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Article

Flexibility and adaptability: Dynamic capabilities for building supply chain resilience

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Abstract: This study investigates the escalating complexity and unpredictability of global supply chains, with a particular emphasis on resilience in the agricultural sector of Antioquia, Colombia. The aim of the study is to identify and analyze the dynamic capabilities, specifically flexibility and adaptability that significantly enhance resilience within agri-food supply chains. Given the sector's vulnerability to external disruptions, such as climate change and economic volatility, a thorough understanding of these capabilities is imperative for the formulation of effective risk management strategies. This research is essential to provide empirical insights that can inform stakeholders on fortifying their supply chains, thereby contributing to enhanced competitiveness and sustainability. By presenting a comprehensive framework for evaluating dynamic capabilities, this study not only addresses existing gaps in the literature but also offers practical recommendations aimed at bolstering resilience in the agricultural sector.

Keywords: supply chain resilience; dynamic capability ecosystem (DCE); collaborative risk management (CRM); Agri-food supply chains; flexibility and adaptability

1. Introduction

The concept of resilience has been worked on from different areas of knowledge: psychology, ecology, materials science, economics and engineering, seen as the capability of a system to face a temporary perturbation while maintaining its structure, essence and dynamism, as well as allowing it to learn and adapt in the face of a disruptive event.

From the supply chain construct, resilience is conceived as the capability that allows the chain to prepare, respond and recover in a minimum time to the occurrence of an unexpected disruptive event, maintaining the continuity of operations at desired levels, as well as to develop strategies that allow it to learn from a casual disruptive event and provide efficient responses, and to develop new capabilities that make it less vulnerable. A resilient supply chain is able to reduce the likelihood of disruption and the time it takes to recover from its original state (Datta et al., 2007). Recovery does not necessarily imply returning to an initial state, but probably consider the achievement of a new conditions or state (Christopher and Peck, 2004). Resilience capabilities and strategies will enable you to maximize risks in a timely manner and at minimal cost.

The resilience of agri-food productive chains has also been studied, given that managing risk and disruptions is even more important due to food security objectives and the challenges associated with seasonality, supply peaks, long supply lead times, climate, pests and perishability, which imply more sources of uncertainty. In addition,

being able to manage and mitigate possible disruptions due to global warming, climate changes and natural phenomena such as landslides and crop flooding, among others different effects caused by humans.

From the universe of dynamic capabilities, we can see how resilience integrates a set of these capabilities, becoming a super capability or robust capability that is based on the integration and coordination of resources, promoting unique and inimitable strategies that generate competitive advantage for supply chains and the organization. Within this universe of dynamic capabilities, flexibility, adaptability, reconfiguration, collaboration, ingenuity and learning stand out. The union and integration of these capabilities enables the construction of dynamic strategies that minimize the impact of unforeseen disruptive events and achieve optimal management of available resources.

For example, flexibility is described by Peck, 2005 as "being able to bend easily without breaking" and has been taken as an inherent element of resilience. For Jüttner and Maklan (2011) flexibility describes how well a system responds when faced with a disruptive event by ensuring continuity. This capability ensures that changes in the face of disruptive events are absorbed by the supply chain, generating assertive responses (Skipper and Hanna, 2009). On the other hand, adaptability is defined as the ability of the system to adapt to the environmental situation, improving or achieving its objectives (Ivanov et al., 2010). According to Cumming et al. (2005) and Fazey et al. (2007) adaptive systems are able to absorb shocks and recover after having suffered a disruption, furthermore, this capability allows the chain to learn, alter its behaviour and maintain its resilient state. In the resilient supply chain literature, Ingenuity is defined as the ability to identify problems, set necessities, and allocate resources to deal with disruptions, ensuring the integrity of the system (Cimellaro et al., 2010).

The objective of the research work from is to analyze in the agricultural sector of eastern Antioquia in Colombia, the dynamic capabilities with the greatest influence on the development and strengthening of resilience in the supply chain for collaborative risk management environments. To the present study, both the literature and theoretical review and the case study developed and presented for the agricultural sector in eastern Antioquia in Colombia focus on highlighting the dynamic capabilities of flexibility and adaptability as the most influential in developing and strengthening supply chain resilience for collaborative risk management environments. While flexibility and adaptability are presented as the most valued, mentioned and appreciated dynamic supply chain capabilities for the development of resilience aligned to collaborative risk management, it is imperative to remember that the supply chain generates an environment of continuous interaction of dynamic capabilities, reflected through an ecosystem of interactive interpenetration that supports the achievement of strategic objectives and organizational sustainability.

By focusing on the ecosystem discourse of dynamic capabilities, we conclude that it should give prominence to the capabilities of flexibility and adaptation, which are perceived and scientifically documented as those capabilities that drive the development of resilience in the supply chain (resilience being seen as the ability to manage collaborative risk in the supply chain in a short time to achieve stakeholder gains).

Earlier studies on supply chain resilience have often faced several challenges that limit their applicability and effectiveness in real-world scenarios. One significant challenge is the lack of a comprehensive framework that integrates various dynamic capabilities essential for resilience. For instance, while some studies emphasize flexibility as a critical capability, they may overlook the interplay between flexibility and adaptability, which can lead to incomplete conclusions about how organizations can effectively respond to disruptions (Jüttner and Maklan, 2011; Peck, 2005).

Additionally, many existing studies tend to focus on theoretical models without sufficient empirical validation. For example, research that proposes frameworks for resilience often lacks case studies or practical examples that demonstrate how these frameworks can be implemented in specific contexts, such as the agricultural sector (Christopher and Peck, 2004). This gap can result in recommendations that are not grounded in the realities faced by practitioners, making it difficult for organizations to translate theoretical insights into actionable strategies.

Moreover, previous literature frequently fails to consider the unique challenges faced by specific industries. For instance, studies that address supply chain resilience in manufacturing may not adequately account for the distinct vulnerabilities of the agricultural sector, such as seasonal variability and dependence on weather conditions (Datta et al., 2007). This oversight can lead to generalized conclusions that do not resonate with the specific needs of agricultural stakeholders.

In summary, the challenges in earlier studies include a lack of integrated frameworks, insufficient empirical validation, and a failure to address industry-specific issues. These limitations underscore the necessity for research that not only identifies dynamic capabilities but also provides practical, context-specific insights that can enhance resilience in supply chains, particularly in vulnerable sectors like agriculture.

The development of this work is structured as follows: in session one there is a literature review, from the constructs: DCV, resilience in the supply chain and resilience as a dynamic capability. The session presents the research methodology for the case development. Section three presents the case study. Session four has the discussion and conclusion.

2. Literature review: Background of the study

2.1. Dynamic capabilities view (DCV)

The origin of the theory of dynamic capabilities (dynamic capabilities view) has its roots in the theory of resources and capabilities or resource-based view, which in turn is based on the work of classic authors of economic thought such as Chamberlin (1933), Ricardo (1817), in addition to the organization theory that has its origins in authors such as Penrose (1959) and Schumpeter (1950), or in the strategic management of authors such as Andrews (1971). For these theories in general, organizations are heterogeneous in terms of the endowment of their resources given their trajectory, experience and strategies used to obtain specific resources, allowing them to develop from these, differentiating capabilities and competitive advantages (Reynoso, 2018).

The resource-based view is based on two fundamental assumptions: the heterogeneity of firms given the acquisition of resources and the persistence in the

heterogeneity of the firm's resource endowments given their imperfect mobility (Barney, 1991). According to Barney (1986), resources become a source of competitive advantage when they fulfil characteristics such as: scarce, valuable, difficult to imitate and substitute.

Similarly, Grant (1991) argues that companies that structure and consolidate their strategies on the basis of their resources and capabilities have a greater chance of success in their market niche than those organizations that are based on the search for a target market, given that the search for resources and capabilities is complex due to the restrictions that exist in the factor market, which increases the risks of loss in a changing environment.

Resources and capabilities can be a solid basis for building organizational identity. Defining the organizational strategy in terms of what it is capable of doing becomes a competitive and differentiating support, in contrast to organizations that define organizational strategy in terms of the needs it can satisfy, i.e., identity is built on the clear definition of its internal resources and capabilities, rather than on the market (Ibarra and Suárez, 2002; Mekhum, 2019).

Resources can be tangible: physical and financial resources; and intangible: human resources, the value of a trademark, patents, manufacturing rights, technology, corporate culture, relationship with internal and external customers among others (Grant 1996; Hall, 1992; Hansen and Wernerfelt 1989; Jacoboson, 1988). Likewise, Wernerfelt (1984) defines resources as those assets that can be tangible and intangible and are linked to the company on a semi-permanent basis like a brand, know how, own technological knowledge, use of personal skills and reinforcement of these, business relations, efficient procedures, capital (Wernerfelt, 1984).

On the other hand, capabilities or competences are a set of knowledge and skills obtained from the collective learning of the organization, a consequence of a structural management of resources, of establishing organizational routines, which are carried out through the exchange of information and the interaction of the organization's human capital (Cuervo, 1993). In a similar vein, for Nelson and Winter (1982), capabilities are defined as "organizational routines" of the firm, which are generated from a pattern of coordination between resources, and by perfecting this coordination, a learning process is acquired through repetition, which is expressed as organizational memory. For Grant (1996), capabilities are regular activities that are made up of a sequence of independent actions that act in a coordinated manner to carry out a specific activity.

Already under the DCV, the company focuses its strategies on the use of available resources and the generation of a pattern of coordination between them, that by perfecting this coordination, an organizational learning process is acquired, leading to the creation of competitive advantages, which are unique and difficult to imitate by rivals. In other words, top management develops confidence in the organization's capabilities to achieve difficult goals, as well as being constant in the incorporation of new capabilities.

In the work carried out by (Garzón, 2015) defines dynamic capabilities as the potentiality of the company to generate and build organizational knowledge from a continuous way to create, improve, protect, integrate, reconfigure, renew, recreate, increase and reconstruct of its core competences, in order to attend the context changes

in markets and technologies, which include the company's ability to shape the environment in which it operates, improving, design and developing new products and/or business processes and implementing new or redefined business models in order to maintain and/or extend sustainable competitive advantages (Junaid et al., 2023; Kodama et al., 2018; Мандал у Mandal, 2017).

In the quest to generate strategic impact, it is necessary for the organization to establish value creation processes based on the dynamic capabilities identified, thus achieving value and competitiveness in a changing market.

- Absorption Capability: is the ability of the firm to recognize, identify, assimilate and exploit information originating from outside for business purposes (Zahra and George, 2002), disaggregates this capability into four dimensions 1) Knowledge Acquisition, 2) Knowledge Assimilation, 3) Knowledge Exploitation, 4) Knowledge Transformation.

  Innovation capability: according to Wang and Ahmed (2004), this is the organization's ability to create new production methods and new products, identify new markets, create or acquire new sources of supply, and create new organizational forms. This capability becomes a link between resources and capabilities when creating new products according to how the market changes. According to Nokaka and Takeuchi (1999), this capability seeks the active exploitation and creation of new and unique knowledge, as well as facilitating its communication, diffusion and transfer within the organization. For innovation capability, dimensions such as: incremental innovation; architectural innovation; radical innovation and conceptual innovation have been proposed (Afuah, 1999, 2003; Hamel, 2000; Hamel and Getz, 2007; Henderson and Clarck, 1990; Kabongo et al., 2017; Kuatko and Hodgetts, 1992; Molina and Munuera, 2008; Shan et al., 2020; Scott, 2011; Tushman and Anderson, 1986; Valdés, 2004). Currently, the integration of Industry 4.0 technologies significantly enhances innovation capability and supply chain resilience. Advanced technologies such as artificial intelligence, blockchain, and IoT enable real-time data sharing, predictive analytics, and automation, fostering collaboration and adaptability across supply chains. These innovations enhance responsiveness to disruptions and facilitate sustainable practices (Abdirad and Krishnan, 2021; Ghobakhloo et al., 2023). By aligning digital transformation strategies with supply chain resilience, organizations can leverage innovation for competitive advantage. Enhanced data-driven decision-making and modular design principles further support innovation and agility, critical to addressing the complexities of modern supply chains (Belhadi et al., 2021; Spieske and Birkel, 2021).
- Learning capability is the sum of individual and collective learning, resulting from internal and external processes of the company (Mertens and Palomares, 2008), it seeks to transform the organization's learning effort into competitiveness. It is also defined as the dynamic potential to create, assimilate, disseminate and use knowledge through the various organizational flows that make possible the formation and training of the organization and its knowledge agents to act in changing environments (Prieto, 2003). The learning capability also defined by Garzón et al. (2013) as the organization's potential to create new individual, team, organizational and inter-organizational knowledge, based on its

culture, allowing it to improve: processes, develop new potential, products and services, oriented towards sustainability; this potential will depend on the organization's ability to know, assimilate and value internal and external knowledge for productive purposes. The following dimensions have also been proposed: acquisition of knowledge capabilities, capability to generate knowledge and capability to combine knowledge.

- Adaptive capability or adaptability: this is the ability to survive and obtain profitability that the organization develops in a dynamic market and involves new elements in the organizational strategy. This capability is aimed at the strategic and structural adjustment of the organization to adapt to the contextual conditions of the organization. The dimensions for this capability are: Strategic flexibility, unstable, stable, neutral. According to McKee et al. (1989), the capability to adapt and counterattack should be developed in the organization according to its characteristics from three states: unstable state; the company decreases its reaction to the environment by shortening its orientation towards the market; stable state; the organization reacts to the market or environment using the ability of observation to identify and meet the needs of this; neutral state; the organization possesses high adaptive capability and is the first to seek new opportunities in the market, investing in resources to adapt in the shortest possible time (Hong et al., 2018; Isnaini et al., 2020; Ju et al., 2019).

These capabilities allow the organization to reconfigure its core resources and adapt to changing market conditions in a faster and more agile way, enabling the company to create competitive advantage.

2.2. Supply chain resilience

The study of resilience has its origins in psychology, from developmental theory, and is an emerging theory in its own right (Ponomarov and Holcomb, 2009). In this area of knowledge, it is conceived "as a concept related to the capability of people to generate adaptive proposals in the face of adversity", the person is in a position to do something if he/she has the opportunity to the circumstances (López, 2015). Likewise, the human sciences have adopted the term to refer to the patterns or actions of people to overcome adverse situations, a resilient person is one who manages to overcome a difficulty (Sánchez, 2003). García del Castillo et al. (2016) frame the emergence of a new concept of resilience related with the physics, in relation to the resistance of materials, as well as the ability to recover its initial state after being subjected to high pressures and forces (López, 1996).

In the same theoretical stream, Holling and Guderson (2001) define resilience as the ability of the system to cope with disturbances and maintain in order all its functions and controls, perception that authors such as Carpenter et al. (2001), added the concept of adaptive cycle, since a dynamic system makes a stable and balanced state, thus concluding that resilience has three main states: the amount of changes that the system undergoes during the perturbation but is able to maintain the same structure, the system is able to maintain itself without reorganizing external factors and finally, the degree of dynamism that generates the system to learn and adapt in the face of the adverse event.

Melnyk (2014) mentions that resilience consists of two critical but fundamental components for a system: resistance and recovery. The first component refers to the ability of the system to minimize the impact of a disruption, the second component refers to the ability of the system to return to normal operation once a disruption has occurred. From the point view of supply chain, resilience is defined as the ability to prepare for, respond to and recover from unexpected disruptive events, maintaining continuity of operations at desired levels, with minimal economic loss and increasing competitiveness (Barac et al., 2011; Christopher, 2005; Romero et al., 2016).

According to Aboah et al. (2019) the definition of resilience in the supply chain is closely related with reactive and proactive actions. Reactive definitions are framed as the response of a system to a disruptive event with no emphasis on recovery, proactive definitions are considered as preventive where they reflect the preparedness, response and recovery of the system to such an event, considering resilience as a strategic and crucial dynamic capability in the organizations that allows the system to achieve a competitive advantage. For Pettit et al. (2010) resilience focuses on unpredictable disruptions, and uncertainty about the likelihood of a disruptive event occurring, placing resilience exogenous the domain of risk management, and highlighting the proactive definition of resilience.

A resilient supply chain is able to reduce the likelihood of disruption, and the time to recover from its original state (Datta et al., 2007). Recovery does not necessarily imply returning to an initial state, but rather the achievement other and probably new state (Christopher and Peck, 2004). It can be assessed in four aspects: preparedness to cope with an unexpected event, response to the event, recovery from the event, and growth or competitive advantage in the face of disruption (Ponomarov and Holcomb, 2009; Sheffi and Rice, 2005). Resilience capabilities and strategies will enable to the organization minimize risk in a timely manner and at minimal cost.

In socio-technical systems, human-machine interaction, the study of resilience has focused particularly on activities in the processing, manufacturing and distribution stages. In socio-ecological systems, human-nature interaction, resilience in the value chain is multidimensional, involving the relationship between people, technical and technological systems, the environment and economic areas that focus upstream (Folke et al., 2010; Ivanov et al., 2019). Resilience in the agricultural and agri-food value chains takes on particular importance because the activities that are planned and executed upstream are crucial, as the outcome of these activities impacts the continuity of the supply chain (Aboah et al., 2019). They also have a cascading impact on intermediary and retail actors (Pereira et al., 2014).

For Carvalho and Cruz (2011) an important topic of resilience analysis is the identification of the initial state of a system. For the agri-food supply chain, the state of resilience is defined by Cumming et al. (2005) as the identity that needs to be maintained in the face of disruption, i.e. ecosystem services act as the state of resilience that needs to be maintained in the face of disruption. Such services are the result of the relationship between human ability, technology, nature (ecology), according to Biggs et al. (2015) are categorized into provisioning, regulating and cultural.

According to Aboah et al. (2019) for the conceptualization of resilience in agri-food systems, three aspects should be considered: 1) analyzing the context and

determining whether the focus will be on sociological or socio-technical resilience, 2) determining the resilience status of the system, as this is the basis for determining resilience levels, and 3) defining the level of research: at the national or food systems level, at the discrete food value chain level and at the individual actor level.

From another perspective Clavijo-Buritica et al. (2022) define agri-food supply chain resilience (AFSC) as the capability to mitigate and manage possible disruptions due to global warming and other type of natural among others caused by human acts.

This scientific paper also contributes to the understanding of dynamic capabilities in supply chains (Alzate and Boada, 2024; Hosseini et al., 2019), particularly in terms of flexibility and adaptability across various models. Specifically, (a) fuzzy control and simulation models, which, according to Jin et al. (2019) and Zhang et al. (2017), can effectively suppress fluctuations and mitigate the impact of uncertainty in nonlinear supply chain systems, thus achieving stable operation. This includes the potential to develop models that address logistical challenges during uncertain and critical delivery times, as highlighted by Irfan et al. (2022). (b) Discrete switched models with robust fuzzy control, as shown by Zhang et al. (2018), demonstrate the capacity for low-cost, robust supply chain operation, ensuring stability even in uncertain environments (Song-ta, 2015). Furthermore, an established strategy utilizing fuzzy emergency models and robust emergency strategies, as described by Lee (2017), aids in determining resilient supply portfolios by allocating emergency capacities to backup suppliers, thereby meeting capacity constraints and minimum order quantity requirements. This approach effectively restores normal supply chain operations when issues arise, while maintaining low total cost and ensuring solid stability (Zhang et al., 2019). Indeed, the implementation of these dynamic capabilities could enhance decision-making through fuzzy logic, which, according to Poornikoo and Qureshi (2019), can significantly reduce the bullwhip effect.

Finally, dynamic supply chain capabilities, as noted by Brusset and Teller (2017), can foster closer integration across tiers and enhance flexibility, ultimately leading to increased resilience in supply chains. This capability supports the development of fuzzy multi-objective models, such as those proposed by Nayeri et al. (2021), which can optimize a sustainable supply chain network by minimizing total costs and environmental damage while maximizing social impact and responsiveness. Additionally, the combined methodology of grey theory and layered analytic network process can effectively quantify resilient strategies for risk mitigation in electronic supply chains (Rajagopal, 2020; Rajesh, 2020).

2.3. Resilience as a dynamic capability

In an organizational context, the concept of resilience has been defined as a capability to recover quickly and effectively from an adverse event (Fahimnia et al., 2015; Gupta et al., 2015; Pettit et al., 2010). Resilience complies with outstanding aspects of the theory of dynamic capabilities given that it provides the organization with the ability to integrate, build and reconfigure external and internal competencies in accordance with existing resources to face a changing and agile environment, generating competitive strategies that are difficult for competitors to replicate. Ivanov (2018) refers to resilience as the ability to adapt decisions and return to performance

under disruptions, through recovery strategies. These strategies allow for managing infrequent risks on both the supply and demand side, providing efficient and rapid recovery after a disruption (Tomlin, 2009). Macfadyen et al. (2015) consider resilience as a "dynamic ability to achieve outcomes despite disruptions and shocks".

Resilience is a dynamic capability that brings together some relevant aspects of other dynamic capabilities, making it attractive to organizations. Resilience has some abilities of the absorptive capability: it is able to read the context and identify adverse events, it provides the tools to exploit the knowledge of human resources, it is able to transform knowledge into robust and resilient strategies. From the capability for innovation, it can adopt strategies such as: creating new processes and products, generating new markets in accordance with the needs of the environment, conceptual innovation, innovation in the management or integration of existing resources to overcome an adverse event, as well as seeking to exploit resources to the maximum and efficiently in the face of a difficulty. From the capability for learning, it takes the ability to create individual, team, organizational and sustainability knowledge. From these aspects, resilience generates survival strategies by configuring resources in such a way as to overcome adversity, and the company builds a learning process that is difficult to replicate and imitate by its rivals. It takes fundamental elements from the capability to adapt and counter-attack, as it allows the restructuring of organizational strategies, as authors such as Gallopin (2006), affirm that through resilience the company can reach an initial or better state than the one it had before faced an adversity. Dalziell and McManus (2004), Gallopin (2006) define resilience as an adaptive capability of the organization to move forward in the face of a disruptive event in order to achieve its purpose.

At the literature review level, based on the perspective of Briano et al. (2009), Jüttner and Maklan (2011) and Ponomarov and Holcomb (2009), they take the elements of resilience and bring them to the level of dynamic capabilities, given that a resilient supply chain is underpinned by elements of resilience, which have been considered for the analysis of the chain under specific contexts of analysis, in order to establish strategies that allow it to learn from disruptive events, provide efficient responses and develop capabilities that make it less vulnerable to threats (Christopher and Peck, 2004). Also, supply chain dynamism positively influences both disruption orientation and resilience, with resilience mediating the relationship between disruption orientation and financial performance (Yu et al., 2019). Several authors have explored the importance of developing dynamic capabilities to enhance supply chain resilience and performance in volatile environments.

Recent research underscores the critical role of supply chain resilience (SCR) in navigating dynamic market conditions. Studies after 2020 emphasize SCR as a dynamic capability, enabling firms to prepare, adapt, and recover from disruptions effectively. Techniques like dual sourcing, digital transformation, and scenario-based planning have emerged as pivotal strategies for mitigating risks. Resilience also correlates strongly with financial performance, acting as a mediating factor between disruption orientation and outcomes (Sultana et al., 2024; Yu et al., 2019). Implementing robust SCR practices ensures firms remain competitive, especially in volatile environments characterized by frequent disruptions (Adobor, 2020; Mehmood et al., 2024).

Dynamic capabilities, particularly supply chain ambidexterity, are essential for fostering supply chain resilience. Supply chain ambidexterity, encompassing adaptability and alignment, equips firms to mitigate disruptions while maintaining operational efficiency. Additionally, supply chain agility mediates this relationship, enabling rapid adaptation to market uncertainties in addition with supply chain flexibility. Recent studies about supply chain ambidexterity emphasize effectiveness in developing resilience despite environmental volatility (Chowdhury et al., 2019; Polyviou et al., 2020). Furthermore, the integration of agility and dynamic resource management significantly enhances resilience outcomes (Altay et al., 2018; Christopher and Peck, 2020). These insights highlight the strategic imperative of resilience-focused supply chain management.

Post-2020 studies emphasize strategies such as digitalization, real-time visibility, and robust risk management to address disruptions, as highlighted during the COVID-19 pandemic. Emerging technologies like AI, IoT, and blockchain further reinforce operational adaptability and resilience (Abourokbah et al., 2023; Choong et al., 2020; Junaid et al., 2023; Kamble et al., 2021; Mohammed et al., 2023). Supply chain resilience integrates technologies like additive manufacturing to balance resilience and efficiency post-COVID-19. Additive manufacturing fosters dynamic capabilities, enabling rapid adaptability and operational continuity through ambidexterity, agility, and collaboration (Belhadi et al., 2022; Belhadi et al., 2020; Gu et al., 2021). Such advancements ensure robust, efficient supply chain performance amidst global disruptions.

In this regard, a literature review of more than 260 scientific articles from scientific journals indexed at the scientific level related with resilience in the supply chain identified that the dynamic supply chain capabilities are addressed in 72 of them, identifying a higher frequency in the literature with the dynamic capabilities of: flexibility, collaboration and adaptability (see **Table 1**).

Table 1. Dynamic supply chain capabilities in the supply chain resilience theme.

Resilience elements	Citation frequency	Percentage	Quotations
Flexibility		22.22%	(Briano et al., 2009; Caniato, 2003; Charles et al., 2010; Chowdhury and Quaddus, 2016; Christopher, 2005; Christopher and Peck, 2004; Hohenstein et al., 2015; Jüttner and Maklan, 2011; Li et al., 2006; Nikookar et al., 2014; Pettit et al., 2013; Ponomarov and Holcomb, 2009; Rice and Caniato, 2003; Sheffi and Rice, 2005; Skipper and Hanna, 2009; Tang and Tomlin, 2008).
Collaboration		19.44%	(Briano et al., 2009; Christopher and Peck, 2004; Faisal et al., 2006; Hohenstein et al., 2015; Jüttner and Maklan, 2011; Pettit et al., 2010; Pettit et al., 2013; Ponis and Koronis, 2012; Ponomarov and Holcomb, 2009; Richey, 2009; Scholten and Schilder, 2015; Soni et al., 2014).
Adaptability		18.06%	(Aboah et al., 2019; Briano et al., 2009; Cumming et al., 2005; Eckstein et al., 2015; Fazey et al., 2007; Fiksel, 2003; Hohenstein et al., 2015; Ivanov et al., 2010; Pettit et al., 2013; Ponomarov and Holcomb, 2009; Sheffi and Rice, 2005; Smith, 2004).
Other capabilities	29	40.28%	
TOTAL		100.00%	

3. Methodology

The systematic literature review methodology developed by Kitchenham (2004) was used to analyze the contributions in the last 18 years related to the literature on

dynamic capabilities that are integrated in the resilient supply chain. This methodological tool allows identifying in an organized and schematic way, the most relevant contributions, trends, research opportunities and gaps in knowledge based on the formulation of research questions. The systematic literature review is underpinned by five systematic and structured stages (see **Figure 1**)

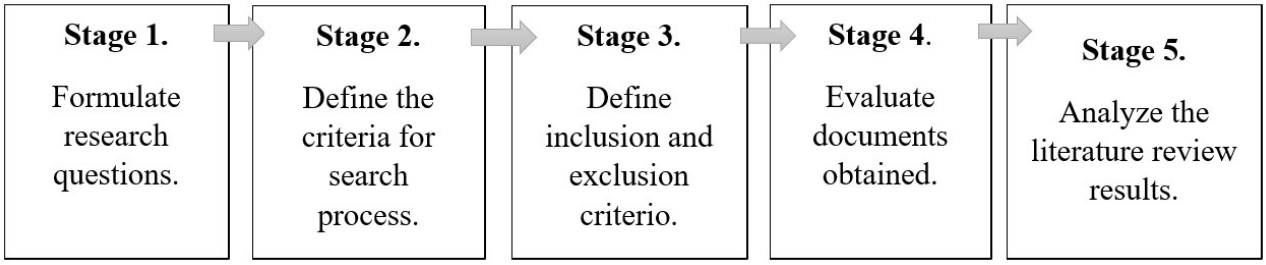

Figure 1. Literature review stages.
Source: Authors' own elaboration (2022).

The following is a detailed description of the research methodology used for the development of the literature review of this paper.

Stage 1: the questions formulated that provide the aim of the study are: Are dynamic capabilities generating resilient strategies in the supply chain? What are the dynamic capabilities that have greater integration and relevance in the agri-food supply chain for collaborative risk management?

Stage 2: Selection of database to consult. The database selected were Science Direct, Scopus, Web of Science and Emerald Insight were selected. In addition, at this stage the keywords to be used were established: supply chain resilience, dynamic capability ecosystem, collaborative risk management, flexibility, adaptability.

Stage 3: The inclusion criteria considered for the filtering of documents were: Articles or research papers published between the periods 2004–2022, peer-reviewed academic literature, empirical and non-empirical studies, articles presenting definitions of supply chain resilience, quantitative and analytical models,

Stage 4: For the review of the identified articles, we started by reading the abstract and then reading the papers in their entirety. In order to filter out irrelevant articles, the judgement of the researchers according to the questions posed in stage 1 was taken into account.

Stage 5: Finally, 73 articles were identified that expose and highlight dynamic capabilities as a strategic factor of resilience in agri-food supply chains and value supply chains.

Similarly, and in order to support the analysis of the literature collected, a case study is carried out based on the information generated from a set of training sessions carried out with two farmers' associations in the department of Antioquia in Colombia. These were carried out within the framework of the strengthening of associativity promoted by the Chamber of Commerce of the region. **Table 2** below describes the stages of the study and the target sample for analysis:

Table 2. Stages of the study and sample.

Activity	Description	Involved
Raising awareness among farmers and associations	Talk on competitiveness and associativity in the framework of the Business Roundtable of farmers from Antioquia invited by the Governor's Office of Antioquia.	Producers Partnerships Marketers Chamber of Commerce Sectoral Committees Government of Antioquia
Design of a training cycle Strengthening of associativity	In conjunction with the regional Chamber of Commerce, the Universidad Nacional de Colombia and the group of researchers, 4 training modules (total 20 hours) are designed, focused on strengthening associativity.	Chamber of Commerce Sectorial Table UNAL Researchers
Invitation to training sessions for associations registered with the Regional Chamber of Commerce (RCC).	Together, RCC and the group of researchers are approaching producer associations in the region to join the training cycle.	RCC Sectorial Table Researchers
Training cycle begins	Two (2) associations are registered, with which the planned 4-module training begins, and which constitute the analysis sample for this study.	CCR Sectorial Table Researchers Invited academics

Source: Authors' own elaboration (2022).

In addition to the above, two research questions were formulated to guide the study and the proposed methodology:

- What specific dynamic capabilities, such as flexibility and adaptability, significantly enhance the resilience of agricultural supply chains in the face of external disruptions?
- How can collaborative risk management strategies be effectively implemented within agricultural supply chains to improve their resilience and recovery from disruptive events?

In order to understand the dynamic capabilities and how they contribute to the development of resilient supply chains, in addition to collaborative risk management in their supply chains, a survey and instrument were developed and applied during the training sessions.

The activities carried out in the different modules (a total of four) were aimed at achieving the coordination of the association, as well as at understanding the capacities involved and how to develop them in order to foster greater cohesion within the collaborative network. The first module was focused on building trust and communication between the actors in the collaborative network, the second on understanding and developing dynamic supply chain capabilities, the third module focused on generating a vision for the future of the collaborative network and the fourth on establishing a baseline to work on strengthening and cohesion of the association.

The question formulated to the participating associations was:

Question 1. If you were the leader or representative of the association to which you currently belong, rank which and in what order you would develop dynamic supply chain capabilities among your partners in order to better manage collaborative

risk and build resilience in the supply chain: Flexibility, Adaptability, Reconfiguration, Collaboration, Integration, Agility, Coordination, Competitive Priorities.

In addition to this, a theoretical-conceptual tool based on Ju et al. (2019) is presented, in addition to the collected and previously filtered literature on organizational and supply chain dynamic capabilities. **Table 3** below shows the constructed tool presenting the explanatory variables of dynamic supply chain capabilities that were assessed by association through a 7-points Likert scale. Question 2 with which the rating of these variables was assessed was: How much do you think this dynamic supply chain capability influences the collaborative risk management and achievements of the partnership?

Table 3. Conceptual-theoretical tool.

Variables Explanatory Statements	**Measuring Instrument**	**Related Literature**
Coordination	Coordination of tasks, resources and objectives between partners Risk and benefit sharing with partners Specific roles and responsibilities among partners Information sharing on partner costs	• Jiang and Li, 2011 • Li et al., 2006 • Mentzer, et al., 2001 • Storer and Hyland, 2011 • Tripathi and Joshi, 2019
Adaptability	Shared goals and objectives among partners Standardization of international requirements among partners Joint plan for monitoring risks in the environment Joint construction of possible risks given in the productive sector environment.	• Aslam et al., 2020 • Chan and Chan, 2010 • Hülsmann et al., 2008 • Ketchen and Hult, 2007 • Lee, 2004 • Stefanelli et al., 2016 • Tuominen et al., 2004 • Whitten et al., 2012 • Xia et al., 2008
Agility	Synchronization of partners' production chains Identification of possible changes given in the target markets (demand) Shared information on partner demand Implementation and design of new processes in the production chain (process innovation). Structuring contingency and crisis management (resilience) plans among partners	• Aslam et al., 2020 • Baker, 2008 • Blome et al., 2013 • Christopher et al., 2004 • Forsberg and Towers, 2007 • Jiang and Li, 2011 • Kareem and Kummitha, 2020 • Lee, 2004 • Li et al., 2006 • Polater, 2021 • Swafford et al., 2008 • Van Hoek, 2006 • Whitten et al., 2012
Competitive Priorities	Formulation of joint strategies for the success of the partnership Operational capability building Construction of a joint plan for productive technification and innovation. Structuring of a quality management system individually and jointly	• Boyer and Lewis; 2002 Ketchen and Hult, 2007 • Lee, 2004 • Storer and Hyland, 2011 • Ward et al., 1998 • Whitten et al., 2012
Reconfiguration	Transformation of the organizational structure for the benefit of the partnership Recognition of the association's own resources and those it possesses Recognition of key routines for the operational performance of the partnership Establishment of checkpoints to prevent disruption among partners	• Blome et al., 2013 • Cao and Jiang, 2020 • de Moura and Saroli, 2020 • Hülsmann et al., 2008 • Masteika and Čepinskis, 2015 • Polater, 2021 • Storer and Hyland, 2011 • Teece et al., 1997

Table 3. (*Continued*).

Variables Explanatory Statements	Measuring Instrument	Related Literature
Collaboration	Building and strengthening the relationship of trust between partners Establishment of operational agreements between partners Joint decision-making in the face of partnership challenges and objectives Establishment of a problem-solving committee among partners	• Allred et al., 2011 • Balcik et al., 2019 • Barratt, 2004 • Colicchia and Strozzi, 2012 • Dani, 2011; Hallikas, 2003 • Kareem and Kummitha, 2020 • Klassen and Vachon, 2003 • León-Bravo et al., 2017 • Polater, 2021 • Ramanathan et al., 2014 • Shin et al., 2019 • Tieman, 2017 • Vilko, 2012
Integration	Complementarity and pooling of resources between partners Integrating key relationships into the partnership value chain Implementation of an integrated information and communication system among partners. Development of processes and/or activities that favour access to economies of scale and improved transaction costs.	• Chang et al., 2008 • Chaudhuri et al., 2020 • Kareem and Kummitha, 2020 • Mentzer et al., 2001 • Polater, 2021 • Rajaguru and Matanda, 2019 • Swafford et al., 2008 • Wu and Ragatz, 2010
Flexibility	Joint construction of strategic planning Reconfiguring individual processes and/or activities to improve the performance of the partnership Establishment of areas aimed at making operational processes more flexible in order to respond more quickly to possible changes. Integration of changes related to organizational structures and technological improvements	• Baker, 2008 • Boyer and Lewis, 2002 • Chan and Chan, 2010 • Cheng et al., 2014 • Choi et al., 2001 • Christopher et al., 2004 • Grant, 1996 • Hülsmann et al., 2008 • Jiang and Li, 2011 • Ketchen and Hult, 2007 • Mangla and Kumar, 2014 • Swafford et al., 2008 • Ward et al., 1998

Source: Authors' own elaboration (2022) based on information from multiple authors.

It should be noted that the question posed for the conceptual-theoretical tool sets out a vision of the development of resilience in the supply chain linked to collaborative risk management with the aim of achieving the achievements of the producers and associations surveyed, and is explained more openly and explicitly during the training sessions conducted with the different actors involved in the field study in order to recognize what the present study seeks to achieve.

Moreover, several studies have been identified that integrate constructs and factors to enhance supply chain resilience and the development of dynamic capabilities. Recent studies have significantly advanced the understanding of supply chain resilience and the role of dynamic capabilities. Kochan and Nowicki (2018) conducted a systematic literature review that identifies key themes and gaps, emphasizing the importance of dynamic capabilities in enhancing resilience, which aligns with the proposed study's focus on these capabilities. Kamalahmadi and Parast (2016) further support this by highlighting how dynamic capabilities mitigate risks, reinforcing the need to investigate specific capabilities like flexibility and adaptability. Polater (2021) provide insights from humanitarian supply chain management, illustrating the application of dynamic capabilities in crisis situations, which can inform the proposed

research. Dubey et al. (2023) explore the relationship between dynamic capabilities and resilience, offering a theoretical framework that the proposed study can utilize. Similarly, Kumar et al. (2024) emphasize understanding the factors contributing to resilience, while Ivanov and Dolgui (2020) stress the necessity for organizations to develop resilience through these capabilities. Soni et al. (2020) present a deterministic modeling approach to measure resilience, suggesting methodologies for the proposed study, and Wang et al. (2016) discuss the role of big data in enhancing supply chain management, indicating how data-driven decision-making can bolster dynamic capabilities. Collectively, these studies provide a robust foundation for the proposed research, highlighting the critical role of dynamic capabilities in fostering resilience within supply chains, particularly in the agri-food sector.

4. Findings

According to the questions presented in the previous section, the results obtained for question 1 suggest that as a producer and association they consider it important to strengthen the individual to be able to achieve coordination, collaboration, and integration, resulting in greater achievements as an association. For this question, an orientation was given on how the development of supply chain resilience enables among others collaborative risk management and better performance of the organization and the partnership. In order of importance, farmers' responses ranked the following capabilities from most to least important to develop in their supply chain: Flexibility, Reconfiguration, Agility, Adaptability, Coordination, Collaboration, Integration, Competitive priorities.

On the other hand, to Question 2 (see Question 2 in **Table 4**) which was formulated after conducting an internalization exercise with farmers about the possible risks they are exposed to and how collaborative risk management and resilience in the supply chain can help to re-establish supply chain operations in case of a disruptive event, the farmers' responses in a consensual and leader-led manner are presented in **Table 4** below:

Table 4. Responses to Question 2 conceptual-theoretical tool.

		Results per Association		
Variable Name		**Association 1**	**Association 2**	**Average**
Coordination	SCDC1	6	5	6
	SCDC2	7	7	7
	SCDC3	3	4	4
	SCDC4	2	2	2
			TOTAL	**5**
Adaptability	SCDC5	7	7	7
	SCDC6	7	7	7
	SCDC7	6	5	6
	SCDC8	7	7	7
			TOTAL	**7**

Table 4. (*Continued*).

		Results per Association		
Variable Name		**Association 1**	**Association 2**	**Average**
Agility	SCDC9	6	5	6
	SCDC10	5	5	5
	SCDC11	3	3	3
	SCDC12	6	5	6
	SCDC13	6	6	6
			TOTAL	**6**
Competitive Priorities	SCDC14	7	6	7
	SCDC15	4	3	4
	SCDC16	7	5	5
	SCDC17	1	1	1
			TOTAL	**4**
Reconfiguration	SCDC18	5	5	5
	SCDC19	7	7	7
	SCDC20	6	5	6
	SCDC21	6	7	7
			TOTAL	**6**
Collaboration	SCDC22	7	7	7
	SCDC23	5	3	4
	SCDC24	6	6	6
	SCDC25	5	4	5
			TOTAL	**5**
Integration	SCDC26	6	2	4
	SCDC27	5	2	4
	SCDC28	5	5	5
	SCDC29	7	7	7
			TOTAL	**5**
Flexibility	SCDC30	7	7	7
	SCDC31	7	7	7
	SCDC32	6	6	6
	SCDC33	6	5	6
			TOTAL	**6**

Source: Authors' own elaboration (2022).

Figure 2 below shows the non-parametric Kruskal-Wallis analysis in which the statistically significant difference in the rating of the dynamic capabilities assessed can be seen (p-value: $0.032 < 0.05$) and analyzed from the influence that these have on the development of resilience and collaborative risk management, specifically highlighting the capabilities of adaptability and flexibility as those that should be further developed and strengthened from the individual development in order to manage risk collaboratively and develop resilient supply chains.

Dynamic Capability	N	Middle Range
Coordination	8	25.44
Adaptability	8	49.56
Agility	10	26.00
Competitive Priorities	8	24.69
Reconfiguration	8	38.94
Collaboration	8	31.88
Integration	8	28.31
Flexibility	8	45.06
TOTAL	**66**	

(a)

STATISTICAL TESTING

	SCORE
CHI-SQUARE	**15.31**
DF	**7**
ASYMP. SIG.	**0.032**

(b)

Figure 2. Kruskal-Wallis test of supply chain dynamic capabilities: **(a)** evaluation middle range; **(b)** statistical testing.
Source: Authors' own elaboration (2022).

The results presented corroborate what producers stated in the answers to Question 1. The answers to question 1 show that the most important dynamic supply chain capabilities to develop and strengthen as producers from the individual producer perspective are flexibility, reconfiguration and agility, which should be prioritized in order to be able to integrate more synergistically into the partnership, The result of **Figure 2** confirms that, by rating the variables and criteria evaluated in a more consensual manner, it is adaptability that they finally considered as the most relevant to be able to manage risk collaboratively as an association and develop resilience in their production chain as a producer.

Adaptability or adaptive capability can be seen as a form of flexibility developed by the supply chain. It allows the supply chain to adapt and respond to possible changes in the environment in which it operates, and to adjust its internal and external structure if required (Aslam et al., 2020; Chan and Chan, 2010; Whitten et al., 2012) which suggests from this essence three (3) dynamic capabilities: flexibility, adaptability and reconfiguration. In addition to this, adaptability allows managing the vulnerability and uncertainty to which the organization and its supply chain are exposed, making it more resilient (Maynez-Guaderrama et al., 2018).

It is therefore important to recognize the definitions of these three capabilities, which are clearly recognized as those that allow the organization to develop resilience in its production chain, in addition to being able to manage risk more strategically. **Table 5** below presents the definitions of these capabilities:

Table 5. Definitions of flexibility, adaptability and reconfiguration.

Adaptability	It can be seen as a type of flexibility that a supply chain can possess or develop, which allows it to respond to the diversity of possible changes in the environment, or some possible disruption on its operations. It is a mechanism to manage uncertainties and changes in the environment or the context where the organization develop its operation.	• Alzate et al., 2022 • Aslam et al., 2020 • Chan and Chan, 2010 • Hülsmann et al., 2008 • Ketchen and Hult, 2007 • Lee, 2004 • Stefanelli et al., 2016 • Tuominen et al., 2004 • Xia et al., 2008 • Whitten et al., 2012
Reconfiguration	Capability interdependent with flexibility. Reconfiguration in the context of an organization, refers to the process of making significant changes to its structure, strategies, resources, or operations in response to internal and external factors. It involves reorganizing and adapting the organization to better meet its objectives and challenges.	• Blome et al., 2013 • Cao and Jiang, 2020 • de Moura and Saroli, 2020 • Hülsmann et al., 2008 • Masteika and Čepinskis, 2015 • Storer and Hyland, 2011 • Polater, 2021; • Teece et al., 1997
Flexibility	Refers to an organization's ability to adapt, adjust, and respond to changes in its internal and external environment effectively. It is the capacity of an organization to be flexible and agile in the face of various challenges, opportunities, and uncertainties. Flexibility in the supply chain refers to the capability of a supply chain system to adapt and respond effectively to changes and disruptions in demand, supply, or external factors while maintaining efficiency and meeting customer requirements. It involves having the agility and responsiveness to handle uncertainties and unexpected events, ensuring that the supply chain remains resilient and effective in dynamic business environments. Flexibility in the supply chain is crucial for businesses to stay competitive, reduce risk, and optimize operations. A flexible supply chain incorporates risk management strategies to identify and mitigate potential disruptions proactively. This may include creating backup plans, diversifying suppliers, or implementing contingency measures.	• Alzate et al., 2022 • Baker, 2008 • Boyer and Lewis, 2002 • Chan and Chan, 2010 • Cheng et al., 2014 • Choi et al., 2001 • Christopher et al., 2004 • Grant, 1996 • Hülsmann et al., 2008 • Jiang and Li, 2011 • Ketchen and Hult, 2007 • Mangla and Kumar, 2014 • Swafford et al., 2008 • Ward et al., 1998

Source: Authors' own elaboration (2022) with information from multiple authors.

As can be seen, these capabilities are closely related to the development of supply chain resilience, especially flexibility and adaptability, which are skills that allow the organization to more comprehensively and strategically manage supply chain resources to respond to change and uncertainty, as well as opening the door to the development and strengthening of other capabilities such as reconfiguration, collaboration and integration.

Moreover, to enhance flexibility and adaptability in agricultural supply chains, stakeholders should consider several actionable recommendations. First, diversifying suppliers can reduce dependency on a single source, allowing for quick adjustments during disruptions (Ghadge et al., 2012). Investing in advanced technologies such as IoT and AI can improve real-time monitoring, enabling swift responses to changes in demand or supply conditions (Wang et al., 2016). Additionally, adopting agile inventory management practices minimizes excess stock while ensuring essential supplies are available, supported by accurate demand forecasting through data analytics (Soni et al., 2014). Regular training sessions for employees on adaptive

practices and crisis management can foster a culture of flexibility (Pettit et al., 2010). Establishing collaborative networks among farmers, suppliers, and distributors facilitates information sharing and joint problem-solving (Kumar et al, 2024). Engaging in scenario planning exercises allows stakeholders to anticipate potential disruptions and develop contingency plans (Hernández et al., 2020). Negotiating flexible contracts with suppliers and customers can help manage risks associated with demand fluctuations (Akbar and Isfianadewi, 2023). Incorporating sustainable practices, such as crop rotation, enhances resilience to climate change (Dubey et al., 2020). Finally, leveraging data analytics to monitor market trends and consumer preferences can guide decision-making and help stakeholders adapt their strategies effectively (Cimellaro et al., 2010). By implementing these recommendations, agricultural stakeholders can significantly enhance their flexibility and adaptability, leading to more resilient supply chains.

5. Discussion and conclusions

Both the literature review and the case study developed and presented for the agricultural sector in eastern Antioquia in Colombia focus on highlighting the dynamic capabilities of flexibility and adaptability as the most influential in developing and strengthening resilience in the supply chain for collaborative risk management environments. However, it is important to note that, within the world of dynamic supply chain capabilities, there are also the capabilities of collaboration and reconfiguration, which were exposed in the literature review and highly valued within the case study analyzed.

Thus, this article argues that while flexibility and adaptability are the most valued, mentioned and appreciated dynamic supply chain capabilities for the development of resilience aligned with collaborative risk management, it is imperative to remember that the supply chain generates an environment of continuous interaction of dynamic capabilities, reflected through an ecosystem of interactive interpenetration that supports the achievement of the organization's strategic objectives and sustainability (Alzate et al., 2022).

Given the above, and visualizing the conception of an ecosystem of dynamic capabilities, the perception of "indivisibility" of the dynamic capabilities of the supply chain is highlighted, so that the positivist reductionist schematization made by the general literature in the eight dynamic capabilities previously described in the work could be questioned: Flexibility, Reconfiguration, Agility, Adaptability, Coordination, Collaboration, Integration and Competitive Priorities; thus prompting the questioning and debate as to whether it will be possible to establish that flexibility and adaptability are really the most important dynamic capabilities for the development of supply chain resilience.

Flexibility and adaptability are just two capabilities that every organization should develop and possess, which are constantly evolving and can be strengthened over time, through the use of resources and exploitation of the company's supply chain capabilities. However, both capabilities should not be dissociated or analyzed separately from the rest of the dynamic capabilities, since they all interact with each other within an integral ecosystem that allows the development of competitive

advantages, in addition to enhancing resilience aligned to collaborative risk management in the supply chain of any organization.

In the same way that an individual develops resilience through a set of skills and capabilities that he or she possesses, organizations need to continuously develop and strengthen dynamic capabilities seen as an ecosystem in which, as an integral entity, the strategic positioning of the company is driven and which also enables the continuous evolution of the supply chain, in order to visualize, plan for and counteract possible disruptive events in the short and medium term.

Finally, by focusing on the ecosystem discourse of dynamic capabilities, we conclude that it should give prominence to the capabilities of flexibility and adaptation, which are perceived and scientifically documented as those capabilities that energize the development of resilience in the supply chain (resilience being seen as the ability to manage collaborative risk in the supply chain in a short time to achieve stakeholder gains).

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