundancy* perspective, safety stock, multiple stocks, and insurance are critical for AFSC practitioners' survival from disasters and disruptions, particularly in the environment where climate change is accelerating. Finally, from the *leadership and flexibility* perspectives, the awarding of universal applied business certifications such as food safety certificate ISO22000 to ensure product quality, and acquiring top management's support to build risk management culture will be useful for AFSC practitioners to survive in this volatile business environment.

## V. Conclusion

In this article, we adopted a SLR approach to identify and analyze 95 articles published between 2004 and 2020 in 43 scientific journals on AFSC risk and resilience management. Overall, this review suggests that, despite some progress in understanding AFSC risks, AFSC resilience, and the relationships between AFSC risks and AFSC resilience capabilities, significant gaps remain.

This article makes two key contributions to the field. *First*, we build a novel one-to-one resilience-risk correspondence model by summarizing the AFSC risks, AFSC resilience capabilities and their interrelationships identified in the literature. Our literature review reveals that most studies propose resilience capabilities to reduce supply, weather-related and biological and environmental risks, whereas other risk types receive relatively little attention. Furthermore, a certain level of transactional and technological risk may promote traceability and collaborative activities. Future research might investigate whether a certain level of risk may trigger AFSC resilience, and through what channels, methods, and activities.

*Second*, this article illustrates recent issues in the AFSC risk and resilience management area by summarizing key characteristics of recent research (e.g., years, countries, research

context, and research methodology), thereby identifying trends and research gaps. For example, with regard to the countries investigated, most empirical studies have used data collected from a single country (e.g., the United Kingdom, the USA, China, India, Australia), highlighting a need for more comparative cross-country analysis. The evidence also suggests that more empirical research should be conducted in less explored countries, such as in Africa and South America. Regarding the agri-food products investigated, the results are heterogeneous, but the focus has been on dairy products, wine, beef, fruit, fresh vegetables, and processed foods. Our results suggest that research should be conducted on a wider variety of agri-food products, such as pork, infant food, animal feed, and beverage as each product has particular characteristics. Regarding the research methodologies adopted, we identify overreliance on cross-sectional research strategies, whereas longitudinal research is lacking. The latter may be more effective for capturing, which AFSC resilience capabilities may have a long-term effects in reducing risks, since more than 80% of companies in AFSCs are SMEs [130]. With regard to the content of research, we categorize the papers into four groups that address 1) AFSC risk identification and assessment, 2) resilience capabilities for building AFSC resilience, 3) relationships between AFSC resilience capabilities and AFSC risks, and 4) understanding the relationship between resilience and other disciplines. Most studies have focused on identifying capabilities for building AFSC resilience in different settings and research contexts, whereas the other three areas have received less attention. Our analysis of group 1 establishes a need to conduct cross-case comparisons and use different assessment methods to acquire a deeper understanding of AFSC risks. The analysis of group 2 reveals that most studies address AFSC resilience from the perspectives of the supply chain collaboration, traceability, and redundancy, whereas very few consider this topic from the perspectives of focal company, consumer trust/responsibility, or knowledge mobilization. Furthermore, our findings suggest that most research fails to consider AFSC resilience measurement, the influence of industry 4.0 technologies on AFSC resilience, and how to configure resources and capabilities to achieve optimal resilience outcomes. In group 3, although resilience capabilities promise positive results in reducing AFSC risks, the outcomes are vague with respect to which resilience capabilities are useful for reducing which AFSC risks. Therefore, a one-to-one correspondence model was suggested to build between AFSC resilience capabilities and AFSC risks through conducting empirical studies. Finally, the analysis of group 4 reveals that studies have considered how to achieve "resilience plus" by integrating other disciplines, such as AFSC resilience and environmental sustainability. Future research might investigate how to create a LARS AFSC and add new dimensions to AFSC resilience through academic cross pollination from other disciplines.

A weakness of this article is that certain literature sources were neglected, including unpublished works, book chapters, and conference papers. Nevertheless, we are confident that our literature review makes a worthwhile and meaningful contribution to knowledge and research through its systematic, clear, and rigorous approach to searching for relevant journal publications.

## Appendix I
## Keywords and Search Strings

| | |
|---|---|
| Keywords | "disruptions," "risk," "vulnerability," "uncertainty," "risk management," "sources of risk," "risk analysis," "risk assessment," "crisis," "threat(s)," "risk assessment," "resilience," "resiliency," "resilient," "robustness," "mitigation," "food supply chain/food value chain," "agricultural supply chain/agricultural value chain," "agri-food supply chain/agri-food value chain," "agribusiness," "perishable supply chain/perishable value chain," "seasonal goods supply chain/seasonal goods value chain" |
| Databases | Web of Science, Business Source Complete, Emerald, and Taylor & Francis Online |
| Search strings | ("disruptions" OR "risk" OR "vulnerability" OR "uncertainty" OR "risk management" OR "sources of risk" OR "risk analysis" OR "crisis" OR "threat(s)" OR "risk assessment") AND/OR ("resilience" OR "resiliency" OR "resilient" OR "robustness" OR "mitigation") AND ("agricultural supply chain/agricultural value chain" OR "food supply chain/food value chain" OR "agri-food supply chain/agri-food value chain" OR "agribusiness" OR "perishable supply chain/perishable value chain" OR "seasonal goods supply chain/seasonal goods value chain") |

## Appendix II
## Step-by-Step Analysis of SLR

| Filter | Description | Web of Science | Business Source Complete | Emerald | Taylor & Francis Online | Total |
|---|---|---|---|---|---|---|
| **Filter 1** | Articles contain selected key words | 401 | 549 | 856 | 613 | 2419 |
| **Filter 2** | Check for and remove duplicates | | | | | 943 |
| **Filter 3** | Review each paper's abstract, introduction and conclusion<br>Apply inclusion/exclusion criteria | | | | | 176 |
| **Filter 4** | Read full articles and eliminate non-relevant ones<br>Cross reference and consult with experts | | | | | 95 |

*Search Criteria for Web of Science*: Timespan: January 2004–December 2020; Citation databases: Science Citation Index Expanded (SCI-EXPANDED)--1970–present; Social Sciences Citation Index (SSCI) –1970-present; Arts and Humanities Citation Index —1975-present; Emerging Sources Citation Index (ESCI)--2015-present; Restrict results by language and document types: English and article; Web of Science Categories: Business; Management; Food science technology; Operations Research Management Science; Agricultural economics policy; Agriculture multidisciplinary; Countries/Regions: All. Search strings searched in the title or topic.

*Search Criteria for Business Source Complete*: Search modes and expanders: Boolean/Phrase and apply related words; Limit your results: Scholarly (Peer Reviewed) Journals; Published Date: January 2004 – December 2020; Publication type: Academic journal; Language: English; Document type: Article; Subject: Supply chains; Supply chain management; Operational risk; Emergency management; NAICS/Industry: Distribution and logistics service; Geography: All.

*Search Criteria for Emerald*: Advanced search: Journal articles; Data range: 2004–2020; Access type: Journal articles; Search strings searched in the title or topic.

*Search Criteria for Taylor & Francis Online*: Date range: 2004–2020; Search strings searched in the title or keywords; Subject: Business, Management and Accounting; Industry and Industrial Studies.

## APPENDIX III
## DISTRIBUTION OF ARTICLES ACROSS JOURNALS IN THE REVIEW

| # | Journal title | Article count | % |
|---|---|---|---|
| 1 | Supply Chain Management: An International Journal | 12 | 12.63 |
| 2 | Production Planning and Control (PP&C) | 7 | 7.37 |
| 3 | International Journal of Operations and Production Management (IJOPM) | 6 | 6.32 |
| 4 | International Journal of Production Research (IJPR) | 6 | 6.32 |
| 5 | International Journal of Production Economics (IJPE) | 5 | 5.26 |
| 6 | Journal of Cleaner Production (JCR) | 5 | 5.26 |
| 7 | The International Journal of Logistics Management (IJLM) | 5 | 5.26 |
| 8 | European Journal of Operational Research (EJOR) | 4 | 4.21 |
| 9 | International Journal of Physical Distribution and Logistics Management (IJPDLM) | 4 | 4.21 |
| 10 | Sustainability | 3 | 3.16 |
| 11 | Journal of Marketing Channels | 2 | 2.11 |
| 12 | Omega | 2 | 2.11 |
| 13 | OR Spectrum | 2 | 2.11 |
| 14 | Risk Analysis | 2 | 2.11 |
| 15 | Transportation Research Part E: Logistics and Transportation Review | 2 | 2.11 |
| 16 | Benchmarking: An International Journal | 1 | 1.05 |
| 17 | Business Horizons | 1 | 1.05 |
| 18 | Business Process Management Journal | 1 | 1.05 |
| 19 | China Agricultural Economic Review | 1 | 1.05 |
| 20 | Computers and Operations Research | 1 | 1.05 |
| 21 | Computers and Industrial Engineering | 1 | 1.05 |
| 22 | Health, Risk and Society | 1 | 1.05 |
| 23 | International Journal of Engineering Business Management | 1 | 1.05 |
| 24 | International Journal of Information Management (IJIM) | 1 | 1.05 |
| 25 | International Journal of Logistics: Research and Applications | 1 | 1.05 |
| 26 | Journal of Business Ethics | 1 | 1.05 |
| 27 | Journal of Dairy Science | 1 | 1.05 |
| 28 | Journal of Environmental Planning and Management | 1 | 1.05 |
| 29 | Journal of Food Distribution Research | 1 | 1.05 |
| 30 | Journal of Food Quality | 1 | 1.05 |
| 31 | Journal of Global Information Management | 1 | 1.05 |
| 32 | Journal of International Development | 1 | 1.05 |
| 33 | Journal of Modelling in Management | 1 | 1.05 |
| 34 | Journal of Operations and Supply Chain Management | 1 | 1.05 |
| 35 | Journal of Supply Chain Management | 1 | 1.05 |
| 36 | Knowledge and Process Management | 1 | 1.05 |
| 37 | Kybernetes | 1 | 1.05 |
| 38 | Management Decision | 1 | 1.05 |
| 39 | Supply Chain Forum: An International Journal | 1 | 1.05 |
| 40 | Technovation | 1 | 1.05 |
| 41 | The International Review of Retail, Distribution and Consumer Research | 1 | 1.05 |
| 42 | Thunderbird International Business Review | 1 | 1.05 |
| 43 | World Development | 1 | 1.05 |
| | Total | 95 | 100 |

## APPENDIX IV
## EMERGED COUNTRIES AND ASSOCIATED AFSCS

| Country | Examples of AFSCs | Author(s)(year) |
|---|---|---|
| Australia | Citrus and fresh food | [22], [113] |
| Brazil | Beef, sugarcane, orange, and mango | [9],[13], [45], [97], [81], [131] |
| Canada | Fruit, dairy and vegetable | [132], [133] |
| China | Grain, wine, milk and infant milk formula, fresh food | [73], [85], [96], [109] |
| Denmark | Dairy, broilers | [134] |
| Finland | Pork and oils | [16] |
| Germany | Canned tomato, dairy | [79] |
| India | Grain, dairy, and halal food | [6], [120], [120], [135], [136] |
| Iran | Rice, dairy, and packaged food products | [117], [137] |
| Italy | Beverage and tomato sauce | [138], [139] |
| Netherlands | Potato, meat, strawberry, mushroom, and fast-moving consumer goods | [14], [21], [60], [140], [141] |
| New Zealand | Wine and dairy | [4], [108] |
| Pakistan | Citrus | [142] |
| Portugal | Processed food | [143] |
| Switzerland | Canned tomato | [144] |
| United Arab Emirates | Packaged food products | [83] |
| United Kingdom | Pork, horsemeat, drink, and beer | [66], [84], [74], [118], [145] |
| United States of America | Egg, processed food, and fresh vegetables | [90], [93], [146] |

## APPENDIX V
## STUDIES' CATEGORIZATION

| Aggregation dimensions | Relevant studies |
|---|---|
| Risk identification (7) | [60], [62], [74], [86], [138], [153], [155] |
| Risk assessment (16) | [5], [6], [8], [13], [14], [26], [53], [63], [72], [79], [119], [135], [136], [142], [148], [150] |
| Risk mitigation (71) | [3], [4], [7], [9], [12], [16], [19], [21], [22], [26], [45], [52], [66], [71], [73], [76], [82], [83], [84], [85], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [101], [102], [103], [104], [105], [107], [108], [109], [111], [112], [113], [114], [115], [116], [117], [118], [120], [121], [132], [133], [134], [137], [139], [140], [141], [143], [144], [145], [146], [147], [149], [151], [152], [154], [156], [157], [158] |
| Risk monitoring (1) | [131] |

## APPENDIX VI
## AFSC RISKS IDENTIFIED IN THE LITERATURE

| AFSC risk categories | AFSC risk factors | Author(s)(year) |
|---|---|---|
| **Supply risk** | Farmers' inability to supply (5), supplier delivery delay (1), poor quality (1), fluctuations in supply market (2), limited knowledge of market requirements (1), collusion amongst suppliers to ration supplies and increase prices (1), distortions in information sharing (1), lack of information sharing among suppliers (4), forecast error (3), poor planning (1) | [3], [6], [8], [9], [45], [62], [71], [72], [87], [131], [142], [147], [148], |
| **Demand risk** | Volatile customer demand (5), customer preference changes (2), food price fluctuations (3), imbalance in offer and demand (2), changes in food safety requirements (5), power asymmetry/imbalance (2), lack of consumer trust and confidence (1) | [3], [8], [13], [22], [62], [72], [74], [101], [102], [148], [149] |
| **Financial risk** | Inadequate financial support (1), delays in accessing financial support (2), uncertain financial support (credit) (1), uncertain interest and exchange rate policies (3), delay in payment and potential non-payment (4), bad debts (1), transaction risks (1) | [8], [62], [66], [77], [92] |
| **Biological and environmental risk** | Thief (2), labor strikes (2), skilled labor shortage (3), high labor costs (1), pests and diseases (4), agro-terrorist attacks (3), contamination relating to poor sanitation and illness (1), contamination affecting food safety (3), contamination and degradation of production and processing processes (1), political uncertainty (e.g., war and protest) (3), economic downturns (3), rapid technological development (2), poor working conditions for employees (2) | [6], [8], [9], [13], [22], [71], [72], [73], [79], [102], [108], [111], [112], [119], [148], |
| **Weather-related risk** | Excess rain (1), heatwaves (2), bushfires (2), extreme drought (3), flooding (2), extreme wind (1), big thunderstorms (1) | [8], [22], [62], [81], [104], [136], [150] |
| **Management and operational risk** | Use of outdated seeds/inputs (1), restricted water supply (1), forecast and planning errors (7), poor quality control (1), poor management decisions in asset allocation (1), tax evasion (1), lack of investment in promoting agri-food products (1), oral contract or agreement with partners (1), potential restrictions on waste disposal (7), decentralized supply chain structure (1), organizational mimicry (1) | [8], [22], [45], [62], [66], [72], [102], [133], [151], [152] |
| **Logistical and infrastructural risk** | Poor performance of logistics service providers (1), inadequate storage capacity) (1), in-transit loss (1), many intermediaries (4), poor infrastructure and insufficient transportation planning (3), lack of timely availability of vehicles (1), poor packaging and preservation (1), poor handling-loading and unloading at different locations (1), changes in transportation (1), high energy costs (3), non-availability of procurement center (2), power disruption (1), low technology risk (2) | [5], [9], [13], [22], [62], [72], [83], [117], [136] |
| **Policy and regulatory risk** | Changing or uncertain monetary situation (1), fiscal and tax policies (4), changing and/or uncertain land policies and tenure system (1), changing and/or uncertain trade and market policies (3), changing and/or uncertain regulatory/legal policies and enforcement (1), animal welfare legislation adversely impacting competitiveness (3), inappropriate production policies (1), constitutional change (1), stricter environmental standards (1) | [3], [5], [62], [66], [102], [103], [115], [135] |

*Note*: Numbers in brackets refer to the number of papers mentioning each risk

## APPENDIX VII
## AFSC RESILIENCE CAPABILITIES IDENTIFIED IN THE LITERATURE

| AFSC resilience capability | AFSC resilience capability factors | Author(s)(year) |
|---|---|---|
| **Supply chain collaboration** | Weather risk-reward contract (1), information sharing (4), collaborative communication (2), joint relationship efforts (1), long-term relationships with suppliers (1), trust (1), coordination contracts based on revenue sharing and wholesale price (2), collective action (2), ICT applications (3), option contract (2), joint purchasing (1), high social capital through active engagement within consortia (1), horizontal and vertical collaboration (1), collaborative planning forecasting and replenishment (1), public-private collaboration (2), consumer trust (3), accountability (1), farmer-buyer relationships (1), farmer entrepreneurship (1), low technology risk (2) | [3], [8], [13], [21], [22], [36], [45], [66], [71], [81], [82], [83], [84], [85], [88], [98], [101], [102], [103], [104], [105], [112], [121], [132], [138], [140] |
| **Traceability** | Blockchain-based technology (5), transaction risk (1) | [52], [76], [92], [93], [94], [95], [153], [154] |
| **Innovation** | Mobile technology applications (1), detection technology (1), internet-of-things infrastructure (1), industry 4.0 (1), blockchain's application (5), organizational culture (1), cloud computing (1) | [12], [52], [74], [82], [93], [94], [95], [97], [107], [108] |
| **Knowledge management** | Mutually created knowledge (1), relational networking (1), effective employee training (2), knowledge sharing (1) | [21], [22], [89], [90], [155] |
| **Redundancy** | Supplier response diversity (1), supplier selection (2), distributed networks of locations (2), multiple sources (3), safety stock (1), insurance (3), government aid (1), contingency planning (2), two-layer network model for electricity (1), corporate social responsibility (1), multiple supply chains (1) | [16], [26], [66], [79], [90], [96], [108], [113], [115], [116], [117], [118], [121], [141], [143], [146] |
| **Leadership** | Top management support (1), risk management attitude of leaders (1) | [7], [86], [87] |
| **Flexibility** | Supply chain redesign (1), business certifications (2), flexible transportations (1), globalization (1), resilient work force (1) | [22], [88], [108], [117] |

*Note*: Numbers in brackets refer to the number of papers mentioning each resilience capability factor

## APPENDIX VIII
## PROPOSED FUTURE RESEARCH DIRECTIONS BASED ON THE LITERATURE

| | Evidence of literature | Research gaps | Future research directions |
|---|---|---|---|
| **Country** | ▪ Focus on countries in Asia, Europe, North America, and Oceania<br>▪ Analyze only single countries' AFSC | • Lack of studies on countries in Africa and South America<br>• Lack of comparative analysis of country- and product-specific risk/resilience | ➢ Conduct AFSC risk/resilience studies in Africa and South America<br>➢ Conduct comparative cross-country AFSC risk/resilience analysis with interdisciplinary teams of researchers |
| **Agri-food products** | ▪ Focus mainly on dairy products, wine, beef, fruit, fresh vegetables, and processed food | • Lack of studies on pork, infant food, animal feed and beverage supply chains | ➢ Conduct research on building AFSC resilience in pork, infant food, animal feed, and beverage supply chains |
| **Methodology** | ▪ Use various research methodologies, including case study (34) (21.05% single case study and 14.74% multiple case studies), modeling (23), theoretical and conceptual (12), surveys (6), literature review (6), and mixed-methods approaches (14)<br>▪ All studies adopt a cross-sectional strategy | • Lack of cross-country analysis using multiple case studies as a research methodology<br>• Lack of research using longitudinal strategy | ➢ Conduct cross-country analysis of AFSC risk/resilience management using multiple case studies<br>➢ Conduct research using a longitudinal strategy |
| **AFSC risk identification and assessment** | ▪ Explore AFSC risks from different perspectives: risk prioritization and interrelationships building (9), quantitative decision models for agri-food business (1), the impact of risks on AFSC performance (2) and transportation systems (1), power asymmetry in AFSC crises (1), identification and analysis of how AFSC risks impact on AFSC's coordination (1), potential for climate shocks to cascade within a region (1) | • Lack of risk identification and assessment using cross-case analyses<br>• Lack of prioritization and interrelationship building using two or more methods | ➢ Conduct cross-case comparisons to better understand product- and country-specific risk types<br>➢ Perform risk prioritization and interrelationship building using two or more decision-making methods |
| **Resilience capabilities for building AFSC resilience** | ▪ Help to understand AFSC resilience with a focal company perspective (1), a critical realist paradigm (1), AFSC resilience features (3) and resilience theoretical framework building (2)<br>▪ Identify AFSC resilience capabilities' in different types of supply chains, including mango (1), cold chains (1), perishable products (1), processed foods (1), and milk supply chain (3)<br>▪ Quantify AFSC resilience in different contexts, such as perishable good with possible port shut downs (1), grain supply chain with an upstream natural disaster (1), robust supply chain design or optimization with uncertain supply and intentional disruptions (3), recovery model for food contamination (1), identification and quantification of AFSC resilience performance indicators (1),<br>▪ Investigate traceability from different perspectives, such as information systems and technology development (5), production and distribution planning (2), information asymmetry and traceability incentives (1), traceability framework building (1),<br>▪ Investigate innovation to build AFSC resilience, such as industry 4.0 (9), and mobile technology (1),<br>▪ Explore AFSC collaboration in supplier selection (2), collaboration level (1), collaborative commerce (1), farmers' entrepreneurship and participation (2), contract application (3), trust-building (1), and vertical and horizontal collaboration (2),<br>▪ Explore redundancy in corporate social responsibility (1), contingency plans (3), sourcing strategies (1), multiple supply chains (1), and response diversity (1)<br>▪ Investigate KM to build AFSC resilience, such as knowledge sharing (1) and relational networking (1),<br>▪ Analyze consumer effects on building AFSC resilience, such as consumers' responsibility (1), trust (2), consumers' perceptions of risks (1), and AFSCs' coordination based on consumers' behavior (1) | • Failure to examine the relationship between a focal company's resilience and the whole AFSC's resilience<br>• Failure to identify resilience capabilities from the perspective of the wine, infant food, and animal feed supply chains<br>• Failure to measure AFSC resilience<br>• Failure to identify and priorities different resilience capability factors in building AFSC traceability<br>• Lack of empirical research on the impact of the application of different industry 4.0 technologies on AFSC resilience<br>• Failure to consider supply chain collaboration as a whole and investigate its relationship with other resilience capabilities<br>• Failure to consider what kinds of resources (tangible and intangible) and capabilities should be reserved to promote resilience<br>• Failure to consider the role of knowledge mobilization in building AFSC resilience<br>• Failure to investigate how to foster resilience from the consumers' perspective | ➢ Examine whether a focal company's resilience may foster the whole AFSC's resilience and through which channels<br>➢ Conduct exploratory case studies to understand what AFSC resilience capabilities can be used for pork, infant food, animal feed, and beverage supply chains<br>➢ Develop a unified resilience assessment framework to evaluate AFSC resilience<br>➢ Conduct empirical research to identify and priorities different resilience capability factors in building AFSC traceability<br>➢ Conduct empirical research on the impact of industry 4.0 technologies on AFSC resilience<br>➢ Consider supply chain collaboration as a whole, and investigate whether it may foster other resilience capabilities<br>➢ Investigate what resources and capabilities should be fostered and configured to achieve optimal resilience outcomes<br>➢ Conduct research on boundary-crossing mechanisms to tackle knowledge boundaries in AFSC<br>➢ Conduct exploratory case studies to understand the impact of consumers' trust/responsibility on AFSC resilience |
| **The relationships between AFSC resilience capabilities and AFSC risks** | ▪ Analyze the effects of different resilience strategies on AFSC risks, such as knowledge sharing on operational risks (1), resilience strategies to reduce ethical issues (1) and COVID-19 pandemic impacts (2), resilience model to reduce quality risks (2), social capital for reducing climate risks (1), trade-offs between disruption and resilience strategies (1), local AFSC resilience to constitutional change (1), food inspection agency to reduce food safety issues (1), resilience model for earthquakes (1), vertical and horizontal supply chain collaboration to reduce vulnerabilities (1), and collaboration to reduce demand uncertainties (1) | • Failure to clarify the relationship between AFSC resilience capabilities and AFSC risks<br>• Failure to consider the positive effects of AFSC risks in facilitating AFSC resilience | ➢ Develop empirical resilience models to clarify the relationship between AFSC resilience capabilities and AFSC risks<br>➢ Revisit existing studies and conduct exploratory case studies to investigate a what level of risk triggers which activities in the AFSC and fosters AFSC resilience |
| **Understanding the relationship between resilience and other disciplines** | ▪ Resilience and environmental management, for instance to understand the alignment between resilience and environmental sustainability (2), and the relationship between resilience practices and environmental sustainability (2), and analyze factors inhibiting resilience and environmental sustainability (2)<br>▪ Resilience and human immune systems, such as using the concept of human immune systems to build SCRes (1) | • Failure to consider how to build LARS (Lean, Agile, Resilient, Sustainable) AFSCs<br>• Failure to consider resilience in other systems/disciplines and clarify the relationship with AFSC resilience | ➢ Summaries the characteristics of lean, agile, and sustainable AFSCs, and combined with the characteristics of resilient supply chains to create a LARS AFSC model<br>➢ Consider academic cross-pollination from other disciplines (e.g., medicine and engineering) and add new dimensions to AFSC resilience |

*Note*: Numbers in brackets refer to the number of papers

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