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# Scrutinising the interplay between governance and resilience in supply chain management: A systems thinking framework

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## ABSTRACT

Supply chain disruptions recurrently challenge end-to-end operations owing to the ambiguous understanding of the role of governance in impacting supply network resilience. This paper scrutinises the relevant literature to understand the plethora of interpretations in supply chain governance and resilience while further providing a new perspective on the representation of the interplay between governance and resilience in supply chains. In this regard, the Systems Thinking lens is adopted to pull together the typologies and constructs of supply chain governance and resilience from the literature. Methodologically, System Dynamics modelling principles are leveraged to capture the underpinning structural interdependencies in a causal loop diagram. The study reveals that endogenous and exogenous supply chain governance processes and mechanisms support the intrinsic and extrinsic resilience in networks. Overall, this research contributes to the supply chain risk management domain by synthesising the interplay between governance and resilience, identifying pertinent typologies, and articulating research propositions that can inform decision-making at policy and management levels.

## 1. Introduction

Supply chain (SC) disruptions, rooted either in natural disasters or man-made upheavals, often have a global impact that leads to high costs ranging from US\$150 billion in 2019 to US\$350 billion in 2017 (Alicke & Strigel, 2020). Any kind of unanticipated SC disruptions will inevitably affect global operations in terms, for example, delayed deliveries or cancelled shipments due to closed ports, thus causing unmatched supply and demand. The risks may increase due to modern practices in global sourcing involving multi-tier suppliers, and at the same time, the related ramifications may exacerbate by the pressures to increase efficiency and reduce inventory (Christopher & Peck, 2004).

There are many notable real-world cases reported in the literature about SC disruptions triggered by unanticipated events. Indicatively, the workers' union strike on the US West Coast in 2002 caused disruptions in containers' transshipment and deliveries to North America and Europe, which affected operations for six months (Cavinato, 2004). In 2011, Japan was struck by the Tohoku earthquake and the subsequent tsunami crippled global manufacturing SCs (Son et al., 2021), including major automotive companies, such as Nissan, Toyota, and General

Motors, hence resulting in economic losses of about US\$235 billion (Oskin, 2017). This catastrophic event also had implications beyond automotive, delaying, among others, the delivery of Apple's iPad 2 tablet (Revilla & Sáenz, 2014) and disrupting the retail SCs on a global scale (Todo et al., 2015; Torabi et al., 2015). In the same year, Thailand experienced one of the worst floods that paralysed the country's transportation facilities (Liu et al., 2016), forcing the computer hard disk drive manufacturer and data storage company Western Digital to suspend manufacturing production (Fuller, 2011).

Although the effects of some disruptions may be relatively straightforward to manage, others may have a much more significant impact on SCs' long-term performance and can be detrimental to companies (Craighead et al., 2007; Schmidt & Raman, 2012). At a more granular level, SC disruptions impact short- and medium-term financial performance due to the ripple effect on the SC and corporate viability, regardless of firm size and/or business/industrial sector. These impacts denote SC resilience as a leading theme in the strategic corporate agendas (Baghersad & Zobel, 2021).

The COVID-19 pandemic reinvigorated the Operations Management community's focus on resilience and highlighted the need to 'relearn

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lessons already learned in research when the next crisis comes around' (van Hoek, 2020). Notwithstanding the plethora of risk management studies motivated by natural and man-made disasters, the pandemic further highlighted the need to consider resilience from an intertwined supply network vantage point (Ivanov & Dolgui, 2020). Such a systems perspective of supply networks is useful in guiding the design of inclusive governance processes and mechanisms, which are paramount for instituting resilient operations in post-crisis periods (Khurana et al., 2021). Governance of people, processes, and technologies is a fundamental overarching element in Deloitte's Risk Intelligent Enterprise Framework for SC resilience (Deloitte, 2012). The need for mitigating the impacts of disruptions and planning in post-disaster eras highlights the requisite for governance processes and mechanisms to ensure the resilience and rebound of SC operations (Deloitte, 2020). The pandemic also clearly showed that organisational and institutional governance structures are still incapable of understanding the vulnerabilities that lead to disruptions in essential supplies, such as hand sanitizers, personal protective equipment (PPE) and medical equipment (McKinsey & Company, 2020). Despite the magnitude of research on the field of SC resilience, the COVID-19 pandemic does seem to teach us another important lesson to comprehend the underpinning constructs/elements and structural interdependence of SC governance and resilience. For example, the failure of global SCs for medical supplies shows us that in the post-COVID-19 era, there is a pressing need to revisit SC governance and resilience, and introduce dynamic and adaptable frameworks that can support timely and sustainable interventions for properly addressing future pandemics (Bhaskar et al., 2020). This need has instigated our first research question:

**RQ1.** – How can SC governance and resilience be understood from a supply network standpoint?

The answer to RQ1 should identify key themes and structural elements of governance and resilience in manufacturing networks. However, in the context of unprecedented disruptions compounded by its uncertainties, there is a greater need to understand the underlying linkages between the elements of governance and resilience (Scheibe & Blackhurst, 2017). Albeit the SC management imperative to understand the interplay between governance and resilience to respond to internal and/or external shocks, this remains a nascent research domain (Bakshi & Kleindorfer, 2009). Owing to the fact that the structured analysis of the interplay between SC governance and resilience can be considered as a complex dynamic system, we, therefore, propose our second research question:

**RQ2.** – What is the interplay between governance and resilience in a supply network system that can inform management directions?

Thereafter, to respond to RQ2, we employ a logic of enquiry owing to the dynamic nature of global disruptions and the associated impacts on SC operations (Forrester, 1961). This dynamic interrelation implies that governance, and subsequently resilience, need to be understood from an inter-organisational and supply network systems' viewpoint (Ahlgqvist et al., 2020). As the notion of SC resilience has to be theorised within a structural and operational dynamics frame (Ivanov & Sokolov, 2019) and considering the role of Systems Thinking as an explanatory process in networked and collaborative governance (Forliano et al., 2020), we argue that the systems analysis approach allows: (i) the investigation of the underpinning mutual influences on the one end; and (ii) the dynamic interrelations and feedback loops pertaining governance and resilience (Stewart & Ivanov, 2019) on the other end.

Inspired by Ferreira de Araújo Lima et al. (2020), we perform an extensive literature review, followed by a critical taxonomy of the outcomes. Using the findings from the literature review and the critical taxonomy, we articulate research propositions pertaining to SC governance and resilience. We take this analysis further by integrating the articulated research propositions in a conceptual framework of a complex system linking SC governance and resilience. In particular, the proposed systems thinking framework captures the interplay among the

corresponding structural elements to explore the underpinning dynamics.

Our research contributes to the intersection of Operations Management and governance fields by applying a systems perspective on the resilience of SC operations; thus, developing a profound understanding regarding the pertinent role of managerial governance, which posits an open issue for policy-making silos and corporate management alike. In this way, this research clarifies the dynamic interlinkages between SC governance and resilience, and informs public and private organisations concerning the impact of governance-centric interventions on SC resilience. From a pragmatic standpoint, the first COVID-19 lockdown across the retail sectors in several countries, occurred during March and April 2020, highlighted a pertinent need on how such interventions can be facilitated in the future and emphasised the lessons learned in that direction.

Considering the above, we organise the remainder of this paper as follows. Section 2 discusses the materials and methods related to this study. Section 3 outlines the concepts of SC governance and resilience relying on existing qualitative evidence. We identify that SC governance processes, mechanisms, and tools, which impact resilience, need to be understood from both endogenous and exogenous perspectives. Additionally, we explore the concept of SC resilience and we propose that it posits an intrinsic and extrinsic SC attribute. The critical taxonomy of the reviewed literature is also provided. In Section 4, we present and discuss the interplay between SC governance and resilience, in the form of a conceptual framework based on Systems Thinking, and we articulate pertinent research propositions to encourage potential research streams. Finally, in Section 5, the study concludes with a discussion of the implications to theory and managerial practice. Limitations and recommendations for future research are also provided.

## 2. Materials and methods

Considering that this research focuses on developing a coherent conceptual structure about the interplay between SC governance and resilience, the object of scrutiny is the extant literature (Webster & Watson, 2002). In this regard, the overall research process includes three stages (Fig. 1). In Stage #1, we analyse qualitative secondary evidence following a narrative review of the extant literature to identify underpinning SC governance and resilience inherent typologies, major system constructs (or elements) and their structural interconnections. To this effect, we express several key findings stemming from the reviewed literature. Following that, in Stage #2, we systematically retrieve pertinent studies on SC governance and resilience, and then we critically taxonomise these based on identified inherent typologies. The taxonomy also informs any dominant interconnections between the system's constructs. In Stage #3, based on Systems Thinking, we map these constructs and their structural interrelations and develop our conceptual framework. We also articulate future research propositions. The literature review protocol and the theoretical lens relevant to this study are exemplified in the following subsections.

### 2.1. Literature analysis

This research applies the traditional 'narrative review' method involving informal approaches to organise and analyse the extant literature (Hammersley, 2001) seeking to identify relevant studies in the field of SC governance and resilience. To this end, we review a considerable number of articles published in peer-reviewed journals to identify inherent typologies in SC governance and resilience. At this initial stage, we select this approach, as opposed to a systematic review, owing to the intention to specify inherent typologies in SC governance and resilience that is an evident knowledge gap in the field of SC management, except for the extant dispersed and random empirical knowledge (Jones & Gatrell, 2014).

Thereafter, we carefully read the papers to familiarise ourselves with

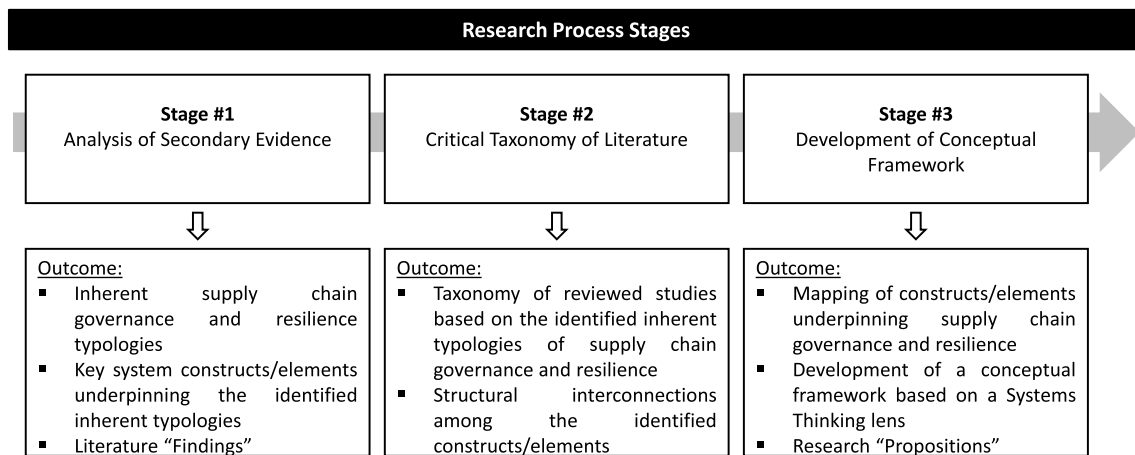


Fig. 1. Research methodology flowchart.

the topics and to make sense of the used/provided data (Conz & Magnani, 2020). The main reason for this content analysis is to coherently triangulate the evidence and understand the relevance of the terms ‘governance’ and ‘resilience’ to other concepts in the SC literature. As a result, we identify key inherent typologies and system constructs/elements thereof, transcending SC governance and resilience. Furthermore, the synthesis of the literature review observations leads us to collate and articulate literature findings. The use of ‘findings’ is helpful as a means of summarising thematically important discoveries and breakthroughs from our review hence limiting biases.

## 2.2. Critical taxonomy

Following an established literature analysis norm (Åberg et al., 2019; Conz & Magnani, 2020; Ferreira de Araújo Lima et al., 2020) and considering the systems view of this research, we proceed to a critical taxonomy of pertinent studies in the field. In this regard, we perform an extensive literature review on the investigated topic by conducting structured Boolean-type searches using appropriate keywords in the Scopus and Web of Science databases (Aivazidou et al., 2016). These two databases are selected as they capture a wide range of scientific journals in the fields of business and management, natural sciences and engineering (Mongeon & Paul-Hus, 2016), where the research areas of governance and resilience are usually represented in. The search strings that have been used are broad and comprise of the following Boolean set: {“supply chain” AND “governance” AND “resilience”}. The search is specified against the ‘Article title, Abstract, Keywords’ field. The time horizon of the publications is left unrestricted.

Focussing on accessing ‘best-quality evidence’ (Tranfield et al., 2003), the literature search is limited to peer-reviewed journal articles written in English. We carefully examine the content of every identified publication to validate its eligibility (e.g., purpose, findings, and/or implications), along with their relevance to the research questions, while bearing in mind the purpose of this research. By applying the above inclusion and quality assessment criteria, we initially retrieved 45 articles. Title and abstract screenings are then performed using certain criteria, including the focus of the topic, the right level of analysis, the proper context of application, area of interest as well as unit of analysis (i.e., firms and not consumers).

By 31 January 2021, a total of 28 articles published in an equivalent number of academic journals passed the quality assessment and are included in our critical taxonomy. Table A1 (Appendix I) summarises the details of the articles that are included in the critical taxonomy, as these are retrieved via the process flow depicted in Fig. 2. The allocation of the taxonomised scientific articles by year of publication is inserted in Figure A1 (Appendix I). Notably, all the collected articles are published

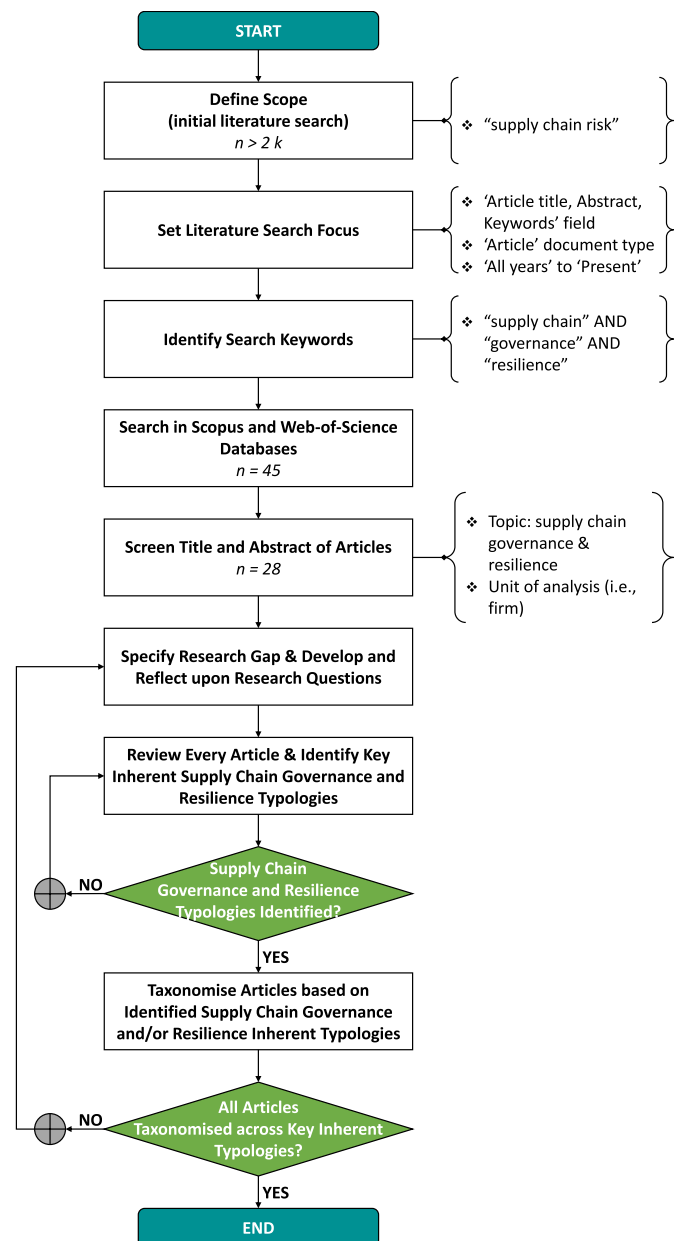


Fig. 2. Critical taxonomy process.



in different academic journals hence indicating that the topic covers a wide variety of scientific areas, such as operations and SC management, environmental sustainability, and public administration. A synopsis of the reviewed articles is inserted in [Appendix II](#).

The metadata of the identified articles are first used for a bibliometric analysis to unveil knowledge domains within the reviewed articles (Sodhi & Tang, 2017). The bibliometric analysis is based on the co-concurrence of keywords in the retrieved articles' titles and abstracts. The resulting network map is illustrated in [Fig. 3](#). The strength of the link between two terms (denoted by the thickness of every connection) indicates the number of publications in which these terms occur together, with the minimum number of co-occurrences set to five. The bibliometric map also indicates that five thematic categories, visualised as clusters of terms (in a different colour), are identified with 'supply chain' and 'supply network' having a significant role and correlation with the terms 'governance' and 'resilience' (indicated via the purple and red-coloured connections, respectively).

### 2.3. Theoretical lens

Systems Thinking is selected as the theoretical lens under which the analysis of the literature is conducted. The reason for selecting this systems-level approach is that it provides an appropriate theoretical view for generating and guiding informative decision insights to SC actors for governance in risky environments, ultimately enhancing the overall network resilience (Govindan & Al-Ansari, 2019). In addition, the general models proposed by Charreaux (2008) and Wirtz (2011) consider corporate governance as a complex dynamic system of actors and mechanisms. To this end, a Systems Thinking approach could be valuable in understanding and mapping the fundamental cause and

effect interrelations among governance and resilience across an SC system (Meadows, 1980).

Spiegler et al. (2012), among others, have studied the dynamics of SC systems and assessed alternative inventory and ordering control policies against resilience, having a view on a specific process, thus providing a demonstration of the usefulness of Systems Thinking as a way to link governance and SC operations. In a similar vein, extant studies have applied systems-level analysis to investigate alternative SC management initiatives for sustainability in multiple sectors, such as agrifood (Aivazidou & Tsolakis, 2021; Tsolakis et al., 2018). Notwithstanding the fact that several similar studies in the literature have tried to approach the topic of SC governance and resilience using other theoretical frameworks, to the best of our knowledge, there is a lack of understanding over the system structure and the underpinning interplay. Therefore, the dynamics view of systems provides an essential, actionable framework from a managerial perspective. In this context, this study aims to provide a greater understanding of the dipole 'governance–resilience' in SCs with a Systems Thinking outlook.

Based on the analysis of the literature and through the Systems Thinking lens, we create a qualitative system map to support the visualisation of the system constructs' structural interrelations. Moreover, in a contemporary literature review, in order to demonstrate the value and contributions from the review, researchers often take a step forward, that is, not just collating extant evidence, but more importantly, trying to explain the connection between existing concepts with a view to suggest or speculate promising future areas of inquiry (Liliani et al., 2020). Therefore, we also articulate propositions for future research.

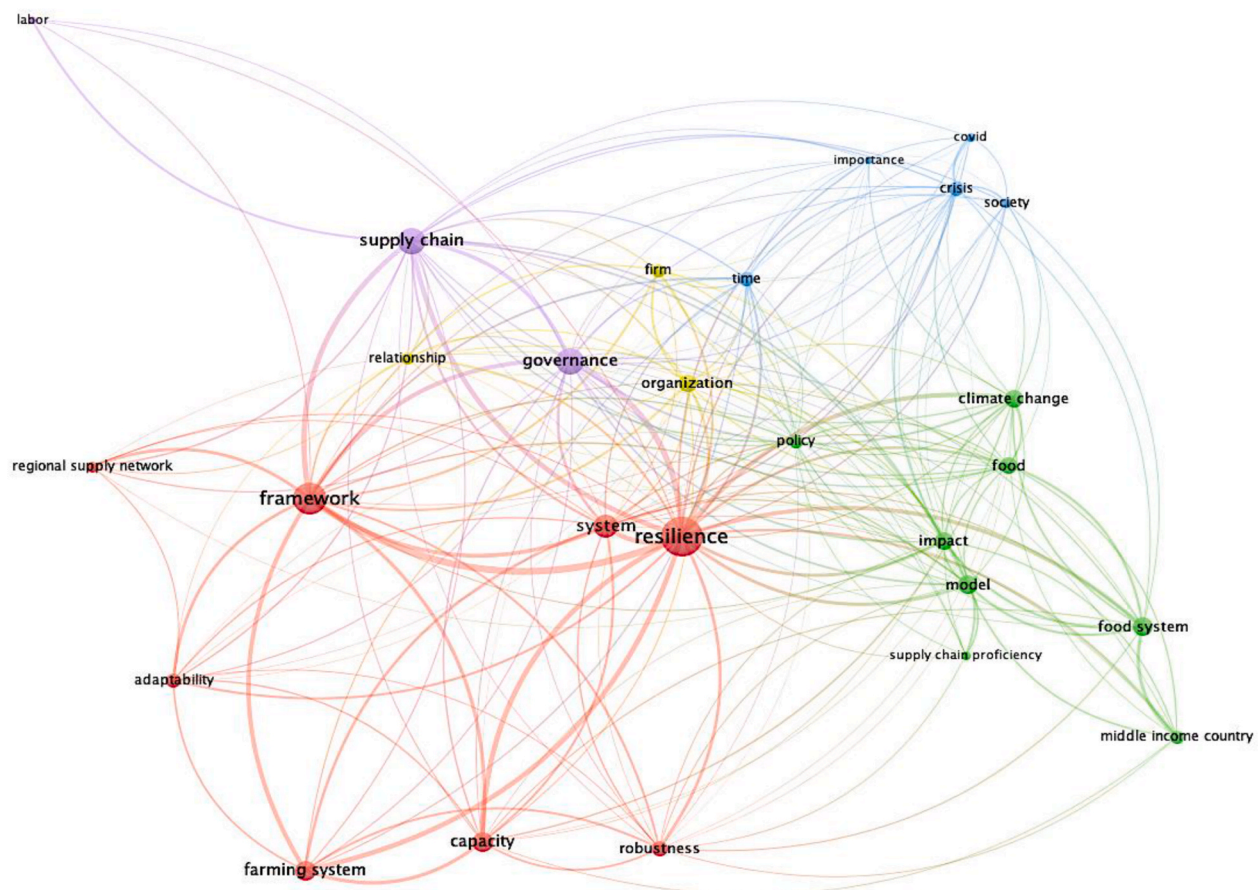


Fig. 3. Keyword co-occurrence bibliometric map of the selected articles (generated by VOSviewer 1.6.16 software).

### 3. Governance and resilience in Supply Chain Management

In this section, the structure of SC governance and resilience is being investigated to identify key themes and structural elements to enhance a researcher's understanding of the underpinning interplay (Forrester, 1961). In the subsections that follow, evidence extracted from the collected literature on SC governance and resilience is discussed, and a series of arguments over the research findings is formulated.

#### 3.1. Supply chain governance

Governance is a term that is often used across many principles with the broad meaning of: '*an institutionalised decision-making process among many independent actors*' (Ahlqvist et al., 2020, p.383). Statsenko et al. (2018a) highlighted the role of formal (i.e., regulations, incentives, programmes) and informal (i.e., social norms, trust, reputation) supply network system governance to foster regional SC structure and connectivity for facilitating technology and knowledge diffusion, thus promoting the resilience of regional economies. In the SC management field, multi-echelon operations in global manufacturing networks imply the need for the involved actors to comply with various national and international legislation and certification standards to limit supply-demand uncertainty, ensure quality, and prevent setbacks (Mazahir & Ardestani-Jaafari, 2020). At an inter-organisational level, contracts detail the duties, rights, and contingencies of firms, and act as safeguards or coordination means (Mesquita & Brush, 2008) to ensure the delivery of specific outputs and resolve any conflicts (Ryall & Sampson, 2009).

In the same context, governance has been generally considered as a set of mechanisms to support and manage the flow of products and services from suppliers to customers and vice versa (Aitken & Harrison, 2013). For example, contracts and trust are recognised as essential forms of contractual and relational governance mechanisms in SCs that can improve performance and reduce opportunism, even in cases where international network actors are located in countries with less effective legal systems (Cao & Lumineau, 2015).

In the SC management field, the concept of governance implies collaborations between organisations participating in an SC, and among firms and governmental agencies, with the ambition to fulfil the needs of diverse stakeholders. Therefore, in this study, we argue that governance can be approached from different, yet complementary, viewpoints, namely: (i) *endogenous governance*, that is, formal and informal processes, mechanisms, and tools to manage the interrelations among network actors; and (ii) *exogenous governance*, that is, official regulations, rules, guidelines, and standards that have jurisdiction over extended network operations. We outline these two viewpoints in the following subsections.

##### 3.1.1. Endogenous governance

Globalisation of manufacturing and business operations results in the formation of complex multi-tier SCs with respective implications on: (i) performance (e.g., inventory and transportation costs, responsiveness); (ii) power balance among SC actors; (iii) network structure (i.e., open, closed); (iv) degree of interdependence among SC members; and (v) stability of relationships among network actors (Mena et al., 2013). In addition, governance structures are established to regulate transactions among actors in an SC and enable self-enforcing agreements (Dyer & Singh, 1998). Gereffi et al. (2005) focussed on inter-firm linkages and identified three essential factors in the governance of global value chains, namely: (i) complexity of transactions; (ii) codifiability of information; and (iii) capabilities of suppliers. The analysis reveals the pivotal role of tacit knowledge and interdependencies among firms within a value chain in driving coordination and competence. Lumineau and Henderson (2012) extended the aforementioned views by considering the influence of buyer-supplier relationship experiences and specific contractual provisions to the design of SC contractual and relational control mechanisms.

Interdependencies of stakeholders within supply networks include sharing resources or trust to foster collaborations and integration for pursuing a common principal mission (Cao et al., 2010) that can ultimately stimulate resilience. On a pragmatic view, natural disasters and national security incidents indicate that collaboration, in this instance, between private organisations and public institutions, can enable learning processes for developing a responses' knowledge-base and guidelines for corrective actions, thus enhancing resilience (Committee on Homeland Security, 2008). From an environmental sustainability viewpoint, SC governance implies the catalytic role of relations among network actors in achieving certain performance objectives, typically focussing on lower tier suppliers (Walker & Jones, 2012). The diverse cultural background of SC partners has a detrimental role in the development of informal endogenous governance mechanisms, further including trust, communication style, and social bonding (Gupta & Gupta, 2019). Evidently, within an SC system, interlinkages among actors are required for both forward and reverse flows (Aitken & Harrison, 2013).

Therefore, we argue that endogenous SC governance can be regarded as the combination of formal and informal arrangements that dictate both the transactional commitments and the underpinning relational exchanges among the involved network parties with regard to value chain flows (e.g., material, data and information, monetary). Consequently, we have the following literature finding:

**Finding 1:** *Endogenous SC governance entails the portfolio of formal and informal arrangements that regulate the business processes, the collaboration, and the transactional relations among partners in end-to-end network echelons of operations.*

##### 3.1.2. Exogenous governance

A plethora of exogenous developments exists regarding SC systems that impact network operations and further entail the adoption of certain management interventions to propel specific objectives, such as sustainable performance (Esfahbodi et al., 2017). In particular, it is recognised that the ability of an SC to be resilient directly links to both the collaboration degree among system stakeholders and the conformance to regulatory constraints imposed by institutional bodies (Gabler et al., 2017). However, Meyer (2020) argued that a systems perspective is required to consider the implications of global governance on resilience in regional settings.

Liability rules, directly and indirectly, shape food SCs by imposing the allocation of obligations and responsibilities among network actors regarding the quality and safety of the traded commodities (Rouvière & Latouche, 2014). The notion of the enforcing role of laws, regulations, jurisdictions and standards in end-to-end SC operations is also notable in the mining and pharmaceuticals sectors with the purpose to ensure public health and safety, avoid illegal practices, and prevent irresponsible material sourcing and counterfeits. To this effect, nowadays, such requirements inform the design of traceability systems enabled by digital technologies, such as blockchain (Hastig & Sodhi, 2020). Furthermore, to safeguard SC resilience against supply disruptions, governmental regulations explore system-wide adaptations in the pharmaceuticals landscape regarding, for example, the potential use of renewable feedstocks as raw materials for the synthesis of active pharmaceutical ingredients (Tsolakis & Srari, 2018). In the manufacturing sector, exogenous driving forces of governance (i.e., institutional pressures) are also reported to act as a key impetus for firms to embrace environmentally sustainable initiatives (Esfahbodi et al., 2017). In the food sector, Meuwissen et al. (2019) recognised the need to ensure governance adaptability at policy-making levels to foster resilience in the farming sector.

Consequently, this research recognises exogenous governance as the official regulatory context and frameworks that legalise and safeguard SC operations; these jurisdictions are external to the SC inter-organisational structure. This research considers only the formal governance directives imposed by national and international regulatory

bodies. As a result, we have the following literature finding:

**Finding 2:** *Exogenous SC governance involves formal contexts entailing guidelines and legislative norms that frame, regulate, and control end-to-end network operations for delivering quality offerings to the market in a sustainable manner.*

### 3.2. Supply chain resilience

Resilience in SC management is often defined as the: ‘ability to recover from disruptions and return to the original state’ (Gligor et al., 2019, p.475). In this regard, resilience can be first understood as a consequence of the internal structure of a firm or an SC that focusses on nurturing capabilities, devising practices, and accessing resources to sufficiently manage situations of internal instability (De Sanctis et al., 2018). For example, the adoption of Industry 4.0 constituent technologies, such as Big Data and Artificial Intelligence, is documented to enhance multi-echelon SCs’ resilience by allowing complete communication among the dispersed and diverse actors (Ramírez-Peña et al., 2020). Digital-enabled real-time data mining, transparency and visibility allow informed decision-making that leads to the efficient design, planning, and management of operations, such as in the shipbuilding industry (Ramírez-Peña et al., 2020).

However, as SC operations unfold in the global business and geographical landscapes, the level of exposure to uncertainties, stresses, and shocks, such as extreme weather conditions, is high, thus challenging the overall networks’ resilience (Govindan & Al-Ansari, 2019). Further external SC disruptions include the volatility of currency exchange rates, customs delays at borders and cyber-attacks, which necessitate the synchronisation among the decision-making processes of the involved network actors to enhance resilience (Katsaliaki et al., 2021).

Noteworthy, despite the extended management literature with resilience-focussed studies, the interchangeable use of the term with ‘agility’ is often contradictory and creates confusion due to common schemes, such as operational flexibility. Indeed, SC agility refers to the: ‘ability of the firm to adjust tactics and operations within its supply chain to respond to environmental changes, opportunities, and threats’ (Dubey et al., 2018, p.131).

In SC management, the concept of resilience denotes the individual SC actors’ capabilities and the entire network to recover from disruptions and restore operations and performance to an even better state than the pre-crisis era. Consequently, we argue that resilience needs to focus on different levels, namely: (i) *intrinsic resilience*, that is, set of capabilities, processes, and tools to recover from internal disruptions that arise either at the level of specific SC actors and/or across the end-to-end value network; and (ii) *extrinsic resilience*, that is, standardised processes and mechanisms to respond and recover from external to the SC of reference disruptions that can have a detrimental impact on the operations across the entire network. We discuss these two viewpoints in the subsections that follow.

#### 3.2.1. Intrinsic resilience

The availability of technical, organisational, and relational skills enables individual SC actors and the respective end-to-end networks to accumulate knowledge and expertise to effectively respond to internal shocks and recover promptly (Gilly et al., 2014). From an SC perspective, rooted in the definition of resilience, the ability to manage uncertainties via informed decision-making and recover SC operations requires end-to-end sharing of data, information, and knowledge (Glickman & White, 2006), considering that: ‘information is the substance from which the managerial decisions are made’ (Forrester, 1961, p.427). Therefore, coordination and visibility among actors in an SC are crucial to orchestrate operations and increase resilience (Christopher & Lee, 2004). In this regard, Emmanuel-Yusuf et al. (2017) developed the Resilience and Livelihoods in Supply Chains (RELISC) framework to comprehend supply systems’ contextual factors to improve resilience,

among others, and revealed the catalytic role of visibility, adaptation, collaboration, and communication as strategic constituents for achieving resilience in dynamically changing operations environments.

Within a turbulent operations environment, to support engineering and ecological resilience in SC management, Eltantawy (2016) recognised the role of endogenous governance capabilities on enhancing SC resilience of buying firms. Furthermore, Aigbogun et al. (2016) investigated the role of Halal logistics on the resilience of respective pharmaceuticals networks. The statistical analysis of the collected survey data revealed that Halal logistics could mediate the multiple principal–agent relations across the network and thus confer SC resilience, owing to the necessary control and assurance activities to ensure conformity of Halal medications to prescribed standards.

From a more focussed view on the shop floor level, for example, the relocation of personnel in tandem with the different attitudes and learning capacities/curves can affect innovation and productivity, thus potentially imperilling resilience (De Sanctis et al., 2018). In this vein, Durach and Machuca (2018) recognised the role of interpersonal relationships among employees in buying and supplying firms for improving the resilience efficacy with suppliers. Following the above-mentioned analysis, we have the following:

**Finding 3:** *Intrinsic SC resilience refers to the capabilities and mechanisms that guide the operations of individual partners, along with their interrelations and coordination across the entire network, to respond to disruptions arising internally for preventing their propagation and minimising any negative impacts.*

#### 3.2.2. Extrinsic resilience

Extending the intra-SC perspective, the structural properties of supply networks that facilitate the mobilisation of resources and adaptability posit an elemental factor in resisting and managing external disturbances (Gilly et al., 2014). Extending this capability-centric notion, resilience shall be viewed as the consequence of the political, cultural, and territorial embeddedness of SCs, particularly in developing countries where governance structures might be ineffective (Tukamuhabwa et al., 2017). Furthermore, the selection process of suppliers is essential for the design of resilient SCs that also foster sustainable performance (Mohammed et al., 2021).

In addition, global SC operations are being disrupted by negative economic, environmental, and social impacts, like in the food sector where adverse weather conditions often result in food shortages and high price fluctuations (Govindan & Al-Ansari, 2019). Esteves et al. (2012) studied the social impact assessment practice and highlighted the need to (re)connect social impact to resilience and engage with SC management to develop demonstrable value. Therefore, we have the following:

**Finding 4:** *Extrinsic SC resilience refers to the capabilities and mechanisms that guide the interrelations and operations across network partners to adjust and respond to external disruptions for managing any negative impacts on network systems’ operations and averting the possibility of disruptions’ internalisation.*

The presented literature analysis documents the multi-dimensional SC governance and resilience character and the need to understand the governing interplay for effective risk management. The key themes that arise in the SC management field have to do with the endogenous and exogenous governance processes and mechanisms to achieve intrinsic and extrinsic resilience in end-to-end operations. Our findings formulate a future research agenda by initially recognising the extant gaps and overlaps in the current body of literature.

### 3.3. Critical taxonomy

The literature analysis clearly documents the multi-dimensional character and complex nature of SC governance and resilience as well as the challenges that should be addressed at both endogenous/



exogenous and intrinsic/extrinsic levels for effective, viable, and sustainable operations. Table 1 presents the resulting critical taxonomy of the systematically reviewed studies. The synopsis of the taxonomised studies is provided in Appendix II. We clarify that the provided taxonomy is by no means an exhaustive list of all relevant studies, but rather acts as a synthesis of the works that have been identified as part of our ongoing research.

Despite the fact that a plethora of studies exists with regard to the examination of governance in a range of sectors, there is a lack of holistic approaches for relevant processes and mechanisms to ensure resiliency in SC systems. This gap is particularly notable considering the fact that most of the risks and disruptions are common in the various sectors (e.g., quality issues, climate change).

More specifically, the research on SC governance and resilience is scattered, with these concepts being rarely jointly studied. Increasing internal shocks (e.g., quality failures) and external risks (e.g., price fluctuations, extreme weather conditions) put pressure for establishing structured endogenous and exogenous governance processes and mechanisms to enhance SC and systems' resilience. However, multifaceted governance challenges that transcend global operations necessitate scrutiny over the interplay between SC governance and resilience. The latter interconnections shall be embedded in a more generalised framework since the scant research evidence is clearly case-dependent.

#### 4. Supply chain governance and resilience framework

This section first elucidates the selection of the System Dynamics as an appropriate approach to investigate the interplay between SC governance and resilience. Thereafter, literature evidence about the rationalisation and structuring of the proposed conceptual framework is provided. In particular, the framework captures the interplay between SC governance and resilience while then leading to the articulation of a set of propositions for testing by future research efforts.

##### 4.1. System Dynamics rationalisation

The notion of SC resilience could be theorised within a structural and operational dynamics frame (Ivanov & Sokolov, 2019), considering the role of System Dynamics modelling as an explanatory process in networked and collaborative governance (Forlano et al., 2020). We argue that the use of this approach allows the investigation of the underpinning mutual influences, dynamic interrelations, and feedback loops between governance and resilience (Stewart & Ivanov, 2019). Specifically, System Dynamics, an analytical approach that complements Systems Thinking, is deemed appropriate for studying SC resilience due to the inherent non-linearity of supply network systems and the dynamics of control mechanisms/policies. In fact, System Dynamics has been used in the investigation of the effects of alternative SC structural elements and configurations on disaster response programmes (Besiou et al., 2014). In addition, Spiegler et al. (2016) used System Dynamics to analyse the resilience of a replenishment system against stock-outs in a UK grocery retailer.

In this view, System Dynamics enables the consideration and comprehension of complex non-linear systems evolving over time in a systematic manner (Forrester, 1961). Following the notion that SC resilience is within the scope of System Dynamics modelling (Pereira, 2009), while further considering the complexity and the dynamic nature of SC operations, this research captures the structural interdependencies among governance and resilience in a Causal Loop Diagram (CLD).

##### 4.2. System mapping and conceptual framework

In the proposed CLD, the complexity and non-linear behaviour underpinning the interrelation between governance and resilience in an SC system are captured via five feedback loops, with each feedback loop capturing a sequence of causes and effects. A change in a particular

variable transcends the entire loop (Georgiadis & Vlachos, 2004), ultimately leading to a decrease (i.e., negative polarity symbolised by '−') or increase (i.e., positive polarity symbolised by '+') in the same variable, hence characterising the loop as balancing (denoted as 'B') or reinforcing (denoted as 'R'), respectively. Setting off from the literature findings, we subsequently gathered our thoughts to synthesise what we term as the SC governance and resilience framework, illustrated in the form of CLD. The CLD captures the interplay among all components of SC governance and resilience.

Overall, our framework comprises two balancing and three reinforcing loops, which afterwards help inform our research propositions (Fig. 4). The system comprises the 'Supply Chain Domain' and the 'Industry/Market Domain' where endogenous and exogenous to the SC governance processes and mechanisms are applied, respectively. The deliberation of dual-level governance domains is fundamental in the system consideration, with similar reflections being documented in other SC areas, such as for environmental certification (Stranieri et al., 2021).

At the 'Industry/Market Domain', in the indicative balancing loop B1, an enhanced 'Regulatory Sufficiency for Disruptions' Management' does not motivate the revision and update of 'Exogenous Governance Processes, Mechanisms & Tools', thus resulting in decreased 'Regulatory Obligations' to which SC procedures and processes need to adhere to, considering the dynamically changing market conditions and operational environment. Typically, stringent 'Regulatory Obligations' imply that the SC ultimately demonstrates enhanced 'Extrinsic Supply Chain Resilience', which in turn leads to improved long-term 'Supply Chain Sustainable Performance' (Ma et al., 2021).

Similarly, in reinforcing loop R1, within the 'Supply Chain Domain', increased 'Research & Development and Investments' lead to a gamut of improved 'Endogenous Governance Processes, Mechanisms & Tools' that allow SC actors to develop capabilities (e.g., transparency) and respond promptly and effectively to contemporary operational disruptions thus leading to enhanced 'Intrinsic Supply Chain Resilience' (Montecchi et al., 2021). Enhanced resilience entails that the SC demonstrates an elevated 'Operational Stability'. A list of the feedback loops is inserted in Table A2 (Appendix III).

##### 4.3. Research propositions

In the Systems Thinking framework depicted in Fig. 4, in the reinforcing loop R1, an increase in 'Research & Development and Investments' enables the development and application of more effective 'Endogenous Governance Processes, Mechanisms & Tools', ensuring a higher degree of 'Intrinsic Supply Chain Resilience'. For example, responses to the COVID-19 pandemic demonstrated that investments in new revenue streams, operational transport flexibility, digitalisation and data management, logistics infrastructure, and optimised personnel capacity were pivotal for the resiliency of logistics services providers (Herold et al., 2021). Except for tangible assets, investments shall also focus on the interpersonal level across all echelons of operations to develop disruption management skills that sequentially strengthen relational and re-deployable organisational and SC resilience (Durach and Machuca, 2018). In turn, elevated internal resilience against internal end-to-end supply system's disruptions entails increased 'Operational Stability' hence preventing operational failures (Suryawanshi et al., 2021). This implies that endogenous governance mechanisms impact the intrinsic SC resilience. Therefore, we put forward our first proposition stating that:

**Proposition 1.** *Investments of money, time and effort in novel processes, skills, mechanisms, and tools to better integrate and endogenously govern network operations can help prevent or mitigate the impact of internally arising disruptions, thus enhancing the intrinsic SC resilience and operational stability.*

In the balancing loop B1, the increased 'Supply Chain Sustainable



**Table 1**  
Critical taxonomy of the existing research.

Author(s)	Sector	Method	Theory	SC Resilience (against)	Govern. Body	SC Governance Challenge(s)	SC Govern.		SC Resilience	
							End.	Exo.	Int.	Ext.
1. Ahlqvist et al. (2020)	N.S.	Literature Review	Systems Theory	• Major incidents impacting critical infrastructures	SCA	• Interaction and sharing of resources among SC members	X		X	
2. Aigbogun et al. (2016)	Pharma	Field Survey	Agency theory	• Quality assurance errors	RB	• Limited flexibility in raw materials' sourcing based on quality standards • Complex relations between predictors and outcomes	X		X	
3. Crane et al. (2019)	Food; Construction; Recreational Drugs	Desk-based Study	Global Value Chains	• Forced labour	RB	• Insufficient governance mechanisms to scrutinise both product and labour SCs • Myopic focus on global value chains, with domestic SCs being overlooked • Limited coordination among governance initiatives, broader regulations and other institutional conditions		X	X	
4. Durach and Machuca (2018)	Mfg.	Structural Equation Modelling	Relational View Theory	• External shocks • Internal shocks	SCA	• Governance mechanisms focus on formal inter-organisational relations management and neglect interpersonal relations	X		X	
5. Edgeman and Wu (2016)	N.S.	Critical Discussion	Sustainable Enterprise Excellence, Resilience and Robustness Model	• External shocks	SCA	• Extant strategies and governance mechanisms do not recognise the synergistic relationships and complex interactions in enterprise sustainable innovation systems	X		X	
6. Eltantawy (2016)	N.S.	Conceptual Analysis	Ecological and Engineering Theory	• Economic shocks • Environmental shocks • Social shocks	SCA	• Risk aversion (i.e., reluctance to invest in new supply management governance forms) • Organisational inertia	X		X	
7. Emmanuel-Yusuf et al. (2017)	Energy	Case Study	Value Chain Analysis; Sustainable Livelihood Approach	• External shocks • Internal shocks	RB; SCA	• Implementation challenges of internal and external governance policies	X	X	X	X
8. Esteves et al. (2012)	Extractive industries	Critical Discussion	Social impact assessment	• Social shocks	RB	• Understanding the dynamics of change and capacities to respond to change		X		X
9. Gabler et al. (2017)	N.S.	Critical Discussion	Resource-based View; Dynamic Capabilities; Competing Values Theory; SC Governance Theory	• External shocks	RB; SCA	• Increase SC responsiveness and resiliency in a dynamic way		X	X	
10. Kahiluoto et al. (2019)	Agrifood	Principal Component Analysis; Clustering Analysis	Hotspots Analysis	• External shocks	RB	• Responses' diversity against climate-related uncertainty and variability		X	X	X
11. Keck and Etzold (2013)	Food	Case Study	N.S.	• External shocks	RB	• Enabling the development of transformative capacities of food system actors • Allowing access of food system actors to financing instruments		X	X	X
12. Khurana et al. (2021)	N.S.	Analytical Hierarchy Process	N.S.	• External shocks	RB	• Regulating end-product price fluctuations • Allow access to financing instruments • Promote demand for domestic offerings • Foster collaboration between government and industry		X		X
13. Lee et al. (2019)	N.S.	Critical Discussion	N.S.	• External shocks	RB	• Communication and information sharing • Experiences sharing • Resources' allocation		X	X	X
14. Luthe and Wyss (2016)	Tourism	Network Analysis	N.S.	• External shocks	RB	• Prepare for gradual changes by fostering social learning and innovation	X	X	X	

(continued on next page)

Table 1 (continued)

Author(s)	Sector	Method	Theory	SC Resilience (against)	Govern. Body	SC Governance Challenge(s)	SC Govern.		SC Resilience	
							End.	Exo.	Int.	Ext.
15. Luthé et al. (2012)	Tourism	Case Study	Social Network Analysis	• External shocks	RB	• React to short-term shocks demanding quick distribution of information and centralised steering of collective action (adaptation)	X	X	X	
16. Luthé and Wyss (2014)	Tourism	Critical Discussion	Social Network Analysis	• External shocks	RB	• Uneven distribution of power and influence due to the core-periphery structure of the network	X	X	X	
17. MacMahon et al. (2015)	Food	Case Study	N.S.	• External shocks	RB	• Develop collaboration, integration and coordination of each actor's individual resources, activities and services		X		X
18. Mancini and Arfini (2018)	Food	Case Study	Convention Theory	• External shocks	SCA	• Poor communication across levels of government		X	X	X
19. McKnight (2019)	N.S.	Critical Discussion	Theory of Composition; Theory of Compilation	• External shocks	SCA	• Sustainability challenges	X		X	
20. Meuwissen et al. (2019)	Agriculture	Mixed-methods	Resilience Theory	• Economic shocks • Environmental shocks • Social shocks • Institutional shocks	N.A.	• Sufficient policy arrangements stimulating the three capacities of resilience, i.e., (i) diversity; (ii) stimulating initiative; and (iii) poly-centricity	X	X	X	X
21. Meyer (2020)	Food	Systematic Literature Review	N.A.	• External shocks • Internal shocks • External shocks	RB	• Quantification of the impact of governance on resilience		X		X
22. Oliver et al. (2018)	Food	Critical Discussion	N.S.	• External shocks	RB; SCA	• Prioritisation of interventions to deliver Sustainable Development Goals	X	X	X	X
23. Pal and Torstensson (2011)	Textile	Principal Component Analysis	N.S.	• Changing market dynamics	SCA	• Mediate operational performance and hence organisational success in a dynamically changing environment	X		X	X
24. Reis (2019)	Food	Literature Review; Interviews	Social Network Theory	• External shocks	RB; SCA	• Formulation of local contingency plans that can support options for meeting food needs during and following a crisis		X		X
25. Schmidt and Matthews (2018)	Food	Critical Discussion	N.S.	• Water, food, energy, climate, and global finance risks • Economic shocks	RB	• Interlinking water, energy, food, and climate crises and their ramifications across multiple sites and scales		X		X
26. Statsenko et al. (2018a)	Mining	Case Study	Complex Adaptive Systems	• Economic shocks	RB	• Multi-layered structure of federal governance systems		X		X
27. Statsenko et al. (2018b)	Mining	Case Study	Complex Adaptive Systems	• External shocks	RB; SCA	• Limited understanding of local industry needs • Lack of feedback mechanisms to monitor outcomes	X	X	X	X
28. Vecchi et al. (2020)	Healthcare	Case Study	N.S.	• External shocks	RB	• Complicated industry specifications • Limited shared values and culture is supplier-buyer relations • Low level of collaboration and information sharing among SC actors • Contractual risks on public procurement • Lack of right skills and access to adequate resources to better assess health organisations' needs and market offerings		X		X

Symbol: SC – Supply Chain; RB – Regulatory Body; SCA – Supply Chain Actor (meaning private organisation).

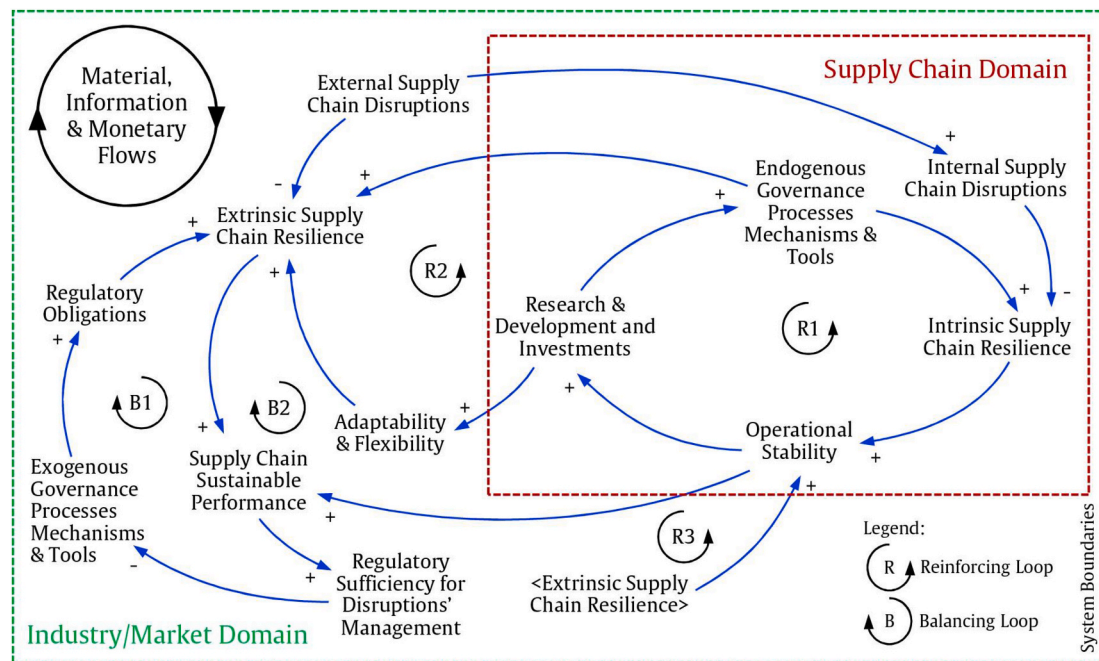


Fig. 4. SC governance and resilience interplay: A systems thinking framework.

Performance' denotes the current-state 'Regulatory Sufficiency for Disruptions' Management' of the regulatory landscape within which SC operations unfold (Tsolakis et al., 2018). In addition, the expansion of operations to international markets necessitates the increased monitoring requirements of regulatory schemes, thus revealing more 'Exogenous Governance Processes, Mechanisms & Tools' and the associated increased 'Regulatory Obligations' such as in the case of organic food global trade (Esteves et al., 2021). Proactive and timely conformance to the diverse and ever-changing global and regional boundaries nurture the capability to persevere the *modus operandi*, thus increasing the 'Extrinsic Supply Chain Resilience'. For this reason, we put forward our second proposition as:

**Proposition 2.** *Ongoing monitoring of the global and regional regulatory contexts increases the ability of SCs to recognise necessary adaptations, and the timely and efficient alignment with the diverse exogenous governance arrangements enhances the extrinsic resilience of the supply network.*

In the balancing loop B2, 'Extrinsic Supply Chain Resilience' helps ensure and improve 'Operational Stability', which in turn has a supporting role on 'Supply Chain Sustainable Performance'. To leverage the stability of operations, 'Regulatory Sufficiency for Disruptions' Management' needs to be an ongoing tenet, particularly within the adaptive global environment of SC operations (Maslin et al., 2019). Thereafter, the realisation of 'Exogenous Governance Processes, Mechanisms & Tools', depending on the regulatory sufficiency level, unveils emerging 'Regulatory Obligations' that improve 'Extrinsic Supply Chain Resilience'. We therefore suggest that:

**Proposition 3.** *Ongoing monitoring of the sufficiency of global and regional regulatory contexts increases the ability of institutional environments to recognise necessary adaptations, and the timely and efficient alignment of the supply networks with these diverse exogenous governance arrangements enhances their extrinsic resilience.*

In the reinforcing loop R2, 'Extrinsic Supply Chain Resilience' advances 'Operational Stability', which subsequently fosters 'Research & Development and Investments' that strengthen the 'Endogenous Governance Processes, Mechanisms & Tools', further improving 'Extrinsic Supply Chain Resilience'. For example, motivated by the disruptions in mission-critical supplies due to the COVID-19 pandemic, Bhaskar et al. (2020) suggested

that a new governance system for interventions by public-health authorities is eminent to reduce inefficiencies and build resilient systems to current and future crises. In this regard, we articulate the following research proposition:

**Proposition 4.** *Resilience against the external supply network environment helps ensure operational stability and informs initiatives that can subsequently help develop endogenous governance processes, mechanisms and tools to safeguard operations and improve extrinsic resilience.*

## 5. Concluding remarks

Black swan events are particularly tricky to predict (Simchi-Levi et al., 2014) yet can have a detrimental impacts on operations and SC management. Scholars and practitioners would therefore need to be inspired and, at the same time, be able to provide resolutions to emerging and unprecedented complexities/challenges (Kastanakis et al., 2019). The devastating COVID-19 pandemic is the most recent, notable exemplar of such incidents, which has indicatively disrupted over 80% of SCs in the UK (Hart, 2020). The pandemic has affected all levels of the underpinning conditions and assumptions in SC management systems (Anker, 2021). To improve SC resilience, the emanating disruptions shall be considered from an integral view of SC dynamics (Olivares-Aguila & ElMaraghy, 2021). In this regard, we have unearthed the extant body of literature, and we identified inherent typologies of SC governance and resilience, namely endogenous and exogenous governance and intrinsic and extrinsic resilience. More importantly, we have identified the structural interconnections among the SC governance and resilience constructs/elements.

Our research also discovers that SC resilience stems from governance processes, mechanisms, and tools, in a dipole relational system comprising a complex system of interactions. In answering the research questions set out in this study, we observed two emerging themes in which SC governance can be elaborated, that is, those endogenous and exogenous processes, mechanisms and tools, be they currently exist or need to be developed, both externally to the supply network and internally among SC actors. We also confirm, via the proposed framework, the manner in which the governance directly or indirectly impacts the intrinsic and extrinsic resilience of SC operations, demonstrating the

interplay of governance and resilience. The proposed framework will allow a more effective structuring of management directions in a supply network.

### 5.1. Academic contributions

In cooperative inter-organisational relationships, like the ones developed across a supply network, relational bonds are more significant for actors (Ring & van de Ven, 2019). However, their relationships are governed by internal and external to the SC, processes, mechanisms, and tools. In this study, we argue that managerial governance impacts SC resilience through a plethora of complex interconnections. For this reason, four research propositions are articulated to elaborate the interplay between SC governance and resilience.

Our paper provides implications for theory in several ways. First, supported by the relevant literature, this research explicitly acknowledges that SC governance shall be regarded from both endogenous and exogenous perspectives. Though sounded rudimentary, this dichotomy is key in recognising the root causes of risks and the resulting disruptions that can negatively impact the intrinsic and extrinsic resilience of SC operations. To the best of our knowledge, this research is the first to clearly consider and define these typologies, namely: (i) endogenous and exogenous SC governance; and (ii) intrinsic and extrinsic SC resilience.

Our findings complement the ones from Li et al. (2014), who identified seven internal and external SC factors that affect the (sustainability) governance of decision-making in the fast fashion industry. However, their framework considers only a directed acyclic pathway from goals to decisions. Our research extends this view by considering the dynamic nature of SC governance and resilience. Exogenous governance interests might impose safeguards within SCs via, for example, warranties and monitoring processes. To accommodate adaptations in exogenous SC governance, internal structures, mechanisms, and tools to manage SC actors' relations, capabilities, financial/information flows, and product and services transactions are required with the aim to mitigate vulnerabilities and foster cooperation.

In this regard, the dominant theoretical perspectives in SC governance include the 'relational governance' and 'contractual governance'. The 'relational governance' focusses on norms and mechanisms that regulate inter-organisational exchanges (Heide & John, 1992; Lusch & Brown, 1996; Macneil, 1980). In a similar way, 'contractual governance' is rooted on transaction cost economics (Williamson, 1985) and refers to the role of contractual directives to dictate formalities of transactions among trading partners (Lumineau & Malhotra, 2011; Reuer & Arino, 2007). The scope of these conceptualisations is mainly on avoiding opportunism and conflicts by informing dispute resolution between trading partners (Wathne & Heide, 2004; Williamson, 1996).

Second, this research explores the interplay between SC governance and resilience, and embraces the relational view of Dyer and Singh (1998). Using our proposed framework, it is arguably straightforward to observe the circumstances where the alignment of transactions among SC partners requires the appropriate endogenous governance structures. These are proven to be vitally important for sustaining a competitive advantage and increasing the network's intrinsic resilience, against, for example, opportunistic phenomena.

Third, our framework implies that a balance between endogenous and exogenous governance processes and mechanisms is required. Specifically, the COVID-19 pandemic revealed congruency between public and private stakeholders' interest towards ensuring higher levels of SC resilience, particularly in the food, pharmaceuticals, and education sectors. Our framework also reveals that exogenous factors can impact endogenous governance; for example, different cultural and value systems in which foreign actors operate can impact trust-based obligations (Ariño et al., 2001). Vice-versa, in the long-term, endogenous forces can impose changes to the exogenous SC system, particularly in modern markets.

### 5.2. Managerial implications

In terms of implications for practice, our proposed framework can explain the causal structure of SC governance and resilience and inform the evaluation of alternative endogenous and exogenous governance options on intrinsic and extrinsic SC resilience. This is in direct support of the development of a transparent-box simulator (Machuca, 1998). The framework can be further programmed into a full-fledged System Dynamics model upon which 'what-if' scenarios can be developed as a basis of enhancing the learning process of decision-makers and SC managers alike.

In addition, the provided CLD model and captured system interconnections could guide practitioners to deploy game-based learning engagements and gain a deeper systemic understanding of SC operational challenges (Lainema & Hilmola, 2005). Thereafter, at a managerial level, the output of such a System Dynamics gamification process could help to systematically define a range of practical governance options and operational goals for increasing short- and long-term SC resilience.

The proposed framework could be embraced by governmental institutions and organisations to advance decision-makers' participatory interactions and facilitate experts' learning through instigating group conversations (Black, 2013). In this regard, the CLD could act as a well-needed learning-oriented SC exploration and a result-driven exploitation medium within the operational risk management domain (Singh & Hong, 2020).

Finally, the framework could be used to guide the policy-level scenario planning by facilitating dynamic analyses of SC disruptions and investigating the responses' outcome based on governance processes and mechanisms already in effect. This is even more prominent for food and pharmaceuticals SCs that require dynamic decision-making in emergency situations, such as the consequent national and regional lockdowns due to the COVID-19 pandemic.

### 5.3. Limitations

This research has limitations that simultaneously provide stimulating grounds for future studies. First, the proposed Systems Thinking framework was synthesised based on secondary evidence. To this end, applying a group model building method, grounded in the System Dynamics literature (Hovmand et al., 2012; Vennix, 1996), is essential for validation and verification purposes. Second, the framework is sector agnostic. Therefore, it requires validation across multiple sectors and geographical areas as stringent governmental regulations are documented to demote resilience like, for example, the stockpiling and environmental regulations in rare earths elements SCs in China (Mancheri et al., 2019).

### 5.4. Future research

While this study has provided a theoretical framework with a set of propositions, we are mindful of the need for validation on SC governance and resilience. The need naturally opens up future research avenues to conduct case studies for refining the propositions. We are also keen to apply the computer-based modelling approach in order not only to visually express the interplay and causality among the constructs in the framework, but also to provide quantitative indications about the strengths of the causality and, indeed, impact. Finally, we are considering conducting empirical research in several SCs in different sectors to learn their idiosyncrasies. This will ultimately help guide the design of more robust SC governance processes, mechanisms to align individual and organisational goals (Zissis et al., 2020), and tools to observe key system constituents that define the systems behaviour and intrinsic/extrinsic resilience.



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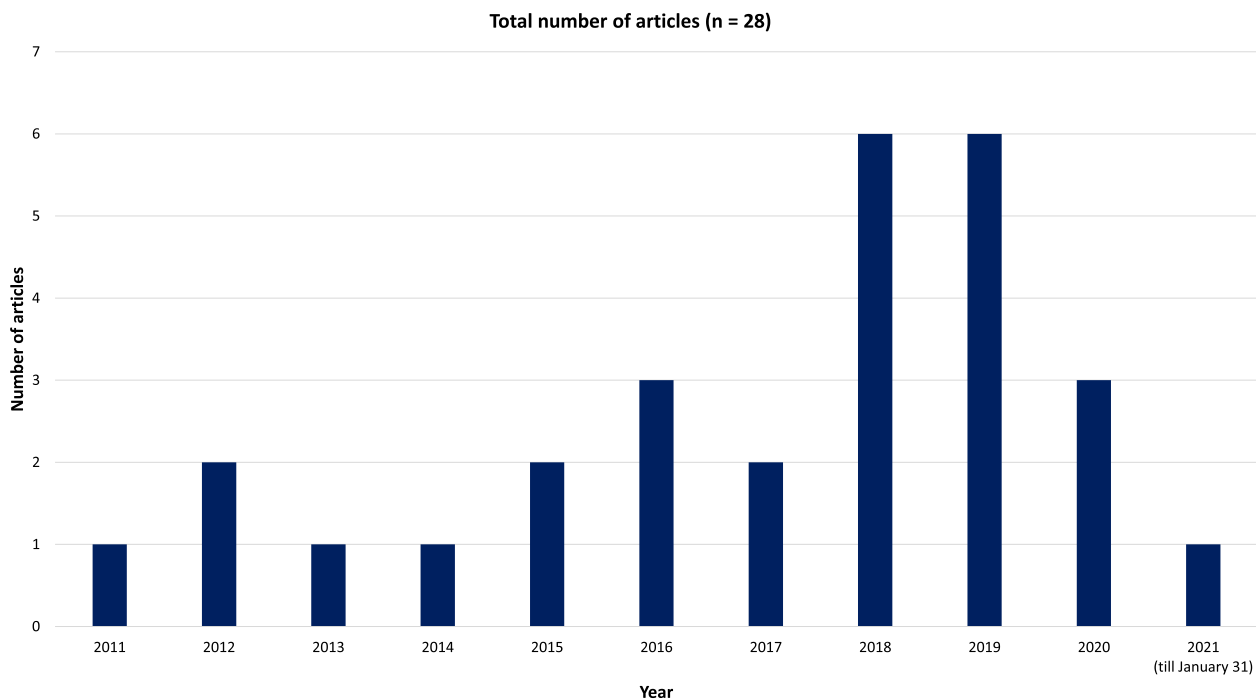
(acronym: HELP) – The HELP project has been co-funded by the European Union and by National Funds of the Countries participating in the Interreg IPA CBC Programme “Greece–Republic of North Macedonia 2014-2020” and has been implemented by the International Hellenic University, The Hellenic Ministry of Interior (Sector of Macedonia-Thrace), the Center for Development of the South-East Region, the Hellenic Rescue Team and the Crisis Management Center.

## Appendix I. Overview of taxonomised articles

**Table A1**

List of scientific articles.

Author(s)	Article Title	Journal
1. Ahlqvist et al. (2020)	Supply chain risk governance: Towards a conceptual multi-level framework	<i>Operations and Supply Chain Management</i>
2. Aigbogun et al. (2016)	The mediating impact of Halal logistics on supply chain resilience: An agency perspective	<i>International Review of Management and Marketing</i>
3. Crane et al. (2019)	Governance gaps in eradicating forced labor: From global to domestic supply chains	<i>Regulation and Governance</i>
4. Durach and Machuca (2018)	A matter of perspective – The role of interpersonal relationships in supply chain risk management	<i>International Journal of Operations and Production Management</i>
5. Edgeman and Wu (2016)	Supply chain criticality in sustainable and resilient enterprises	<i>Journal of Modelling in Management</i>
6. Eltantawy (2015)	Towards sustainable supply management: Requisite governance and resilience capabilities	<i>Journal of Strategic Marketing</i>
7. Emmanuel-Yusuf et al. (2017)	Resilience and Livelihoods in Supply Chains (RELISC): An analytical framework for the development and resilience of the UK wood fuel sector	<i>Sustainability</i>
8. Esteves et al. (2012)	Social impact assessment: The state of the art	<i>Impact Assessment and Project Appraisal</i>
9. Gabler et al. (2017)	Disaster resilience through public-private short-term collaboration	<i>Journal of Business Logistics</i>
10. Kahiluoto et al. (2019)	Decline in climate resilience of European wheat	<i>Proceedings of the National Academy of Sciences of the United States of America</i>
11. Keck and Etzold (2013)	Resilience refused wasted potentials for improving food security in Dhaka	<i>Erdkunde</i>
12. Khurana et al. (2021)	Now is the time to press the reset button: Helping India's companies to become more resilient and effective in overcoming the impacts of COVID-19, climate changes and other crises	<i>Journal of Cleaner Production</i>
13. Lee et al. (2019)	Public-private partnership operational model – A conceptual study on implementing scientific-evidence-based integrated risk management at regional level	<i>Journal of Disaster Research</i>
14. Luthe and Wyss (2016)	Resilience to climate change in a cross-scale tourism governance context: A combined quantitative-qualitative network analysis	<i>Ecology and Society</i>
15. Luthe et al. (2012)	Network governance and regional resilience to climate change: Empirical evidence from mountain tourism communities in the Swiss Gotthard region	<i>Regional Environmental Change</i>
16. Luthe and Wyss (2014)	Assessing and planning resilience in tourism	<i>Tourism Management</i>
17. MacMahon et al. (2015)	Connecting resilience, food security and climate change: Lessons from flooding in Queensland, Australia	<i>Journal of Environmental Studies and Sciences</i>
18. Mancini and Arfini (2018)	Short supply chains and protected designations of origin: The case of parmigiano reggiano (Italy)	<i>Ager</i>
19. McKnight (2019)	The role of firms in resilient systems: A multi-level framework	<i>Canadian Journal of Administrative Sciences</i>
20. Meuwissen et al. (2019)	A framework to assess the resilience of farming systems	<i>Agricultural Systems</i>
21. Meyer (2020)	The role of resilience in food system studies in low- and middle-income countries	<i>Global Food Security</i>
22. Oliver et al. (2018)	Overcoming undesirable resilience in the global food system	<i>Global Sustainability</i>
23. Pal and Torstensson (2011)	Aligning critical success factors to organisational design: A study of Swedish textile and clothing firms	<i>Business Process Management Journal</i>
24. Reis (2019)	Five things government can do to encourage local food contingency plans	<i>Journal of Environmental Planning and Management</i>
25. Schmidt and Matthews (2018)	From state to system: Financialization and the water-energy-food-climate nexus	<i>Geoforum</i>
26. Statsenko et al. (2018a)	A complex adaptive systems governance framework for regional supply networks	<i>Supply Chain Management</i>
27. Statsenko et al. (2018b)	A supply network governance framework: a case study of the South Australian mining industry	<i>Journal of Global Operations and Strategic Sourcing</i>
28. Vecchi et al. (2020)	Medical supply acquisition in Italy and the United States in the era of COVID-19: The case for strategic procurement and public-private partnerships	<i>American Review of Public Administration</i>



**Fig. A1.** Distribution of taxonomised articles by year of publication.

## Appendix II Synopsis of taxonomised articles

Ahlqvist et al. (2020) conducted an extended literature review and proposed a conceptual framework for stressing the role of inter-organisational governance as an enabler of effective supply chain (SC) risk management. The proposed multi-level framework describes risk governance mechanisms by combining the domains of SC management and risk management and societal safety. Aigbogun et al. (2016) conducted a questionnaire-based survey over pharmaceutical industry experts and found that Halal logistics mediate the relationship between SC capabilities, vulnerabilities, and resilience. In addition, Crane et al. (2019) studied secondary evidence from UK-based companies and identified governance gaps in terms of forced labour in global value chains. The study findings suggest that to ensure resilience in terms of labour, governance initiatives shall consider both the product and labour SC, focussing not only on international operations, but also mainly on domestic SCs.

Durach and Machuca (2018) analysed survey data from manufacturing companies in Austria, Germany, and Switzerland, and showed that interpersonal skills and complementarity are catalysts for firm resilience. Such interpersonal dimensions in buyer-supplier relationships impact organisational-level resilience hence indicting the need for setting pertinent governance mechanisms. Furthermore, Edgeman and Wu (2016) reviewed the Sustainable Enterprise Excellence, Resilience, and Robustness (SEER2) model and discussed that ethical, efficient, and effective enterprise governance shall be enhanced to respond to challenges with regard to people, planet and profit sustainability dimensions. The key recognition is that SC interrelations, and not individual network actors, need to be at the centre of SEER2 and other relevant models. Eltantawy (2016) conceptually investigated the contrasting aspects of environmental and economic resilience in SC management. To this effect, the author proposed a framework that describes governance processes and structures that can enable supply management engineering and ecological resilience.

Emmanuel-Yusuf et al. (2017) explored the dynamics underpinning socioeconomic benefits and their impacts on a UK wood-fuel SC resilience and sector growth by developing and implementing the Resilience and Livelihoods in Supply Chains (RELISC) framework. The framework's application revealed that socioeconomic benefits, SC resilience, and sectors' development shall be approached holistically through capturing many system aspects, such as SC governance and structures, institutional processes and policies, availability of resources, stakeholders' perceptions and decisions. Additionally, Esteves et al. (2012) discussed the role of social impact assessment in a changing economic landscape and commented the need of institutional governance responses for ensuring social and environmental resilience. In this regard, the study also highlighted the need for social performance management in SCs for the welfare of all involved stakeholders. Gabler et al. (2017) realised the dynamic complexity of relationships pertaining disaster SC management and suggested short-term collaborations among public and private organisations for disaster resilience.

Kahiluoto et al. (2019) used statistical analyses to investigate the resilience of staple food crops in major European countries against climatic variability. The study findings suggested that national action plans and the Common Agricultural Policy of the European Union shall consider the dynamic changes in climatic conditions by incentivising SCs to leverage complementary responses to critical weather events thus enhancing the resilience of cropping systems and food security. In a similar vein, Keck and Etzold (2013) discussed Dhaka's food system and pinpointed the role of food network actors in ensuring system's resilience under ecological, economic and political crises. The study highlighted the catalytic role that central governance can have in enabling the transformative capacities of regional food systems' actors for ensuring food system and social resilience against disturbances, such as production disruptions (e.g., adverse weather conditions) and prices' fluctuations. More recently, Khurana et al. (2021) identified and prioritised essential factors that can help companies to overcome crises, by examining the case of India at the outbreak of COVID-19 pandemic. Through analytic hierarchy process (AHP) analysis, the study findings revealed the factors that can help companies to improve their resilience in post-crises eras; the 'Role of governance' found to be the most important of these factors. Lee et al. (2019), motivated by natural disasters in Asia, discussed that disaster resilience and SC integrity can be achieved through innovative technologies and collaboration on information sharing, resources' allocation and risks' communication/awareness among stakeholders in public-private partnerships, across different regions.

Luthe et al. (2012) investigated the social processes of governance and their impact on resilience towards climate change, through conducting a social network analysis to the tourism industry-dependent Swiss Gotthard region. The study findings indicated that to increase regional resilience to climate change, mechanisms are required that ensure economic diversification and a governance network structure for stability, flexibility, and innovation. Similarly, Luthe and Wyss (2014) viewed tourism systems as interrelated social-economic-ecological systems where network governance is required to: (i) prepare for disturbances through decentralised processes of social learning and (ii) respond to disturbances via ensuring flexibility through centralised collective action. Such governance provisions could increase the capacity of tourism systems to ensure resilience against disruptions, such as climate change and economic crises. What is more, Luthe and Wyss (2016) studied the resilience of tourism systems to climate change, at both regional and local levels. In particular, through a network analysis of primary data, the authors concluded that to ensure resilience of the Swiss Surselva–Gotthard tourism socio-economic system against climate change, a network governance perspective is required at different scales. Governance shall foster social learning and innovation to prepare for gradual changes and enable adaptability to respond to short-term shocks that demand quick distribution of information and centralised steering of collective action.

MacMahon et al. (2015) studied the resilience of the food supply system in the Australian state of Queensland, in the post-flooding of 2010/2011. The observations revealed that resilience to climate change should be an inclusive concept focussing on not only business continuity and community self-sufficiency, but also considering adaptation, learning, relationship-building, and social well-being as well. In addition, the study revealed that important food security actors are often excluded from decision-making about governance responses to disruptions. Mancini and Arfini (2018) studied the short food SC of the Parmigiano Reggiano cheese along with its governance for improved resilience during the economic crisis era 2007–2012. The governance of the Parmigiano Reggiano SC, and of other Protected Designation of Origin products, is complex as it involves multiple internal and external stakeholders. However, such a complex governance proved to be necessary for the economic, social and environmental sustainability of local food production systems under global market pressures. Also, McKnight (2019) argued that inter-firm practices of self-governance and interdependencies, along with SC collaboration, are antecedents of network system resilience in terms of sustainability.

Meuwissen et al. (2020) developed a framework for evaluating and operationalising resilience in European farming systems. The authors applied a mixed-methods approach on the arable farming system in Veenkoloniën, the Netherlands, and recognised the need to ensure governance adaptability at both the policy-making and farm levels to foster resilience. Meyer (2020) systematically reviewed the literature on food system resilience in low- and middle-income countries and highlighted the need to quantifying resilience to analyse the impact of transformation in terms of sustainable outcomes and food security. The author noted that extant studies do not typically evaluate the impact of governance on food systems' resilience while a systems perspective is required to consider the resilience implications of global governance on regional settings. Oliver et al. (2018) discussed the global food system and observed that governance at all levels is needed to improve the resilience of food SCs and deliver multiple UN Sustainable Development Goals.

Pal and Torstensson (2011) considered organisations as complex adaptive systems and explored the role of three-dimensional concurrent engineering on devising and sustaining critical success drivers for improved operational performance and organisational profitability. Through investigating Swedish textile and clothing firms, the authors identified intangible value propositions, such as organisational culture, leadership, and governance as pivotal design elements for organisational resilience in dynamic market environments. Reis (2019) investigated the food supply network in the Australian regional context of South-East Queensland and focussed on supply disruptions due to extreme weather conditions. Through a literature review and experts' engagement, the author articulated policy recommendations for developing food-related disaster resilience at a community level.

Moreover, Schmidt and Matthews (2018) examined the role of global financial networks in promoting the governance and security of water, energy, food, and climate. Through a critical analysis of the literature, the authors stressed that governing the interlink among water, energy, food, and climate crises, across multiple sites and scales, can propel the resilience of environmental and economic systems. Statsenko et al. (2018a) studied the combined effect of regional SCs and governance to the economic resilience of regions. Based on empirical research on the South Australian mining sector, the authors proposed a governance framework highlighting the role of formal (i.e., regulations, incentives, programmes) and informal (i.e., social norms, trust, reputation) supply network system governance to foster regional SC structure and connectivity for facilitating technology and knowledge diffusion, thus promoting resilience of the regional economy. Statsenko et al. (2018b) also stressed the need for policy-makers and industry stakeholders to undertake initiatives for increasing connectivity among business actors in the mining industry of South Australia to propel the adaptability, responsiveness and resilience of the regional supply network. Finally, Vecchi et al. (2020) investigated the resiliency of the procurement system of materials in the COVID-19 era, via examining the cases of Italy and the US. The authors stressed the need for public governance entities to co-design procurement systems with business stakeholders and shift the focus from a compliance-based perspective to a risk management and collaborative perspective.

### Appendix III. Feedback loops

**Table A2**

Structure of the feedback loops of the conceptual framework.

Feedback Loop	Causal Effect Sequence
Reinforcing, R1	Operational Stability → Research & Development and Investments → Endogenous Governance Processes, Mechanisms & Tools → Intrinsic Supply Chain Resilience → Operational Stability
Reinforcing, R2	Operational Stability → Research & Development and Investments → Endogenous Governance Processes, Mechanisms & Tools → Extrinsic Supply Chain Resilience → Operational Stability
Reinforcing, R3	Operational Stability → Research & Development and Investments → Adaptability & Flexibility → Extrinsic Supply Chain Resilience → Operational Stability
Balancing, B1	Extrinsic Supply Chain Resilience → Supply Chain Sustainable Performance → Regulatory Sufficiency for Disruptions' Management → Exogenous Governance Processes, Mechanisms & Tools → Regulatory Obligations → Extrinsic Supply Chain Resilience
Balancing, B2	Operational Stability → Supply Chain Sustainable Performance → Regulatory Sufficiency for Disruptions' Management → Exogenous Governance Processes, Mechanisms & Tools → Regulatory Obligations → Extrinsic Supply Chain Resilience → Operational Stability

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