

# Supply chain sustainability and risk management in food cold chains – a literature review

Risk  
management in  
food cold  
chains

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## Abstract

**Purpose** – This article aims to evaluate published food cold chain (FCC) literature against risk management and supply chain sustainability concepts.

**Design/methodology/approach** – The article uses the theory refinement logic proposed by Seuring *et al.* (2021) to analyze the contents of FCC management-related literature published over the past 20 years. A sample of 116 articles was gathered using Web of Science and subsequently analyzed. The respective articles were then systematically coded against the frameworks of Beske and Seuring (2014) and Vljajic *et al.* (2012), which focused on building sustainable and robust supply chains, respectively.

**Findings** – The literature review revealed that debates around managing contemporary sources of disruptions/vulnerability and making FCCs more sustainable and resilient are gradually developing. However, an overarching risk management perspective along with incorporating social and environmental dimensions in managing FCCs still needs the adequate attention of the respective research community.

**Research limitations/implications** – The deductive internal logic of theory refinement approach used in this paper could have been further strengthened by using additional frameworks. This limitation, however, opens avenues for further research. The findings of the paper will stimulate the interest of future researchers to work on expanding our understanding related to sustainability and risk management in FCCs.

**Originality/value** – The paper is the first attempt to organize published FCC literature along dimensions of supply chain sustainability and risk management. The paper thus provides the respective researchers with a foundation that will help them adopt a focused approach to addressing the research gaps.

**Keywords** Food cold chain (FCC), Sustainable supply chain management (SSCM), Literature review, Vulnerability, Risk management

**Paper type** Literature review

## 1. Introduction

Concerns to evaluate food value chains for their sustainable performance are increasing in recent times (Mangla *et al.*, 2018; Siems *et al.*, 2021). On the other hand, supply chains handling perishables are more intricate to manage owing to the product vulnerability and associated physical and market risks. Challenges like supplier failures, supply/demand fluctuations and quality deprivation lead to compromising the competitiveness of these supply chains in domestic and global markets. Furthermore, the challenges are further exacerbated if one appreciates the critical nature of the products they deal with and the multi-disciplinarity of

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food cold chains (FCCs). Efficient management of FCC thereby becomes an even daunting task for the respective managers. Furthermore, a string of food scandals in recent past (Wee *et al.*, 2015; Smith and McElwee, 2020) and fragility of the established supply chain structures brought to light by COVID-19 (Kazancoglu *et al.*, 2022) have accentuated the need to make food supply chains more resilient and sustainable. Consequently, the importance of building sustainable and robust infrastructure of food supply chains is being increasingly realized by the relevant stakeholders (Durach *et al.*, 2017; Gholami-Zanjani *et al.*, 2021).

Perishable products are inherently prone to deterioration with time, leading to huge economic losses and food safety issues. A consistent monitoring of storage and transportation environment thus becomes vital if one has to slow down the products' deterioration and growth of certain microorganisms having shelf life-limiting characteristics (Ovca and Jevšnik, 2009; Wang and Zhao, 2021). The quality of perishable products like medicines, blood, flowers, fresh fruits and vegetables, seafood, processed meat, dairy products and frozen food remains highly dependent upon the environmental conditions under which they are stored and moved along the supply chain. Inappropriate handling, non-availability of related equipment and poor transport infrastructure results in substantial product losses. In the food and agriculture sector, food loss or waste approximately amounts to one-third of global production in terms of weight due to poor product handling during storage and transportation operations.

Food supply chains, because of certain inherent characteristics like seasonality and relatively shorter shelf life of the products, are more vulnerable to supply disruptions. Furthermore, in the wake of stringent standard requirements and higher consumer expectations on food integrity, the quality parameters of the product itself can also not be compromised.

In recent years, academicians and practitioners have therefore focused their attention on designing robust food supply chains capable of addressing the challenges of disruptions (Shashi *et al.*, 2018). This has resulted in development of extensive literature dealing with various dimensions of FCCs. Furthermore, the advent of industrial scale processing of fresh and packaged food has brought to light sustainability-related concerns associated with how food supply chains operate (Aruoma, 2006). Incorporating sustainability-related principles in management of FCCs has therefore time and again been advocated by concerned researchers (Validi *et al.*, 2014; Sgarbossa and Russo, 2017). An overview of the published literature around FCC reveals that optimally designing FCC to make it more robust in face of contemporary supply chain challenges particularly in the aftermath of pandemic (Qian *et al.*, 2022) and making it more sustainable remain two core debates (Kaipia *et al.*, 2013). However, within the domain of FCC, the literature around both debates, i.e. designing resilient and robust cold chains and supply chain sustainability, though extensive remains disorganized and disjointed. Contemporary research, on the other hand has revealed that the concepts of robustness/resilience and sustainability are not only interrelated, but can also potentially complement each other for designing effective and efficient supply chains (Nayeri *et al.*, 2021; Kazancoglu *et al.*, 2022; Silva and Ruel, 2022).

Appreciating this research gap, our research intends to assimilate and organize the FCC-related literature around the themes of risk management and sustainability. We have used the frameworks proposed by Vlajic *et al.* (2012) and Beske and Seuring (2014) to analyze the related literature. The former for examining supply chain risk and the latter for appreciating sustainability perspective in the published FCC literature. To achieve this, the results of the current work are derived by coding and analyzing FCC-related literature against the constructs defining external and internal sources of vulnerability for designing robust supply chains (Vlajic *et al.*, 2012; Wieland and Wallenburg, 2012) and respective indicators of sustainability (Beske and Seuring, 2014). In doing so, the current research provides a clearer understanding of how the concepts of risk and sustainability are examined by the researchers

working in the domain of FCC. This will help future researchers in integrating both concepts on theoretical front, while also enabling practitioners to approach FCCs with intention of making them more robust and sustainable at same time.

The rest of the paper is organized as follows. The next section presents the background and introduces the relevant terminology and frameworks. Section three elaborates the research methodology. Next, the descriptive findings of the literature review are presented in section four. Section five and six elaborate on the supply chain sustainability and risk-related debates in FCC-related literature respectively. Section seven presents the discussion and towards the very end the conclusion is presented in section eight.

## 2. Literature review

### 2.1 Food cold chain management

The equipment, facilities, processes and information management structures utilized to preserve and enhance the shelf life of perishable products from production to the end consumer are collectively referred to as “cold chain” (Montanari, 2008; Tsai and Pawar, 2018). One of the important factors on which perishable products’ quality and shelf life depend is the maintenance of appropriate temperature conditions (Montanari, 2008). Pre-cooling facilities, controlled atmosphere storage warehouses, refrigerated vehicles, refrigerated display cabinets and consumers’ refrigerators, help avoid temperature abuse of perishables and form key constituents of cold supply chain infrastructure. Furthermore, modern day cold chain management is multi-disciplinary in nature, in the sense that it requires an understanding of the product itself (e.g. perishable food, fresh agriculture produce, medicines and seafood), logistics, information and communication technologies (ICT), civil engineering and also the mechanisms of heat transfer.

The intersection of agriculture and food sciences, construction and logistics management, ICT and thermodynamics set the case of FCCs distinct from more conventional supply chains dealing with non-perishable products. A typical FCC consists of pre-cooling facilities, cold stores and warehouses, refrigerated carriers and traceability measurement instruments (Joshi *et al.*, 2012). The performance of FCC depends on multiple factors, which can be categorized under five broad categories, i.e. infrastructure, integration, stakeholders interest, value addition and partners’ performance (Shashi *et al.*, 2018). Furthermore, FCCs, specially those dealing with fresh produce “feature high fresh food quality and safety, high energy consumption, and poor economic and environmental sustainability” (Liao *et al.*, 2023).

Food is lost during production, storage, transportation and retailing in low-income countries whereas in developed economies, food is primarily wasted at retail and consumer premises (Vlajic *et al.*, 2012). However, the amount of food loss does not differ substantially in developed and developing economies. Enhancing awareness of consumers and government’s legislation on food safety has upgraded food supply chains. Food supply chains, particularly fresh FCCs, are inherently prone to multiple risks and uncertainties (Van Der Vorst and Beulens, 2002). Short shelf life due to the perishable nature of the fresh products, stringent traceability requirements, multiple suppliers, long distances, demand and supply-related market uncertainties and operational inefficiencies are factors that add to the complexities of managing fresh food supply chains. Consequentially, supply chains dealing with fresh agriculture produce must devise exclusive mechanisms and innovative strategies to preserve the respective products’ integrity and quality (Huang *et al.*, 2023).

Developed economies have focused much on developing FCC infrastructure as it remains the prerequisite to the skillful execution of cold chain processes to gain such advantages as prolonged shelf life and better quality and quantity of fresh agriculture produce. Development of a sound FCC infrastructure is dependent upon holistic integration of all the respective actors from producer/farmer until the end consumer. Latest advancements in

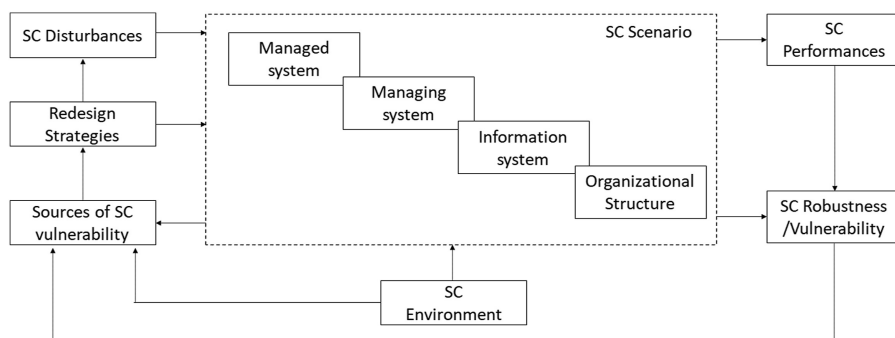
the area of ICT have made possible efficient and effective exchange of information among geographically dispersed and otherwise disconnected supply chain actors (Loisel *et al.*, 2021). The coordination among supply chain actors is of pertinent importance for building robust FCC, capable of achieving shared objectives of concerned stakeholders (Van Der Vorst and Beulens, 2002). Real-time exchange of information has enabled better management of demand and supply requirements by enhancing shelf life of products. Moreover, state-of-the-art decision support systems have helped firms to avoid products' quality and quantity loss and better educate consumers about the involved processes, which is considered an efficient trust building instrument (Busse *et al.*, 2016).

The quality of fresh products remains a linear function of time at a specific temperature. Time and temperature thus remain two important factors determining the shelf life of perishable agriculture products (Ndraha *et al.*, 2018). Efficient logistics and supply system provide a series of facilities for maintaining ideal conditions for handling respective products within a given temperature range, from the point of origin to the end consumer (Tsai and Pawar, 2018). Temperature-controlled supply chains thus remain prerequisite for proper post-harvest storage and transportation of food products. Modern technologies like controlled atmosphere storage and modified atmosphere packaging have made it possible to navigate and monitor the temperature and humidity of perishable products all along the supply chain and consequently increase their shelf life (Huang *et al.*, 2023, Hsiao *et al.*, 2018).

Moreover, value addition and cost minimization through making supply chains more efficient have become the focus of fresh food distribution systems (Sousa-Gallagher *et al.*, 2016). Value addition in the context of fresh food chains is largely dependent on increasing the shelf life of the perishable products and decreasing post-harvest losses. Which itself is the result of collective efforts of all the supply chain actors and not the sole responsibility of the focal firm. As the supply chains have become global, the associated risks posed by human and natural factors have increased. A conscious effort towards making supply chains lean and decreasing the buffer inventories have also made supply chains more prone to supply disruptions. "Vulnerability" thus has become an inherent character modern day supply chain. Moreover, supply chains dealing with perishable products like fresh food are more prone than ever to all the various types of risks having their source in the product they are dealing with or processes they are composed of (Jia *et al.*, 2024).

Having appreciated the challenge, academicians and practitioners have become more focused on designing robust food supply chains capable of attending to the challenges of disruptions (Wieland and Wallenburg, 2012; Durach *et al.*, 2017). Robustness refers to "the degree to which a supply chain shows an acceptable performance in (each of) its KPIs at various levels of disturbances" (Vlajic *et al.*, 2012). Firms, therefore, increasingly find themselves caught in a dilemma with robustness and vulnerability occupying two sides of the pendulum.

Appreciating the challenge, Vlajic *et al.* (2012) have developed a framework (Figure 1) for designing robust food supply chains while taking into consideration the associated uncertainty and risk factors. The theoretical framework takes a comprehensive account of sources of vulnerabilities and disturbances in food supply chains (Vlajic *et al.*, 2012). The authors have categorized supply chain risks in two broad categories, i.e. internal and external sources of supply chain vulnerability. Internal sources of supply chain vulnerability lie within the supply chain scenario, which is represented by managed, managing and information systems and organization structure (see Figure 1 and Table 2). The external sources of supply chain vulnerability remain within the external environment. Some of these are controllable to certain extent, e.g. societal and or financial sources and others are not, e.g. market sources (see Table 2). The current research therefore takes the framework as the core theoretical foundation to investigate the risk management-related debates in the published FCC focused literature (Wieland and Wallenburg, 2012).



Source(s): Adopted from Vlajic *et al.* (2012)

Risk  
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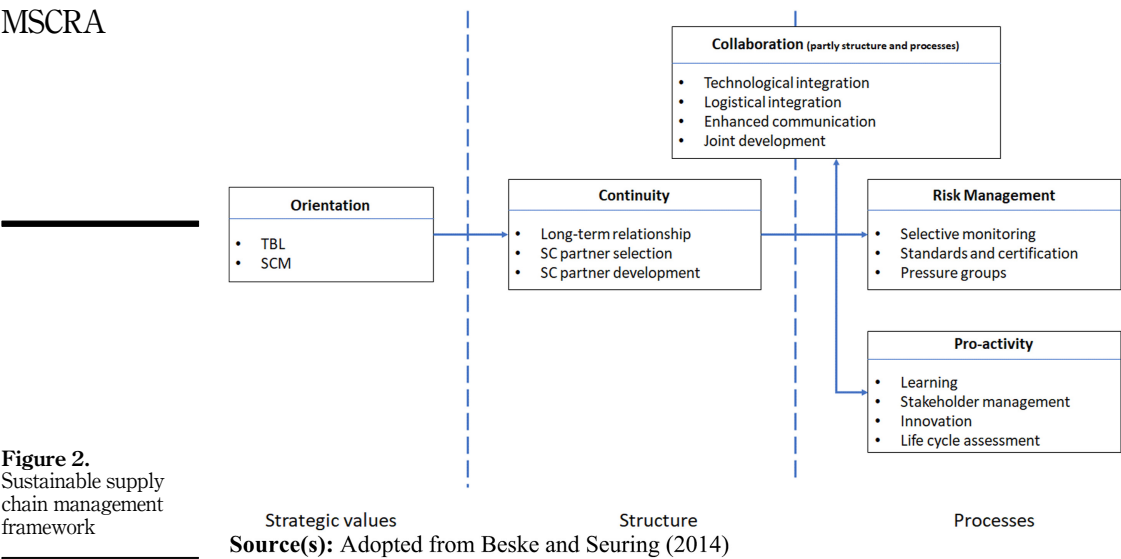
**Figure 1.**  
Framework for  
designing robust FCC

## 2.2 Sustainable supply chain management

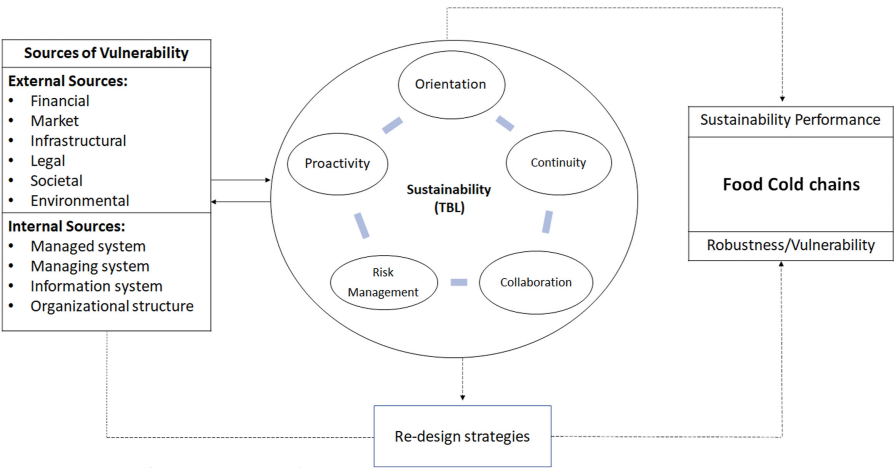
Managing contemporary supply chains on sustainable basis has been presented as a solution for addressing various ecological and social dilemmas that have emerged as a result of uncontrolled rent seeking economic activity in food supply chains (Carter and Easton, 2011; Pagell and Shevchenko, 2014). The domain has considerably evolved over time and continues to develop while taking in its purview new concepts and contexts (Beske and Seuring, 2014). Seuring and Müller (2008) have defined sustainable supply chain management (SSCM) as “the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e. economic, environmental, social, into account which are derived from customer and stakeholder requirements.” This conceptualization of SSCM is broad enough to capture social, economic and ecological development while managing flow of goods/services, information and capital in a network structured supply chain composed of direct and indirect actors. Beske and Seuring (2014) have further elaborated the concept and have presented a framework highlighting the strategic and operational dimensions of SSCM. The framework (Figure 2) while focusing on the categories of orientation towards SSCM, collaboration, continuity, risk management and pro-activity can be considered as a guide that can inform organizations about the strategic, structural and process focused steps that they can take to make their supply chains more sustainable.

Food supply chains due to the fragile and crucial nature of the products they handle have gathered special attention in context of sustainability (Beske *et al.*, 2014; Zhu *et al.*, 2018). Food supply chains (i.e. cold chains dealing with perishable products or those handling grains and related staples) have substantial ecological, social and economic footprint. This has resulted in development of comprehensive literature advocating for and analyzing food supply chains from sustainability perspective (Sgarbossa and Russo, 2017; Zhu *et al.*, 2018). Augmenting the work of Shashi *et al.* (2018), who have conducted a structured review of FCC-related literature and presented a conceptual framework, the current research tends to analyze the FCC literature more from a sustainability perspective. This will help bridge the apparent gap of a conscious analysis of how sustainability-related concepts have been studied by the researchers working in the domain of FCC. Consequently, helping in a more systematic development of domain of sustainable FCC management (Kaipia *et al.*, 2013).

Towards this end we will use the SSCM framework of Beske and Seuring (2014) (Figure 2) to analyze FCC-related published literature. Figure 3 presents a conceptual framework showing our understanding of how the two frameworks, i.e. Vlajic *et al.* (2012) and Beske and Seuring (2014) are interrelated in development of sustainable and robust FCCs.



**Figure 2.**  
Sustainable supply chain management framework



**Figure 3.**  
Conceptual framework

Tables 1 and 2 present an elaboration of the constructs used by Beske and Seuring (2014) and Vljajic *et al.* (2012) in their respective frameworks. This will help the readers acquaint with the constructs in whose backdrop the current research has analyzed FCC literature.

3. Methodology

Systematic literature reviews have played a crucial part in advancing various dimensions of scientific knowledge. Fink (2014) has defined literature review as “a systematic, explicit and reproducible design for identifying, evaluating and interpreting the existing body of recorded documents”. Medicine is credited as the first academic discipline that introduced systematic



Constructs and practices		Explanation	Risk management in food cold chains
Orientation	Triple bottom line (TBL)	This indicates an orientation of top management towards integrating the three dimensions of sustainability at strategic level (Economic, social and environmental)	
	Supply chain	This represents a dedication of managers “to integrate supply chain management thinking and goals into their day-to-day decision making”	
Continuity	Long-term relationship	This represents establishing a trust based mutually beneficial relationship among various supply chain actors at structural level	
	Supply chain partner development	This practice of continuity focuses on development of “overall capabilities of a partner rather than a one-time performance gain”	
	Supply chain partner selection	Supply chain partner selection advocates identifying key supply chain partners that can optimally contribute towards the sustainability-related goals. This may require a reduction in supplier base	
Collaboration	Technological integration	This represents presence of appropriate technology, e.g. IT infrastructure to support efficient collaboration among respective actors	
	Logistical integration	To strengthen collaboration this practice represents engagement of supply chain actors in planning and forecasting-related activities	
	Enhanced communication	This is considered as a practice vital for collaborative approach. Information sharing is perceived as an enabler of collaborative business relationship	
	Joint development	This collaborative practice represents engagement of supply chain partners in practices like joint product development and design for achieving sustainability-related objectives	
Risk management	Selective monitoring	Selective monitoring becomes easier due to implementing standards and an adherence to minimum sustainability performance by various supply chain actors becomes possible	
	Standard and certification	This represents adoption of relevant environmental and social standards (e.g. ISO 14001) as a risk management strategy. The practice also adds legitimacy to business and help integrate external stakeholders of a company	
	Pressure groups	Various pressure groups can be a source of risk, e.g. NGOs which highlight the firms’ weak points and can also be a valuable partner that can provide “knowledge of possible risks and add legitimacy”	
Pro-activity	Learning	This indicates development of an organizational culture and structure that is open to and enables learning from others (i.e. wider body of stakeholders)	
	Stakeholder management	This indicates pro-active engagement with various direct and indirect stakeholders to gather sustainability-related information and counter pressure groups	
	Innovation	This indicates investment in “development of sustainable products and services” to embrace sustainability strategies	
	Life cycle assessment	“This informs product design and, in some cases, supplier selection” for reducing environmental footprint	

**Table 1.**  
Sustainable supply chain management constructs taken from Beske and Seuring (2014)

literature reviews and today they remain significant contributions for advancement of knowledge in many domains (Durach *et al.*, 2017). The field of supply chain management has witnessed an increase in number of systematic literature reviews in recent years which have significantly contributed towards advancing the theory and knowledge (Birkel and Muller,

Constructs and practices		Explanation
Supply chain disturbances		“A minor or major deviation, or failure of one or more logistics processes triggered by unexpected events in the supply chain or its environment resulting in poor performance of the process itself, company and potentially along the supply chain in a given time period”
Redesign strategies		“Sets of strategic and tactical plans and operational actions that aim to reduce the vulnerability of supply chains based on one or more redesign principles that make changes in elements of supply chain scenario”
Supply chain robustness		“The degree to which a supply chain shows an acceptable performance in (each of) its key performance indicators (KPIs) during and after an unexpected event that caused disturbances in one or more logistics processes”
Supply chain scenario		Is an internally consistent view of a possible instance of the logistics supply chain concept, i.e. the managed, managing, and information systems and organization structure”
Internal sources of supply chain vulnerability	Managed system	This “refers to the physical design of the network and a facility and all other elements that perform logistic activities (such as equipment, vehicles and people), as well as product characteristics”
	Managing system	This “refers to planning, control and co-ordination of logistic processes in the supply chain while aiming at realizing strategic supply chain objectives and logistical objectives within the restrictions set by the supply chain configuration
	Information system	This “refers to information and decision support systems within each of the decision layers of the managing system (from annual to daily planning), as well as the IT infrastructure needed”
	Organization structure	This “refers to tasks, authorities and responsibilities of the departments and executives with the organization and supply chain as well as the coordination of tasks in order to realize defined objectives”
External sources of supply chain vulnerability	Financial sources	Financial sources of supply chain vulnerability include such aspects as, market price fluctuation, currency fluctuation and regional economic downturns
	Market sources	Market sources of vulnerability include risks originating from such factors as market decline, variability, and seasonality in availability of raw materials, variability in quality of raw materials and variability in demands
	Legal sources	This depicts vulnerability arising from change in laws and regulations along with change in country dependent rules in food safety
	Infrastructural sources	Infrastructural sources of vulnerability include low level of development in transport infrastructure, not sufficient traffic capacity and uneven level of technological development (industry)
	Societal sources	These sources of vulnerability include political unrests, criminal acts, negative public reactions, industrial actions and changing customer attitudes towards product/process
		These sources of vulnerability include natural disasters, e.g. geological and meteorological, biological factors, manmade hazards and other unpredictable factors

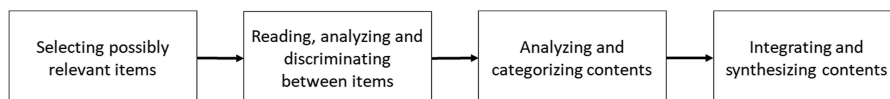
**Table 2.**  
Supply chain  
vulnerability (risk) and  
robustness constructs  
taken from [Vlajic  
et al. \(2012\)](#)



2021). By defining and refining related constructs and concepts, and assimilating the published knowledge, systematic literature reviews have remained in forefront of defining the directions of future research.

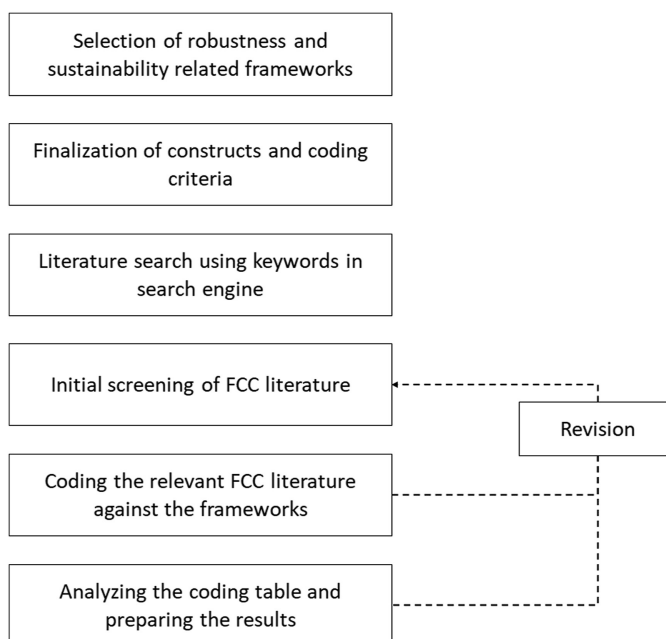
Among the various approaches to conduct literature reviews (see for example, [Shashi et al., 2018](#); [Kolk et al., 2014](#)), employing theory to do systematic literature review remains an established technique ([Zorzini et al., 2015](#)). [Seuring et al. \(2021\)](#) have highlighted four approaches to theory-based literature reviews, which they name as theory building, theory modification, theory refinement and theory extension. The extent research aligns more with the theory refinement approach, by employing theoretical frameworks of [Vlajic et al. \(2012\)](#) and [Beske and Seuring \(2014\)](#) to analyze literature related to FCCs. The former being internal (deductive internal), while later, external (deductive external) to the domain of FCC management. In deductive internal version of theory refinement approach for conducting literature reviews constructs from within the theoretical domain (FCC in our case) are taken to analyze the literature. Contrary to this, in deductive-external version, constructs from outside the theoretical domain are taken to analyze the literature.

Moreover, we followed the recommendations of [Hart \(2001\)](#) to conduct this structured literature review (see [Figure 4](#)). The broad steps proposed by [Hart \(2001\)](#) were further expanded to build the clarity in the literature review process (see [Figure 5](#)). The literature for



**Source(s):** Adopted from Hart (2001)

**Figure 4.**  
Literature review  
process



**Source(s):** Authors' own creation

**Figure 5.**  
Research process

this structured review was gathered using different derivatives of the term “food cold chain” as key words. The web of science search engine gives the possibility of using different keyword combinations to make literature search more comprehensive. An effort has been made to ensure maximum coverage of the relevant literature by using different keywords in the first “rough” search. In this phase of literature selection, we found the keywords “food cold chain, food supply chain, food cold supply chain, food chain, food cold value chain, agriculture cold supply chain, sustainable food chain, sustainable food cold chain, sustainable food supply chain, risk management, and vulnerability”, covered most of the published peer-reviewed articles related to our interest. For the sake of this study, we have used all the possible combinations of these keywords to identify the relevant literature for this study. Consequently, any bias in key word selection was avoided. Web of science and Scopus were used as the key search engine to gather the literature. Initial search yielded a total of 301 articles. To avoid selection of ad hoc list of articles for this review process and work with the most relevant published literature on FCCs, the research team screened the articles gathered during the first search by analyzing abstracts and keywords. In the screening process emphasis remained on selecting the publications focusing on issues like supply chain disruptions, redesign strategies, vulnerability, resilience and/or sustainability in FCCs. This implied all the research articles primarily looking at the FCC from an engineering perspective were dropped. Also, the first search produced articles talking about pharmaceutical cold chains, which were eventually excluded.

Furthermore, the current research took account of only the literature published in English language and in peer-reviewed journals. Consequently, research reports, books, conference papers and working papers were all excluded. As far as the time horizon is concerned we have included all the relevant articles published till 2023 in the review process (from a time perspective the earliest article included in this review is [Sanderson-Walker, 1979](#)). These considerations thereby defined the boundaries of this research which [Seuring and Gold \(2012\)](#) consider as crucial for a quality literature review. This multi-stage screening process finally yielded a total of 116 articles, which were then taken further in the literature review process.

Next, each of the 116 articles was analyzed and coded in MS Excel against the frameworks of [Vlajic et al. \(2012\)](#) and [Beske and Seuring \(2014\)](#). Moreover, the articles were also coded against such aspects as journal of publication, year of publication, methodology employed for data collection, supply chain focus of the respective article (i.e. focal, dyad or supply chain wide) and regional focus. Coding against these dimensions helped us ascertain the target audience, appreciate the predominant methodology employed and understand the foci prevalent in the relevant FCC literature. The binary coding process helped in the later descriptive analysis of the literature while employing different statistical techniques. The procedure was instrumental in getting a clearer appreciation of how the respective authors working in the domain of FCC dealt with the concepts of supply chain disruptions and sustainability. This also helped identifying the research gaps related to development of robust and sustainable FCCs.

It is worth mentioning that we have also run contingency analysis to identify any potential correlations among the various constructs. However, no substantial significant paired relationships among the respective constructs could be identified ([Khalid and Seuring, 2019](#)).

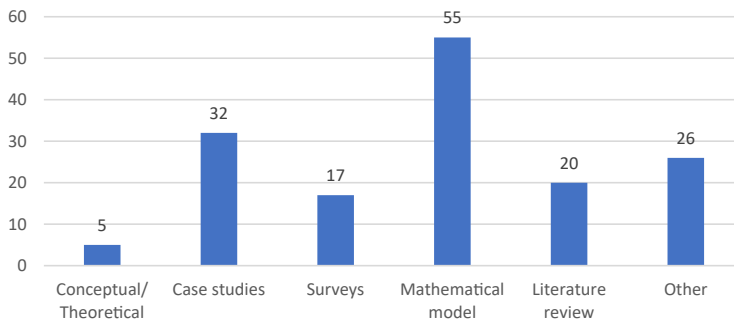
#### 4. Findings

This section will elaborate the methodological character and disciplinary focus of the FCC-related literature. An analysis of the FCC literature in context of [Vlajic et al. \(2012\)](#) and [Beske and Seuring \(2014\)](#) will be presented in the next section.

The findings revealed that 14% of the articles reviewed in this literature review were qualitative while the remaining 86% were quantitative in nature. Moreover, we learned that

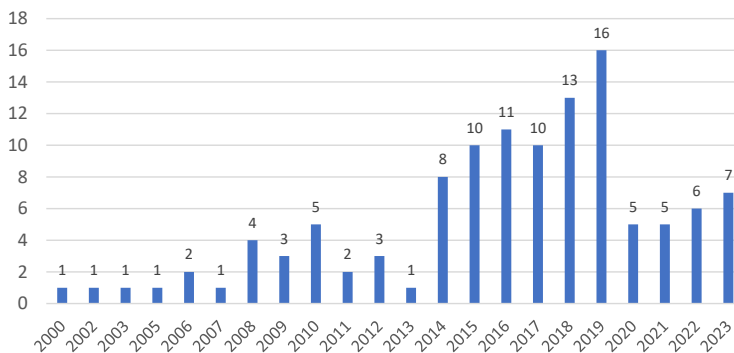
the respective researchers have extensively used various simulation and modeling techniques to analyze FCC. It was learned that bulk of the FCC literature (44% of the papers we have analyzed) is modeling focused, e.g. [Giannoglou et al. \(2014\)](#), [Zhu et al. \(2014\)](#), [Huang et al. \(2023\)](#), [Masudin et al. \(2021\)](#) and [Tsang et al. \(2018\)](#). This is followed by case-based papers which constitute 27% of the articles we have analyzed, e.g. [Defraeye et al. \(2016\)](#), [Liao et al. \(2023\)](#), [Marchi and Zanoni \(2022\)](#) and [Wu and Hsiao \(2021\)](#). Together, the modeling and case-based papers constitute 81% of the sample. The majority of the remaining 19% of the papers have focused on presenting technological advancements happening in the field of FCC and some survey studies, e.g. [Magnussen et al. \(2008\)](#), [Lu et al. \(2021\)](#) and [Arslan et al. \(2023\)](#). A critical observation was the fact that the FCC literature is particularly devoid of sound conceptual and theoretical studies, which may obstruct development of the field (see [Figure 6](#)). The total number of papers in [Figure 6](#) i.e. 155 are more than the articles used in the extant literature review, i.e. 116, since we have categorized some papers as to be employing more than one methodology for support its analysis.

The analysis showed that academic interest in exploring FCC issues is gradually increasing. This is depicted by a consistent increase in number of yearly publications targeting FCC (see [Figure 7](#)). Food focused journals, e.g. *Journal of Food Engineering* and *Food Control* took lead in this development (see [Appendix](#)) by running some special issues between 2014–2019 targeting FCC-related topics (e.g. “responsible research and innovation in the food value chain” in *Food Control*). The sharp decline in FCC literature publications in



Source(s): Authors' own creation

**Figure 6.**  
Methodology  
employed



Source(s): Authors' own creation

**Figure 7.**  
Yearly distribution of  
publications

Figure 8.  
Supply chain focus of  
the FCC literature

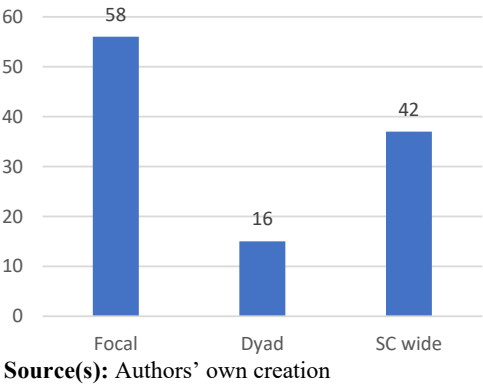
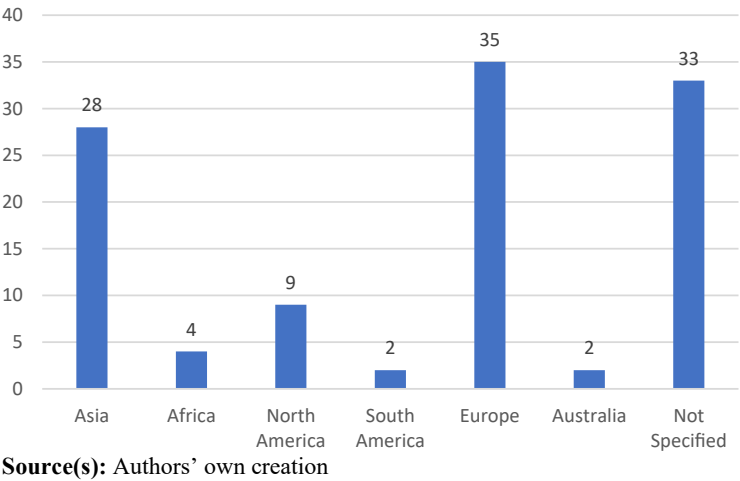


Figure 9.  
Regional focus of the  
FCC literature



2020 can be attributed largely to the disruptive impact of the COVID-19 pandemic. Lockdowns and travel restrictions hindered data collection, while the pandemic's effects on food supply chains prompted a shift in research focus towards addressing new challenges and optimizing cold chain logistics for resilience in the face of unforeseen disruptions in supply and demand, e.g. [Lu et al. \(2021\)](#) and [Qian et al. \(2022\)](#).

As far as the supply chain focus of the FCC literature is concerned, most of the articles are individual firm focused (see [Figure 8](#)) and discuss various dimensions of optimizing firm performance in context of FCCs, e.g. [Calanche et al. \(2013\)](#). Another 37% of the articles we have analyzed tend to analyze the related issues from a comprehensive end-to-end supply chain perspective, e.g. [Jedermann et al. \(2017\)](#), [Arora et al. \(2023\)](#) and [Awad et al. \(2020\)](#).

Furthermore, looking at the FCC literature from a regional perspective, Europe appears to take the lead with 35% of the articles taking FCCs of Europe as their epicenter of analysis, e.g. [Likar and Jevšnik \(2006\)](#) (see [Figure 9](#)). This is followed by 28% of the articles being Asia focused, e.g. [Kuo and Chen \(2010\)](#). 33% of the papers we have analyzed appeared more general in nature and did not mention the regional focus.

A crucial research gap which we intend to highlight here is related to under representation of Africa and South America in FCC literature. However, these continents occupy an

important place in global food chains thus future researchers need to analyze the FCC-related issues in context of Africa and South America.

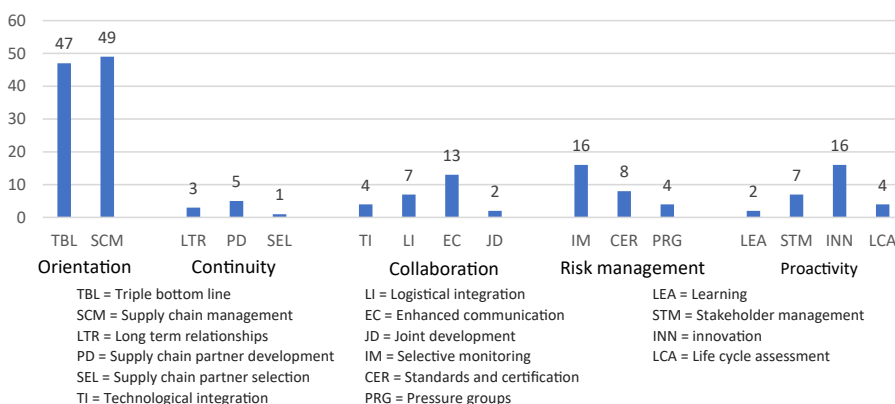
Risk  
management in  
food cold  
chains

## 5. Sustainability in food cold chains

For analyzing FCCs from a sustainable supply chain perspective, we have evaluated FCC literature against the Beske and Seuring (2014) framework (see Figure 2). The framework presents a comprehensive set of sustainable practices, while looking at the supply chain from strategic, structural and process standpoints. The five broad dimensions which represent the all-embracing sustainable supply chain practices are orientation, continuity, collaboration, risk management and pro-activity (see Table 1). Though the framework could be improved further by adding constructs related to such contemporary phenomenon as for example, digitization and market dynamism, they play a part in shaping the modern discourse of SSCM. We consider the framework mature enough to use for the analysis of the subject matter of this study.

The main discourse surrounding sustainability in the context of FCCs has often involved the triple bottom line values, emphasizing economic, social and environmental aspects of sustainability. Regardless of the broad advocacy and refinement of sustainability theory, as mentioned in the work of Touboulic and Walker in 2015, a critical need for further research remains still to delve into the multidimensional aspects of these theoretical propositions into some tangible practices in the context of FCCs. To promote sustainability, it is imperative for practitioners and researchers to bridge this gap and explore the practical characteristics of SSCM research. By doing this, industry practitioners will be able to develop more effective strategies aligning with the broader goals of sustainability and ensure that these principles are not just theoretical ideals but actionable and achievable standards within the FCC industry. Figure 10 presents how frequently various supply chain sustainability-related constructs and practices have been discussed by the FCC researchers. This gives the understanding of relevance and importance associated by contemporary FCC literature with sustainability-related constructs and practices. Consequently, identifying the relevant research gaps and conducting more focused research, targeted at making FCCs more sustainable will become easy and prolific.

Looking at Figure 10, it is obvious that researchers working in the domain of FCC have frequently advocated for incorporating triple bottom line dimension at the firm's strategic



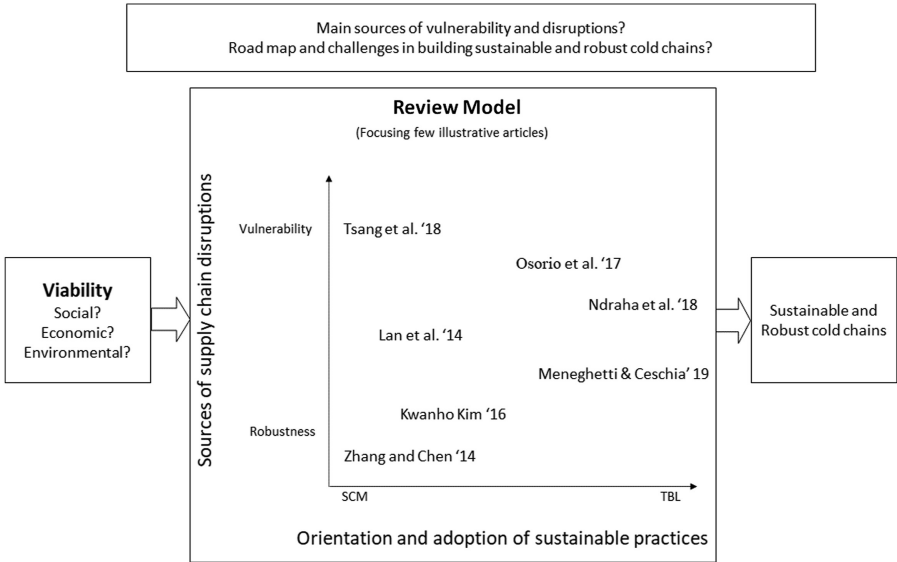
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**Figure 10.**  
Sustainable supply  
chain management  
constructs/practices in  
FCC literature

level and evaluating FCCs from an end-to-end supply chain perspective. The relevant literature thereby underlines the importance of making the supply chain and triple bottom line perspectives part and parcel of the firm’s broader business strategy (Siddh *et al.*, 2021). An orientation of the top management towards sustainability anyhow remains first step in starting the transition process towards making supply chains more sustainable (Silva *et al.*, 2022).

Having said that, looking at Figure 10, it is obvious that the sustainable supply chain practices which are part of the four constructs, i.e. continuity, collaboration, risk management and pro-activity have been scantily referred to by the FCC researchers. For instance, though Beske and Seuring (2014) consider supply chain partner selection, technological integration and joint development as important structural enablers for a firm to achieve its sustainability-related objectives, none of the papers we have analyzed discuss these practices. Similarly, enhanced communication with supply chain partners enabling development of long-term relationships have also been marginally referred to by the FCC researchers, e.g. Hsiao and Huang (2016). Moreover, the relatively advanced and more mature forms of collaboration, i.e. participation in supply chain partner development-related activities and supplier integration on logistical front have also not been considered adequately in the FCC literature. For instance, we found only three articles talking about the partner development in terms of capacity building of growers with advanced production technologies and handling/ transportation of perishables in a sustainable way to achieve the sustainability in FCCs, e.g. Govindan. In Figure 11, we’ve organized articles that primarily delve into supply chain management and the triple bottom line. This arrangement highlights the extent to which these articles connect coded constructs with either robustness or vulnerability assessments.

On the risk management side, the practices like supply chain partner monitoring, use of standards and certifications and compulsion by pressure groups on businesses to become more sustainable have yet to be properly analyzed by the FCC researchers. Looking at this one can conclude that while proper appreciation of risk management-related aspects remains



**Figure 11.**  
Broad overview of  
coded articles

Source(s): Authors’ own creation



vital for the supply chains handling time-sensitive perishable products, FCCs have not been adequately evaluated in this backdrop. This research gap needs immediate attention in the wake of various food scandals brought to light in recent years (Smith and McElwee, 2020). Furthermore, looking at the risk management-related issues in FCCs is also important to avoid any supply-demand mismatch in market to occur, ensure price stability and provide final consumer with healthy food of prime quality. Figure 11 explains the orientation of core articles included in this review either towards sustainability (TBL) or SCM or its focus on robustness or vulnerability based on frequency of majority factors describing main constructs.

Concerning the sustainable supply chain practices grouped under the pro-activity construct, innovation stands out tall in Figure 10. This speaks of the fact that the FCC literature underlines the need of developing novel solutions to optimize performance of FCCs (Zhang *et al.*, 2003; Zhang and Chen, 2014; Zhu *et al.*, 2018). Moreover, most of the innovation-related debates focus on the technological aspects of FCCs. Consequently, there still exists space to analyze innovation in FCC from a business and management perspectives and naturally from an operations and supply chain management-related lens as well. However, other aspects contributing to development of a pro-active and sustainable FCC like learning, stakeholder management and life cycle assessment have failed to gain attention of the FCC researchers.

Looking at the coding results it is apparent that concerned researchers have yet to work on understanding various dimensions of managing FCCs more sustainably. Particularly we need to develop more comprehensive theoretical models, elaborating the mechanism of developing sustainable FCCs.

## 6. Risk management in food cold chains

The FCCs are inherently prone to various types of risks, some of these are more internal in nature, e.g. product-related hazards, and some are more external in their origin, e.g. demand fluctuations. Given the dynamic and uncertain nature of FCCs, vigorously following a comprehensive risk management program becomes eminent to make respective supply chains more robust and resilient (Manuj and Mentzer, 2008; Diabat *et al.*, 2012). Vlajic *et al.* (2012), have presented a comprehensive framework for designing robust food supply chains (see Figure 1). The framework takes into account various food supply chain-related sources of disturbances and vulnerabilities and also presents respective supply chain strategies to deal with them. The framework also captures both internal and external dimensions of food supply chains in context of identifying sources of risks (see Table 2). The authors have categorized food chain-related risks in three broad categories. *Quantitative dimension* relates with “unexpected changes in quantity” of products mostly happening downstream a supply chain. *Qualitative dimension* is concerned with risks associated with “unexpected changes in quality of materials”. Finally, *time dimension* captures the disturbances that are “related to unexpected changes in beginning or ending of process realization, or process duration (i.e. delays or idle times).” Evaluating the FCC literature against this backdrop revealed that though FCC risk-related research has taken account of all three dimensions (sources) of risks, however, qualitative sources of food risks remained the prime focus area (see Figure 11). This is understandable if one appreciates the fact that the food scandals, bringing the food supply chains in limelight of global attention, mostly fall in the domain of “quality dimension” of risk categorization.

Concerning risk management through redesigning supply chains, Vlajic *et al.* (2012) propose two groups of strategies, i.e. *disturbance prevention* and *disturbance impact reduction*. Disturbance prevention deals with “the reduction of disturbance frequencies and its sizes, i.e. acting in advance in order to eliminate, avoid or control any direct cause of disturbances

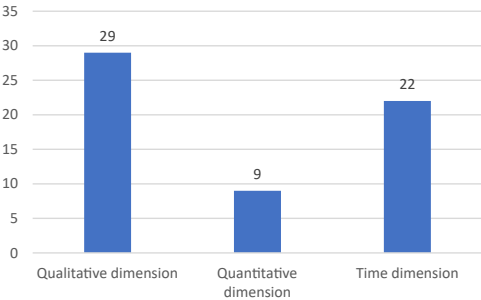
**Figure 12.**  
Nature of food supply  
chain risks

**Figure 13.**  
Redesign strategies

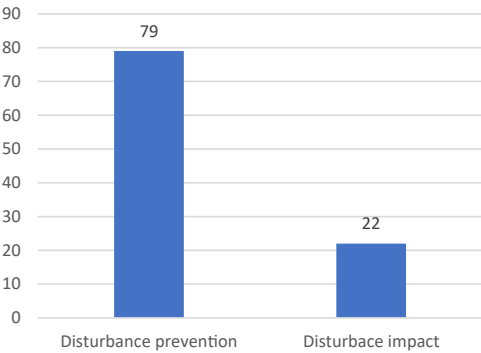
(which can be any source of vulnerability)". Disturbance impact reduction strategies imply "a change of the characteristics of the supply chain scenario elements, such as using buffer stocks or increasing process flexibility". The results of our literature review disclosed that bulk of the FCC literature, i.e. 79 out of 116 articles we analyzed talked about disturbance prevention strategies (see [Figure 12](#)). Therefore, the literature seems proposing adoption of pro-active measures to prevent disturbances from happening rather than adopting a reactive approach to contain the risk once it has hit the food chain.

FCCs are part of a wider ecosystem and do not operate in isolation. The dynamic nature of this broader business environment creates uncertainty and making supply chains vulnerable and fragile ([Manuj and Mentzer, 2008](#)). Operationalizing framework of [Vlajic et al. \(2012\)](#), we have studied the FCC-related literature against six sources of external risks, i.e. financial sources, market sources, legal sources, infrastructural sources, societal sources, environmental sources. The results are shown in [Figure 13](#) (a, b, c, d, e, f).

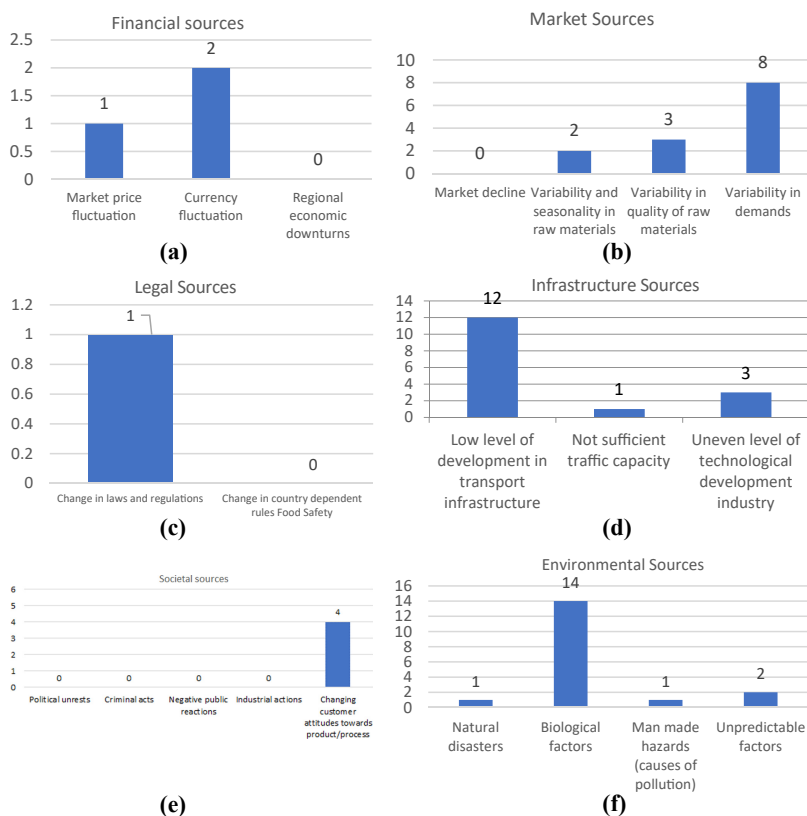
The three external sources of FCC risks which stand out tall in [Figure 14](#) are risks due to variability in demand (b), risks originating from low level of development in transport infrastructure (d) and risks due to biological factors (f). This shows that FCC literature considers these three external sources as relatively more important in making food supply chains vulnerable. Market demand uncertainty due to changing customer demands, coupled with phenomenon like Bullwhip effect are some of the factors creating demand variability-related risks ([Lan et al., 2014](#); [Raut et al., 2019](#)). Food supply chains operating in low-income/emerging economies having ill-developed communication and transportation infrastructure are exposed to yet another type of external risks ([Siddh et al., 2020](#)). Poor infrastructure in



**Source(s):** Authors' own creation



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**Figure 14.**  
External sources of  
food cold chain risks

these regions restricts the efficient movement of food products from farm to market resulting in significant post-harvest losses. Likewise, absence of adequate cold chain infrastructure may compromise the recommended transport conditions as temperature sensitive products travel from farm/factory to market/consumer. Consequently, quality deterioration or even food spoilage results in erosion of service quality and revenue losses (Aung and Chang, 2014). Perishable food products are also prone to biological risks as they move along the supply chain. Contaminations caused by unhygienic food handling coupled with lack of appropriate transportation and storage mechanisms favors growth of food spoiling biological agents. Both fresh and processed food chains remain susceptible to biological hazards, requiring implementation of efficient monitoring and control mechanisms along food supply chains (Jedermann *et al.*, 2017; Ndraha *et al.*, 2018).

In addition, the review revealed that the other external originators of FCC risks, considered important by Vlajic *et al.* (2012), have not been adequately captured by the FCC literature. For instance, factors like political unrest, negative public reactions, economic downturns and changes in food safety rules though important in today's dynamic business environment, still need to be properly studied in context of FCCs. Likewise, the market-related factors making FCCs susceptible, like variability in quality and quantity of raw materials due to seasonal nature of food products are yet to be adequately analyzed.

In addition to external sources, FCCs are also vulnerable owing to characteristics internal to the supply chain. Vljajic *et al.* (2012) have categorized the internal sources of food supply chain risks in four groups, i.e. managed systems, managing systems, information systems and organizational structure (see Table 2). Our literature review has also analyzed how the respective scholars have looked upon these internal sources of FCC disruptions (see Figure 15 a, b, c, d). Figure 15 shows that the FCC literature has dealt relatively more often with internal sources of disruption that fall in the purview of “managed system” than others. As has been mentioned earlier in Table 2, the term “managed system” takes account of supply chain disruptions caused by the loopholes in physical design of supply chain network, facilities, logistics infrastructure and product characteristics. Furthermore, within the managed systems the greater attention has been given to analyzing the restrictions to use of sophisticated equipment as a source of FCC disruptions (28 papers talk about this phenomenon, e.g. Wang *et al.* (2010), Jedermann *et al.* (2017)). This on one hand shows the scholars are increasingly appreciating the usefulness of employing modern technology to monitor the food as it travels along a cold chain, while on the other this reveals that the limited use of the related technology remains a point of concern.

Having said that, apparently, except managed systems the other sources of FCC disruptions still need to be worked upon rigorously. Furthermore, Figure 15 (b, c, d) shows that we still need to inform ourselves how FCC disruptions originating from managing systems, information systems and organizational structure are affecting the efficiency of FCCs.

A particular exception is vulnerability due to “lack of information visibility”, part of information systems group (Busse *et al.*, 2016). The source of risk has been talked about by 29 papers. Apparently, this in congruence with the observation in managing systems category where risks due to “restrictions of use of sophisticated equipment” got the most frequency counts. As in the FCCs the sophisticated equipment is very often used to communicate the characteristics of local environment in which food has been stored or transported in the chain to its various stakeholders (Wang *et al.*, 2010).

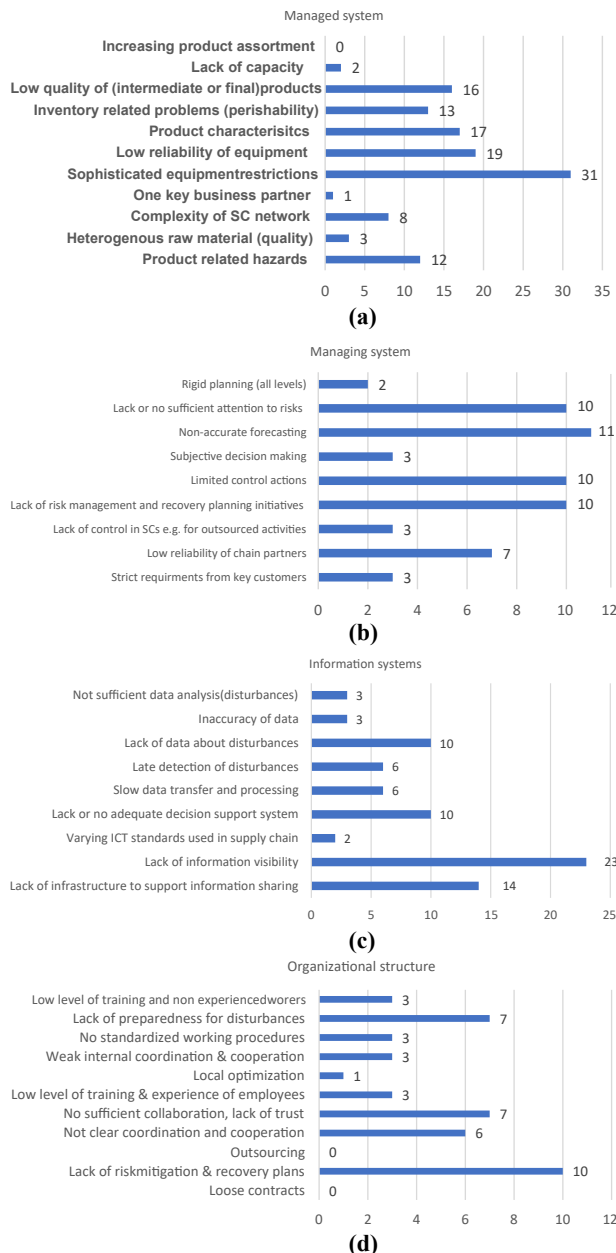
Taking stock of the results of the literature review in context of framework proposed by Vljajic *et al.* (2012), it is obvious that from a research perspective we still have to travel a long way to make FCCs more resilient and robust. This opens many opportunities of future research targeting implications and management of internal and external sources of risks for the FCCs.

## 7. Discussion

Cold chains are crucial for continuous supply of fresh and healthy food to human beings. This remains true both for the food consumed as fresh as well as for the packaged/frozen food. Efficient management of the FCCs makes possible the delivery of the product(s) as per consumer needs, thereby avoiding any demand/supply mismatch in the market. Cold chains by ensuring the integrity of food as it travels along the chain make possible for the producers (farmers and/or food processors) to get the optimum return for their hard work. This enables the producers’ efforts not get spoiled owing to the environmental factors which can easily be manipulated by human intervention. The resulting returns at farm and/or factory levels eventually create more employment opportunities along the food value chain and contribute to societal growth. On the other hand, failure consequences of these life sustaining supply chains go beyond consumer dissatisfaction or firm revenue and may culminate in a societal chaos (Khan *et al.*, 2022). Likewise, incompetent administration of food chains result in creation of huge wastes, managing which remains a mammoth ecological challenge we are struggling to deal with (Kaipia *et al.*, 2013; Krishnan *et al.*, 2020).

Due to their importance not only from a business but also from social and ecological perspectives, researchers have been analyzing FCCs from multiple dimensions, these include, technology (Magnussen *et al.*, 2008), management (Ndraha *et al.*, 2019), logistics (Zhang and Chen, 2014), thermodynamics (Ndraha *et al.*, 2018), product (Jedermann *et al.*, 2017) and engineering (Mercier *et al.*, 2019) perspectives. This corresponds with the multi-disciplinary nature of FCCs. These varied efforts of academic inquiry, bring diversity and enable looking

## Risk management in food cold chains



Source(s): Authors' own creation

**Figure 15.**  
Internal sources of food cold chain risks

at the phenomenon under investigation from multiple standpoints. However, organizing this diverse literature becomes eminent to keep related debates on track, highlight research gaps, give a direction to future researchers and thus support healthy growth of the discipline itself. In this context, literature reviews remain an important tool to enable gradual advancement of

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knowledge in a systematic fashion. Literature reviews remain an important part of logistics and supply chain management-related research, contributing towards development of theoretical frameworks, broadening horizon of academic research and providing practical insights (Touboulic and Walker, 2015; Durach *et al.*, 2021).

The extant literature review contributes to the advancement of FCC literature on two fronts. First, on the methodology side, we have employed theory refinement approach of Seuring *et al.* (2021), to assimilate the related literature. The extant research thereby further develops and connects the predominant techniques of conducting literature reviews in domain of FCCs with theory. The research will thus guide relevant future researchers to use literature reviews as a theory building tool. While confining ourselves in the extant research to analyze FCC literature against the sustainability and risk-related theoretical constructs, we have shown how theory can be employed to make sense of the published literature and contribute to the development of the field.

Risk management and Sustainability in the FCC can be considered as interconnected. This interconnection stalks from the complex nature of cold chain operations, which involve transportation, storage and distribution, making them vulnerable to associated risks. Sustainable practices in FCC can reduce the environmental impacts by minimizing energy consumption, emissions and food waste. Moreover, they comprise the concepts of social responsibility, ensuring fair labor practices and sustainable engagement, which are vital for risk management. Economic resilience can also be strengthened by sustainable investments, offering protection and reducing costs may cover financial risks. Increasing compliance with regulatory standards and meeting stakeholder expectations further mitigate risks and maintain reputation. Consequently, a holistic approach, considering broader impacts, can enable a comprehensive cold chain management strategy.

Second, making FCCs sustainable and resilient have been highlighted as a way forward in backdrop of volatile business environment (Zanoni and Zavanella, 2012; Stone and Rahimifard, 2018). The pandemic has further fortified the importance of these concerns (Qian *et al.*, 2022). In this context, while focusing on supply chain sustainability and risk management, the findings of the literature review show how the two concepts have been taken up by the FCC researchers. This has helped organize and appreciate the by far discrete FCC literature around the two core themes. The related research gaps have been highlighted and the analysis will thereby serve as the first step in specifying the direction of FCC-related future research targeting sustainability and risk management concepts.

Concerning sustainability, it has been observed that the FCC researchers have loudly advocated for making triple bottom line principles and an end-to-end supply chain orientation part of the mindset of the company (Pagell and Wu, 2009). This will require an emphasis of the firm's top management and a dedication to make FCC operations more sustainable while appreciating a holistic supply chain understanding. A focus on vision and mission remains the first step if the intent is to disrupt the status-quo for good. However, unless and until the novel ideas become part and parcel of firm's culture and translate into routine activities, the fine notions remain abstract and over time lose their value.

Unfortunately, the literature review reveals a likewise case for sustainability in context of FCCs. Leaving the triple bottom line focused strategic values aside, the structure and process-related supply chain aspects have largely been overlooked in the debate of sustainability in FCC literature. This indicates little appreciation for the practical relevance of sustainability theory by the researchers working in domain of FCCs. Though the sustainability theory has been extensively advocated and fine-tuned (Touboulic and Walker, 2015), the research still needs to evolve on exploring various dimensions of translating those propositions into practice in context of FCCs. This acknowledgment shall encourage understanding and evaluating the structure and process related aspects of FCCs in the backdrop of sustainability. We believe focused efforts in this direction will help guide practitioners in addressing pressing questions and concerns and consequently contribute to making FCCs more sustainable.



Regarding risk management in FCCs, the two theoretical frameworks we have used for this literature review complement each other. Analysis of FCC literature against [Beske and Seuring \(2014\)](#) framework has revealed little appreciation for the risk management-related practices by FCC researchers. [Vlajic et al. \(2012\)](#) have further elaborated the various dimensions of food supply chain-related risks. Coding and subsequent analysis of FCC literature against the [Vlajic et al. \(2012\)](#) framework supports the findings of [Beske and Seuring \(2014\)](#) in terms that FCC literature still needs to evolve on risk-related dimensions. Furthermore, the findings of the review revealed that FCC literature has mainly talked about the food quality-related risks, while overlooking risks having their source in “pure” market-related factors, e.g. supply/demand mechanisms. Based on this one can see that we need to streamline our focus and understand how the various dimensions of financial, market, legal, infrastructural, environmental and social risks are impacting the FCCs. Also, we know that various risks cast their shadows differently on supply chains operations ([Rao and Goldsby, 2009](#)). An understanding of risk impact helps manage respective risks more appropriately and more attentively. The extant review shows that the FCC literature needs to evolve on understanding the risk impact. By far the prime focus has remained on risk prevention ([Baldera Zubeldia et al., 2016](#)), more focused approaches on understanding risk impact can help us develop tailored strategies to effectively deal with FCC-related uncertainties.

From the relationship management perspective, efficient handling of time-sensitive products along the supply chain inherently demands close coordination among the respective actors. FCCs being responsible for storage and transport of perishable products demand trust-based relationships to be nurtured among the respective actors. Supply chain structures developed on basis of long-term relationships have been considered as a fundamental requirement for making them sustainable ([Beske and Seuring, 2014](#)) and resilient ([Scholten and Schilder, 2015](#)). However, the review showed that by far the FCCs have rarely been evaluated in perspective of supply chain relationships. This is quite surprising in terms that agriculture and food focused literature evaluating food chains from a governance perspective advocate both informal and formal relationships playing their part in the functioning of respective supply chains ([Zhang and Aramyan, 2009](#)).

### 7.1 Future research directions

Though it is always challenging to clearly categorize and identify the current state of theory related to a particular domain of inquiry, using the terminology of [Durach et al. \(2021\)](#), the findings of the current literature review shows that the FCC literature still is in a “nascent state of theory”, as answers to many fundamental “why” are still missing. The literature review highlights extensive avenues of future research in the domain of FCC. The current research revealed that the contemporary FCC management-related debates mainly target the technological and modeling aspects. However, because of the perishable and crucial nature of the products they handle, FCCs also demand academic scrutiny from risk and sustainability perspectives. The results of this review have highlighted that the FCC literature still needs to evolve in these dimensions. Furthermore, we still need to fully understand the dynamic attributes of relationships in FCCs to make them more sustainable and resilient. Some of the questions which future research shall try to explore have been highlighted in [Table 3](#).

1	How food cold chains can be optimally structured to make them more sustainable?
2	How the supply chain design attributes impact food cold chain sustainability?
3	How inter-firm relationships impact sustainable performance of food cold chains?
4	Which factors will determine the food cold chain resilience in post-COVID world?
5	How can we make food cold chain more resilient against the external risks?

**Table 3.**  
Potential future research questions

### 7.2 Research implications

We believe this work will contribute to the development of FCC-related literature in at least three ways. First, this will provide future researchers with a clear appreciation of the current state of research at the intersection of vulnerability, resilience and sustainability in context of fresh FCCs. This will trigger new research questions and stimulate further research in the field. Second, the findings of this paper have highlighted that the research in the field has overlooked environmental and societal sources of risks impacting FCC. Supply chains are considered as part of the wider socio-ecological landscape (Wieland and Wallenburg, 2012). Overlooking the relationship of FCC with the wider environment in which they operate will do little good in developing our understanding of operational and strategic features of the respective supply chains. By underlining the missing link between FCC and wider society, this literature review will encourage systematic exploration of interaction between the two.

### 7.3 Research limitations

The deductive internal logic of theory refinement approach, used in this paper, could have been further strengthened by using more diverse theoretical frameworks. This limitation, however, opens avenues of further research. The findings of the paper will stimulate interest of future researchers to work in greater details on expanding our understanding related to sustainability and risk management in FCCs.

## 8. Conclusion

Interest for understanding the functioning of FCCs has been growing among the stakeholders since a few years (Shashi *et al.*, 2018). Consequently, the related literature has been gradually evolving. However, due to the multi-disciplinary nature of FCCs, contemplating multifaceted efforts becomes challenging. Furthermore, streamlining these multidimensional efforts to achieve the common goal(s) becomes a more pressing concern.

With the advent of mechanization and state-of-the-art advancements in area of redesign technologies, it has become possible to transport the otherwise time-sensitive products over long distances (Van Der Vorst and Beulens, 2002). Various technologies providing temperature-maintenance have made food supply chains global. Today, FCCs are not confined to specific regions or continents. While these advancements have brought along tremendous trade opportunities, related risks and sustainability concerns have also increased manifold. Repeated occurrence of various food scandals has time and again highlighted the vulnerability of FCCs. Moreover, challenges like food wastes (particularly post-harvest fresh food losses), equitable distribution of supply chain rents and creation of inclusive business opportunities along supply chains have underlined importance of managing FCCs sustainably.

In this background, this paper has reviewed and organized the published FCC literature around the themes of FCC risk management and sustainability. Employing the theory refinement logic the current research has evaluated the FCC literature against the frameworks of Vljajic *et al.* (2012) and Beske and Seuring (2014). We have tried to appreciate the risk management and sustainability concepts in FCCs. The methodology has enabled us to comprehensively capture how the risk management and sustainability-related strategic and structural concepts have been studied by the FCC researchers. The findings indicate that a thorough comprehension of strategic, structural and operational aspects of risk management and supply chain sustainability still remains a work-in-process in FCCs. The supply risk and sustainability-related literature has extensively evolved over the years; however, it has largely focused on the conventional and more “general purpose” supply

chains. Food supply chains have their unique nature and exclusive requirements, but the development of the needed solutions have been overlooked. This failure on part of concerned researchers has resulted in providing little guidance to practitioners to make FCCs more robust and sustainable. We consider this contribution as a first step towards encouraging and sensitizing supply chain researchers to start exploring issues we have tried to highlight for the sustainable development of FCCs.

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### Further reading

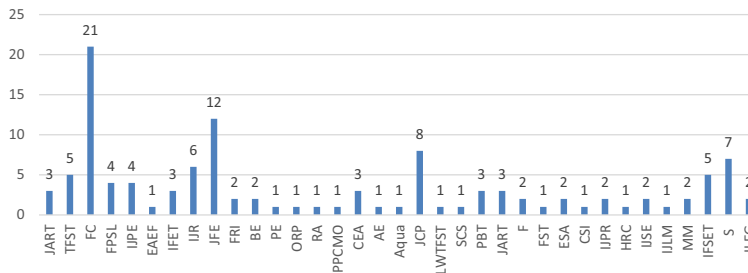
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## Appendix

### Journal-wise distribution of FCC literature



Journal name	Abbreviation	Journal name	Abbreviation
Journal Of Applied Research and Technology	JART	Risk Analysis	RA
Trends In Food Science & Technology	TFST	Production Planning & Control: The Management of Operations	PPCMO
Food Control	FC	Computers And Electronics in Agriculture	CEA
Food Packaging and Shelf Life	FPSL	Applied Energy	AE
International Journal of Production Economics	IJPE	Aquaculture	Aqua
Engineering In Agriculture, Environment and Food	EAEF	Journal Of Cleaner Production	JCP
Innovative Food Science and Emerging Technologies	IFET	LWT - Food Science and Technology	LWTFT
International Journal of Refrigeration	IJR	Sustainable Cities and Society	SCS
Journal Of Food Engineering	JFE	Postharvest Biology and Technology	PBT
Food Research International	FRI	Journal Of Applied Research and Technology	JART
Biosystems Engineering	BE	Frontiers in Psychology	FP
Procedia Engineering	PE	Food Science and Technology	FST
Innovative Food Science and Emerging Technologies	IFCET	Expert Systems with Applications	ESA
Operations Research Perspectives	ORP	Computer Standards & Interfaces	CSI
International Journal of Production Research	IJPR	Computers & Industrial Engineering	CIE
History Of Retailing and Consumption	HRC	Microprocessors And Microsystems	MM
International Journal of Sustainable Engineering	IJSE	Innovative Food Science and Emerging Technologies	IFSET
International Journal of Logistics Management	IJLM	Foods	F
Sustainability	S		

**Source(s):** Authors' own elaboration

Risk  
management in  
food cold  
chains