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Models and Strategies for Supply Chain Synchronization: A 2010-2025 Review of Small Business and Agro-Industrial Sector Experiences

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Abstract:

Purpose: This article presents a systematic review of the knowledge management literature focused on integration strategies and models in supply chain (SC) collaboration. Although prior research highlights the benefits of SC linkages, limited attention has been given to the specific strategies and models that enable and govern their integration.

Design/methodology/approach: A four-phase systematic review was conducted, analyzing 184 publications from 2010 to 2025 in both Spanish and English. The study examines: SC collaboration improvement, quantitative integration methods, integration strategies, and the development models for effective SC coordination.

Findings: The results demonstrated the critical role of digital technologies and collaborative approaches for small and medium-sized enterprises (SMEs) in maintaining competitiveness and long-term viability. Significant differences in linkage models and strategies were observed across continents, with most integration strategies developed at the initial stages of the SC. More than 50% of the studies report linkage activities between suppliers, organizations, and customers. Information exchange between SC actors was identified as a key factor in reinforcing these connections.

Research limitations/implications: The study is limited by the scope of the publications reviewed, which are confined to literature published between 2010 and 2025. Future research could explore more diverse regional contexts and expand on the evolving technological challenges faced by SMEs in SC collaboration.

Practical implications: SMEs must adopt digital technologies to overcome resource constraints and enhance their ability to integrate into global SCs. The research identifies region-specific strategies and tools that can guide SMEs in adopting context-appropriate models for effective SC collaboration.

Originality/value: This study provides new insights into the differentiation of SC integration models and strategies across continents, particularly within the agro-industrial sector. It offers a comprehensive analysis

of the digital and structural challenges that SMEs face and describes practical solutions to enhance SC integration through tailored regional strategies.

Keywords: supply chain models, agro-industrial chains, supply chain strategies, agro-industrial SMEs, digital collaboration, supply chain integration

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1. Introduction

The supply chain (SC) is a network of organizations operating horizontally or vertically, including manufacturers, logistics operators, retailers, and customers, that collaborate to produce, market, and deliver products or services to specific market segments (Bautista-Santos et al., 2015). In this network, material, information, and economic flows reflect the relationships between buyers and sellers (Tarofder et al., 2019). Effective coordination of these activities through collaborative systems should result in higher profits and enhanced customer service for SC participants (Salas-Navarro et al., 2017).

In recent years, increasing global competition, industrial dynamics, and market volatility have intensified the pressure on organizations to respond efficiently and strategically to market demands (Silva-Rodríguez, 2017; Tao & Koo, 2024). Additionally, sustainability requirements, technological advancements, and evolving consumption trends have increased the complexity of supply chain management (Zhang & Qu, 2023). As a result, companies must not only optimize internal processes but also strengthen integration and collaboration among the entire SC to remain competitive (Jraisat et al., 2023; Santos-Larrazabal & Basterretxea, 2023).

Despite extensive research on synchronization and coordination strategies, there remains limited clarity regarding the contextual factors that determine their effectiveness across industries and geographical settings. Many studies focus on the advantages of specific strategies without fully addressing the conditions under which they are most effective, as suggested by Pezeshki et al. (2013). This limitation reduces the applicability of these approaches across different industries, particularly in SMEs and agro-industrial contexts.

This gap in the literature highlights the need for a comprehensive understanding of how synchronization strategies can be tailored to distinct sectors and environments, especially when considering varying economic and cultural settings. To address the gap, this study systematically analyzes and classifies SC synchronization and coordination strategies reported in the literature between 2010 and 2025. This research aims to provide a comprehensive understanding of how strategies, models, and contextual factors influence SC development and integration.

The article underscores the practical relevance of these strategies by outlining successful combinations in various contexts, helping readers understand how and why certain strategies work. Thus, the objective of this study is to examine SCM from two perspectives: interlinking strategies and models within production environments. Following the introduction, the article is structured as follows: the Materials and Methods section outlines the search strategy and criteria for selecting the analyzed papers (based on Snyder (2019), the Results section describes SC linkage models and strategies, and finally, the Discussion and Conclusions sections highlight future directions for SC linkage strategies

2. Literature Review

2.1. Supply Chain Integration and Collaboration

Supply chain integration (SCI) is recognised as a strategic and operational approach that enables companies to coordinate the flow of information, materials, and decisions across SC actors, improving performance and value creation (Flynn et al., 2010; Manik, 2022). Under this logic, integration translates into strategic, operational and financial benefits, derived from process optimization, cost reduction and increased agility and flexibility. These benefits are consolidated as competitive advantages through strengthening stakeholder relationship, enabling organizations to better adapt to dynamic and uncertain environments (Anwar et al., 2025). Furthermore, SCI enhances the capacity of companies to develop collaborative projects and drive innovation in complex contexts, where interorganizational coordination is essential (Anwar et al., 2025; Flynn et al., 2010; Patrucco et al., 2025; Xue et al., 2025).

The literature also emphasizes that SCM is based on collaboration among actors to plan and control flows from supply to final customer, reinforcing the need for coordination structures based on mutual benefit (Cano et al., 2015). In this context, SC bring together interdependent interests that must be strategically aligned, going beyond individual efforts (Álvarez, 2010; Wu et al., 2023; Zhang & Qu, 2023). Collaboration has been positively associated with social impact and conflict reduction within SC, highlighting its relevance as a coordination mechanism (Alsheyadi et al., 2024; Wu et al., 2023).

From a coordination perspective, supply chain synchronization has been managed through mechanisms such as collaborative activities, risk management via information flow, and the exchange of information between SC members (Hossain et al., 2017). In addition, the use of information and communication technologies (ICT) has been identified as a key factor in strengthening the integration and efficiency of the SC (Harianto et al., 2024; Ran et al., 2020), along with collaborative decision-making among stakeholders (Agarwal et al., 2020).

Recent studies (2020–2025) emphasise that digital technologies such as artificial intelligence, blockchain, and IoT play a central role in enhancing SC integration, resilience, and decision-making under uncertainty, particularly in SMEs facing structural constraints (Bigliardi et al., 2026; Kouhizadeh et al., 2021; X. Lu et al., 2025). These technologies contribute to improving visibility, coordination, and traceability, although their adoption depends on organizational capabilities and contextual conditions.

In this sense, coordination between stakeholders, technical support, and collaboration help to mitigate conflicts within the SC (Liu, Wang & Xu, 2020). Additionally, strategies focused on sustainability, innovation, and collaborative governance have been explored to strengthen integration (Cicerelli & Ravetti, 2024; Kumar et al., 2019; Pezeshki et al., 2013).

Supply chain integration requires the coordinated interaction of human, technological, and process dimensions to improve overall performance (Hakim et al., 2018; Ramirez et al., 2021). However, this integration is influenced by contextual and geographical factors. SMEs in developing countries face structural constraints such as limited access to finance, inadequate infrastructure, and insufficient training, which directly affect their ability to implement SCI effectively (Ralahallo et al., 2024).

Since the emergence of Industry 4.0, technologies such as IoT, blockchain, and artificial intelligence have reshaped SC dynamics. IoT enhances integration and collaboration, while blockchain increases transparency and trust, although both require advanced technological capabilities (Kouhizadeh et al., 2021; Younis et al., 2026). Artificial intelligence supports decision-making under uncertainty, but its adoption in SMEs is limited by lack of expertise and investment capacity (Baryannis et al., 2019; Bigliardi et al., 2026).

The integration of information technologies has redefined competitiveness, linking internal process flexibility with external SC integration (Alarcón-Grisales et al., 2016; Jraisat et al., 2023; Santos-Larrazabal & Basterretxea, 2023). However, their impact depends on their alignment with collaborative strategies and organizational capabilities. In this context, the use of emerging technologies contributes to reducing uncertainty and improving decision-making performance (Xue et al., 2025).

Overall, SCM and SCI are strategic, cross-organizational approaches that coordinate and synchronise SC flows, strengthening organizational resilience, adaptability, and competitiveness in uncertain environments; however, their application remains underexplored in SMEs, where structural and contextual constraints hinder effective integration (Anwar et al., 2025).

2.2. Supply Chain Strategies and Models

A SC strategy is defined as a comprehensive framework designed to integrate and coordinate activities across various links, spanning from raw material procurement to the delivery of final products to consumers (Bakhshi-Movahed et al., 2023). This strategy emphasizes the importance of collaboration, operational efficiency, and flexibility, alongside the integration of advanced technologies to enhance visibility and facilitate real-time decision-making within the SC (Naseem & Yang, 2021; Sègbotangni et al., 2025). The ultimate objective of a SC strategy is to optimise efficiency, minimize costs, elevate the quality of products or services, and bolster the overall competitiveness of the sustainable SC network (Laari et al., 2017; Bui et al., 2021).

In contrast, a SC model refers to the structural framework that operationalises the strategy by defining the configurations of actors, processes, and interactions within the SC. It specifies roles, information flows, decision-making structures, and resource allocation mechanisms (Harrison et al., 2019). Depending on the context, such models can adopt vertical, horizontal, or hybrid integration methods, tailored to meet the specific operational requirements and challenges faced by the SC (Dubois & Gadde, 2002).

While prior research has examined strategies and models separately, there remains a limited understanding of how these elements interact to shape SC performance across different contexts (Ghadge et al., 2012).

The literature reveals three major gaps. First, there is limited attention to the specific strategies and models that underpin SC linkages, particularly regarding the conditions under which they are most effective, as many studies focus on isolated benefits without considering contextual applicability (Pezeshki et al., 2013; Zhou et al., 2024; Sègbotangni et al., 2025). Second, there is insufficient clarity on how contextual factors—such as regional, sectoral, and firm-size characteristics—influence the effectiveness of synchronization strategies, restricting their transferability across different environments (Rius-Sorolla et al., 2020; Tran et al., 2024). Third, the literature remains predominantly focused on large firms, leaving SMEs and agro-industrial sectors underexplored, despite evidence that these organizations face structural barriers such as limited bargaining power, resource constraints, inadequate infrastructure, and regulatory challenges that hinder effective SC integration (Alam et al., 2025; Arellano-Rodríguez, 2024; Hakim et al., 2018; Manik, 2022; Ralahallo et al., 2024; Showole & Jaiyeoba, 2024).

3. Materials and Methods

From Snyder, 2019 the stages of the systematic review were defined in four phases: design, conduct, analysis, structure and writing of the review.

3.1. Design

Three research questions were posed: PI-1) What "chaining strategies" are currently being used in production systems, PI-2) In which link of the chain are chaining strategies being used, PI-3) What "chaining models" to improve the SC in relation to the customer-supplier have been reported which contributed to chaining?

The search for information was conducted in the ScienceDirect, Scopus, and Google Scholar databases, in English and Spanish, in the period 2010–2025. Book chapters, unpublished manuscripts, conference proceedings, and dissertations/theses were not included. The fields and terms used in the search were: "coordination mechanism" "supply chain coordination". In the Spanish search: "encadenamiento productivo" "cadena de suministro", "integración en la cadena de suministro", with the operator OR. An initial sample of 5946 documents was obtained documents.

3.2. Conduction

The first screening was carried out based on the criteria "Chaining Strategies in Supply Chain", "Supply Chain Model", "Quantitative Methods Integration in Supply Chain", "Models improve Supply Chain customer-supplier-inventory".

As a result, 523 publications were retrieved (Figure 1). In the elimination of duplicate documents, 153 documents were removed. The resulting documents were sorted by year of publication to have a chronological order. A final filtering was carried out based on the quality criteria of the publications (JCR, Scopus indexing), and their alignment with the research questions. In the end, a total of 184 publications were selected for review.

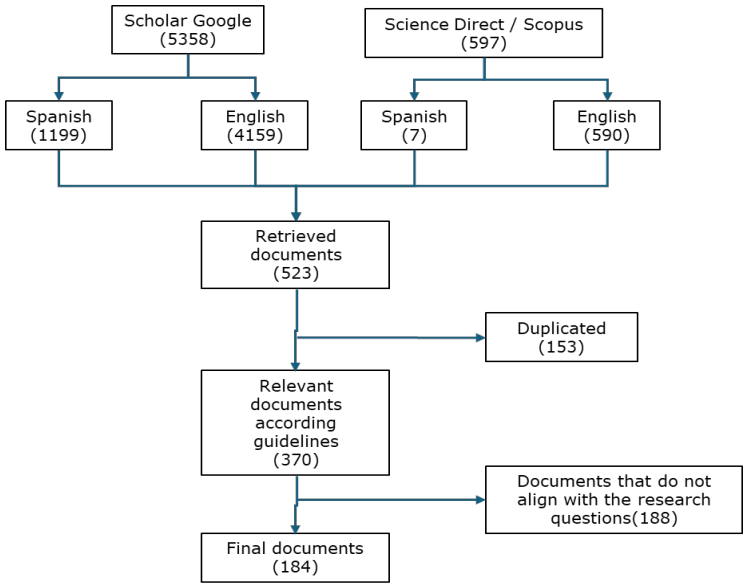

Figure 1. Reviewing process

3.3. Analysis

The 184 papers were concentrated in a spreadsheet. The classification of the articles was done by article name, author, year, strategy/model, database, and SC link. The Figure 1, details the process of analyzing and debugging the identified works.

A descriptive and exploratory bibliometric analysis was carried out using Vosviewer software. The criteria of co-authorship and term co-occurrence were applied to the 182 selected studies, which were exported from Mendeley 2.144.0 in RIS format. Full counting was used, with a minimum threshold of one document per author.

3.4. Structure and Wording

Based on the analysis, four central axes of study in SCM are highlighted: 3.1) Models for improving the SC in customer-supplier relations; 3.2) Quantitative methods for SC integration; 3.3) SC interlinking strategy; 3.4) SC linkage models.

4. Results

4.1. Models for Improving the Supply Chain in the Customer-Supplier Relationship

Resource planning assists organizations in efficient decision making in terms of sourcing from the purchase of materials, components and raw materials. Akyuz and Gursoy (2020), argue that this translates into strategic decisions such as "how much to buy and when to buy". Although, in SMEs, it is common to find processes based on the experience of the person in charge of the economic unit and disjointed between the demand and the production capacity of each company. For these companies, it is important to assume models of inventory management that increase productivity based on data and information (Sánchez-Olivos et al., 2013). In this business context, organizations often lack control over the management of their projects, and each SC actor controls their internal operations without considering their external operations, which often leads to synchronization problems in the SC (Dallasega & Rauch, 2017).

In general, to address integration problems between companies with poor control and management of their operations, the evaluation of the SC is strategic to ensure the supply of materials (Mendoza-Mendoza et al., 2014).

In different ways and with different approaches, attempts have been made to describe, manage, monitor and administer the supply chain (SCM) as a means of understanding its behavior and the effect it has on particular organizations or members of the chain (Goli & Davoodi, 2018). However, as SCM is wide and varied, the emergence of "inventory control models", rather than narrowing and helping to understand it, has posed increasing challenges (Derigent et al., 2021) when integrating SC members.

Among the Supply Chanin Coordination Models, the SCOR model was identified as the most widely used in Europe, describing processes, key performance measures, and best practices, which aligns SC processes with key business functions and objectives (van Engelenhoven et al., 2023) to improve the efficiency of firms and regulate the measurement of their performance (Saleheen & Habib, 2023). Table 1 presents 14 models reported in the literature to improve efficiency and coordination in supply chains.

Model	Purpose in the Supply Chain: Community/Continent
Stock management Model	Optimizing supply, balancing risks, and reducing inventory costs (Arango-Serna, Zapata-Cortés & Gómez-Montoya, 2010): Colombia/Latin America
Risk Management Model	Coordinating prices, demand, and costs in disruption scenarios (Chen et al., 2012): China/Asia
Dynamic capability-based SC coordination	Improve enterprise flexibility, quality and costs through effective coordination with SC members (Gao & Tian, 2014): Spain/EU
SCM from joint distribution of materials	Improve income and quality of materials input through cooperation and information sharing (Li & Liu, 2015): China/Asia
Model Supplier Relationship Management	Fostering close customer-supplier relationships, reducing costs (Ramos-Maldonado et al., 2015): Chile/Latin America
SCM by strategic guidelines	Reducing costs through a linear programming model for the health sector (Balcázar-Camacho et al., 2016): Colombia/Latin America
Centralized decision-making model in SC with co-creation of consumers and retailers	Coordinate the chain through centralized decision making. This Model considers retail price, sales volume, effort and total profit of the SC for co-creation (Lu & Wang, 2017): China/Asia
Relational Coordination Model	Strengthening the quality of relationships and sales through coordination in SC members (Margalina et al., 2019): Ecuador/Latin America.
Closed Loop SCM (CLSC)	Reducing environmental pollution through revenue sharing contracts (Mohsin et al., 2020; Zhu et al., 2018): China/Asia
Coordination mechanism through contracts	Based on cooperative game theory. It seeks rational allocation with contract strategy (Zhong & Huo, 2018): China/Asia
Multi-step global SC and coordinated approach	Coordinating facilities of multinational enterprises (MNEs) based on maximization theory, employing numerical analysis to show that the global network benefits the performance of MNEs (Zhang & Wang, 2019): China/Asia
Global SC, mathematical modeling and shared growth	Evaluate profit allocation in a global setting using mixed integer linear programming (MILP) (Huang et al., 2019): USA/America
Coordination model using digital technologies	Improving the coordination and performance of SC actors through Digital Technologies. This model is demonstrated through numerical simulation (Ran et al., 2020): China/Asia This model represents a technological enablement based on information processing (such as the Internet of Things and big data) to reduce uncertainty in decision-making (Xue et al., 2025): China.
SC inventory coordination with a holistic perspective	Improving collaborative inventory management in the retail industry (Agarwal et al., 2020): India/Asia

Table 1. Models to improve the SC in the customer-supplier relationship

In Colombia, inventory management models aim to create a competitive advantage by efficiently balancing input supply, minimizing the risk of shortages, and reducing the costs associated with excess inventory. In China,

inventory management strategies focus on coordinating prices, demand, and production costs to enhance SC resilience in the face of potential disruptions. Additionally, approaches in China include reducing environmental pollution through closed-loop contracts and leveraging digital technologies to improve SC coordination and overall performance.

In India, inventory coordination in supply chains has been analyzed from a holistic perspective, with a focus on the retail sector and the role of collaboration under uncertainty. This recurring theme is explored in various models, which also examine co-creation between consumers and retailers to optimize prices, sales volumes, and total profits. Meanwhile, in Spain, SC coordination efforts have focused on enhancing firms' dynamic capabilities, particularly in production, quality, cost management, and operational flexibility. In the USA, linear programming has been utilized to foster shared growth and manage exchange rate fluctuations, leading to a more resilient global SC.

These models reported in various countries integrate strategies such as cooperation, inventory management, technology utilization, and centralized decision-making. By fostering collaboration among different participants in the SC, these models have demonstrated improvements in efficiency and resilience of the chain. For instance, in India, the focus on collaboration under uncertainty highlights the importance of co-creation between consumers and retailers to improve prices and sales volumes. Similarly, in Colombia and China, strategies emphasize balancing input supply and coordinating prices and demand to strengthen the supply chain's resilience against disruptions. Digital technologies integration into data analysis and automation has proven to facilitate real-time decision-making, allowing SC operations to be more responsive and adaptable to disruptions. Ultimately, this holistic approach leads to greater sustainability and profitability in supply chains.

4.2. Quantitative Methods in Supply Chain Coordination

Quantitative methods have been utilized as a key strategy for coordinating operations in the SC such as transportation and supplier selection, to ensure the supply of materials and inputs (Mula et al., 2008; Díaz-Madroñero et al., 2010; Vosooghidizaji et al., 2020). These methods facilitate the integration of resources and information among economic actors by supporting the management of complex processes, including outsourcing, globalization, and technological innovation (Derigent et al., 2021).

In situations where uncertainty hinders effective coordination among SC actors, simulation has proven to be an effective technique for evaluating logistical performance. Arshinder et al. (2011), Grzybowska and Kovács (2017) and Zhao et al. (2019) highlight its ability to model complex scenarios and evaluate strategies that enhance operational efficiency. However, its practical application in the primary sector remains limited due to nonlinear processes and high implementation costs (Shaban et al., 2020).

Although operations research has proven useful for addressing complex challenges in the integration and coordination of supply chains, simpler methods, such as linear and visual techniques, are often preferred for decision-making. This is due to technical limitations, such as the difficulty of accurately modeling all the variables withing the study scenario, the need for complete and precise data, as well as high computational costs and the time required to develop and implement the models. Moreover, the dynamic nature of supply chains, which demands frequent updates, further complicates the coordination among multiple actors with diverse objectives (Rius-Sorolla et al., 2020).

Finally, experimental design has established itself as a powerful tool for analyzing and evaluating alternatives in the SC. This technique has proven compatible with operations research, simulation, and system dynamics models, allowing for accurate assessments of key interactions and the optimization of logistical processes (Díaz-Madroñero et al., 2010).

4.3. Supply Chain Integration Strategies

The formation of clusters and productive linkages among economic agents within a SC has become essential for micro and small entrepreneurs seeking to improve their competitiveness and sustainability (Timeridjine & Kaci, 2024). These strategies not only strengthen local economies but also support regional development (Alinsaoui et al., 2024; Timeridjine & Kaci, 2024), particularly in agro-industrial regions of developing countries, where logistical challenges often constrain product commercialization (Barbero, 2010; Selvananthana, 2024).

The findings of this study identify two key linkage models within SCs. The first model, known as the "cluster model," aims to foster collaborative relationships among suppliers, competitors, and other clusters, thereby leveraging local resources to build a self-sustaining logistics ecosystem (Akyuz & Gursoy, 2020; Flórez-Martínez & Ward-Argota, 2013). The second model is based on forward and backward linkages, enables small firms to become suppliers to larger companies. This approach optimizes the production and delivery of goods and services by aligning them with specific customers demand requirements (Zuluaga-Mazo et al., 2011; Ruiz-Torres et al., 2013; Astudillo-Arias et al., 2020).

4.4. Supply Chain Integration Models

Supply Chain synchronization models provide an integrated structure among members, enabling key actors to exchange real-time information about their interests. This shared responsibility enhances production planning based on actual market demand, aiming to minimize logistics costs and ensure accurate and timely supply in terms of both quantity and delivery (Sarache et al., 2004). The use of information technologies is a key strategy in synchronization, treating the inventories of all agents as a single entity in real time and strengthening delivery logistics (Arboleda & Patiño, 2014).

Table 2 linking strategies that foster a collaborative flow of information aligned with common objectives. These strategies are particularly notable for their contributions to the goods and agri-food industries, advocating the efficient integration of key links: Supplier (P), Organization (O), and Customer (C). This is especially relevant in complex and highly competitive environments, positioning these strategies as essential for improving the resilience and competitiveness of the goods and agribusiness sectors.

Strategy/Model (P-O)	Purpose in the Supply Chain: Community/Continent
Strategy based on production scheduling	Analyze the impact of information sharing in a dyadic SC (supplier-manufacturer) with several resources available for production processing (Ortiz-Vargas & Montoya-Torres, 2012). España/UE; (Lee et al., 2016): China/Asia
Price-contract model	Combines the Black-Scholes rule and the supplier contract option strategy to verify the best pricing model (Zhao & Huo, 2013): China/Asia
Trust-based strategy with "reward-punishment" component	Reward-punishment coordination mechanism based on trust between SC levels (Pezeshki et al., 2013): Iran/Asia
Analytical model based on EOQ	Analytical model for the determination of the optimal production batch based on the EOQ model (Lambán-Castillo et al., 2014): Latin America
Demand-driven materials supply management model	Integration and synchronization of activities and inventories required to meet demand (Arango-Palacio & Zuluaga-Mazo, 2014): Colombia/Latin America
Multi-level inventory strategy for perishable items	Synchronizes production and delivery cycles at a lower total cost by scheduling buyers' delivery days and their coordination with the production cycle (Rahdar & Nookabadi, 2014): Iran/Asia
Strategy based on information-sharing coordination	Coordinating and scheduling supply in the supply network of a company (Zamora-Aguas et al., 2017): Latin America The exchange of information is central to both Supply Chain Integration (SCI) and IoT-based Information Integration (Anwar et al., 2025): China/Asia
Strategy based on supplier-company inventory levels	Determine the levels of process integration and collaboration between SC actors (Salas-Navarro et al., 2017): Colombia/ Latin America
Supplier Selection Strategy	Provides a trade-off method for evaluating supplier alternatives (Luthra et al., 2017): Asia
Supplier Selection Strategy	Seeks to reduce the variables proposed by the client and the technical criteria of suppliers by considering sustainable dimensions (Yazdani et al., 2017): Spain/EU
Pricing strategies for manufacturer and retailer through two-party tariff contract	They present centralized and decentralized decision-making models for mixed-channel SC from offline to online with pricing strategies for the manufacturer and retailer to coordinate the SC system (Cheng & Zhang, 2017): China/Asia

Strategy/Model (P-O)	Purpose in the Supply Chain: Community/Continent
Supplier Selection Strategy	Incorporate environmental criteria in conventional supplier selection to promote CSPM, under modeling of uncertainty in decision-making (Banaeian et al., 2018): Asia
Model based on compensation-revenue sharing	Based on a revenue sharing compensation contract between suppliers, benefits are possible (Chen & Song, 2014): China/Asia
Strategy/Model (O-C)	**Supply Chain Purpose: Community/Continent**
Uncertain demand based fuzzy optimization model	Modeling SC production planning with demand uncertainty (Mula et al., 2008): Spain/EU It addresses environmental demands and complexity using mathematical tools to meet information processing needs when data is imprecise (Xue et al., 2025): China
SC coordination via credit option contract	The model shows that the credit option contract can perform channel coordination in a decentralized SC with a manufacturer and a buyer in a multi-period environment (Hasani & Khoshalhan, 2011): Iran/Asia
Strategy based on transport theft risk analysis	Identify variables that influence the risk of transport theft to support decision-making in the creation of security schemes to improve SC chaining (De-la-Torre-Romero et al., 2014): Mexico/Latin America
Strategy based on joint inventory replenishment policy	Comparing inventory cost reduction (centralized vs. decentralized approach), through retailers' inventory replenishment policies, using the periodic review policy (Delgado et al., 2017): Colombia/Latin America
Strategy based on resilience metrics	Develop and validate a resilience metric in a two-link SC with disruptions in the transport process (Romero-Rodríguez et al., 2017): Colombia/Latin America
Price-based strategy as an element of coordination between manufacturer and retailer	The optimal pricing strategy for the manufacturer and retailer is analyzed, considering price sensitivity and product substitutability, using the Shapley value. Coordination and its benefits are evaluated by numerical simulation (Li, 2018): China/Asia.
CLSC coordination model with a focus on differential pricing strategy	The differential pricing strategy is analyzed when emergencies simultaneously affect market size and production costs of new and reprocessed products, seeking coordination through a two-party tariff contract (Zhao et al., 2019): China/Asia
Inventory model for deteriorating items in a two-tier CS using a cost-sharing contract	Based on a leader-follower game, where the manufacturer sets wholesale prices, and the retailer determines the order quantity and final price, using a cost-sharing contract to coordinate both parties (Momeni et al., 2019): Iran/Asia
SC Inventory Coordination Model (SCICM)	The model functions as a coordination mechanism in a complex supply flow network. The model used ranking method for an evaluation and prioritization of suppliers based on five criteria determined by retail industry data. (Kumar et al., 2019): India/Asia
Model for Closed Loop SC coordination	Evaluate how closed-loop SC coordination through corporate social responsibility increases sales, creates value for manufacturers, and improves coordination between suppliers and customers (Long et al., 2020): China/Asia
Logistics services model from a customer experience level perspective	Demonstrates that seamless coordination of the logistics service SC can be achieved if quality monitoring and buy-back contracts are adopted simultaneously (Liu et al., 2021): China/Asia Focus on personalization and responsiveness through CRM systems to track interactions and improve customer loyalty (Anwar et al., 2025): China/Asia

Table 2. Organization-Customer Integration Strategy and/or Model

Table 2 outlines the strategies and models reported in the literature during the study period for synchronizing the supplier-organization-customer (P-O-C) relationship in the SC. These strategies focus on enhancing operational efficiency, reducing costs, and improving coordination among chain actors. In Asia, approaches such as "coordination through revenue-sharing contracts" or "JIT batch division" are explored to foster better cooperation between members. Stackelberg game theory frequently appears in these models, addressing decision-making under asymmetric power dynamics and tight delivery schedules.

In Europe and Latin America, strategies aimed at improving logistics planning and synchronization processes are particularly notable. For instance, the "collaborative dynamic planning model" and "synergy-based strategies" optimize comprehensive decision-making, with SMEs reporting enhanced competitiveness through these logistics management models.

Some authors highlight contributions regarding the internal and external integration of the SC. (Arellano-Rodríguez, 2024) emphasizes that SCI generates benefits through suppliers, internal integration and customers, while Baryannis et al. (2019) and Bigliardi et al. (2026) discuss technology adoption and the barriers. On the other hand, Pezeshki et al. (2013) y Rius-Sorolla et al. (2020) offer insights into the need to contextualize synchronization strategies.

The literature focuses on three key themes: 1) integration and collaboration within the SC, with an emphasis on coordination mechanisms, the exchange of information, and relationships between customers and suppliers (Hossain et al., 2017; Alsheyadi et al., 2024; Arellano-Rodríguez, 2024); 2) digitalization and the adoption of technology, primarily the Internet of Things (IoT), blockchain, and artificial intelligence, as tools to improve visibility, transparency and decision-making; however, adoption of these technologies remains low due to a lack of technical, technological and financial capacity, particularly among SMEs (Kouhizadeh et al., 2021; Bigliardi et al., 2026; Younis et al., 2026); 3) optimization methods such as simulation, linear programming, inventory models and other operations research techniques used to coordinate operations, evaluate logistics performance or select suppliers, which are hindered by the high costs involved in their development (Rius-Sorolla et al., 2020; Shaban et al., 2020; Vosooghidizaji et al., 2020). Therefore, SMEs tend to rely on simpler and more accessible techniques, which, while easier to implement, may limit the effectiveness of SC optimization.

Figure 2 shows that the research field is highly fragmented, with 34 clusters that are not interconnected; no single central author has been identified within the discipline. This is because authors work primarily within their own groups, due to geographical divisions, or because they focus on specific topics within the same field. Ghadge, Samir, Loranca, and Adarme represent the strongest link strength in their research groups. A total of 184 links (pairs of collaborating authors) were recorded, with a total link strength of 60.5, indicating that most collaborations are weak; this explains the presence of numerous marginal authors. Finally, the color variation indicates that research in this area has grown in recent years; it can be inferred that the blue nodes represent the founding authors. There are opportunities to integrate research approaches, foster collaborations between groups, and, in the future, identify unifying theoretical models.

An analysis of term co-occurrences identified the *supply chain* and *cluster* as the one that groups the research studies together, positioning itself as the central link and theoretical framework. The proximity of the other terms suggests that the literature converges on a view of supply chains in which collaboration and cooperation are fundamental. The SCI defines how a company collaborates with its partners (Ramirez et al., 2021; Anwar et al., 2025). To manage its processes effectively, the organization requires coordination mechanisms – namely, the technical and operational protocols needed to align with other stakeholders in the SC – this interdependence (Ahumada & Villalobos, 2011; Ran et al., 2020), which explains their online presence (Figure 3).

Integration (blue cluster) represents the strategic and relational dimension of organizations (Flynn et al., 2010; Ramirez et al., 2021). In the agri-food sector, this is a key factor in building trust due to the high degree of fragmentation among stakeholders (small producers, distributors and customers); without the development of trust, any collaboration is unlikely to be viable in the long term. Coordination (red node: coordination mechanism-supply chain-supplier-development-chain) represents the rules governing the functioning of integration; given the uncertainty of demand, SMEs require contracts and shared information for their long-term integration (Arshinder et al., 2011; Kumar et al., 2019).

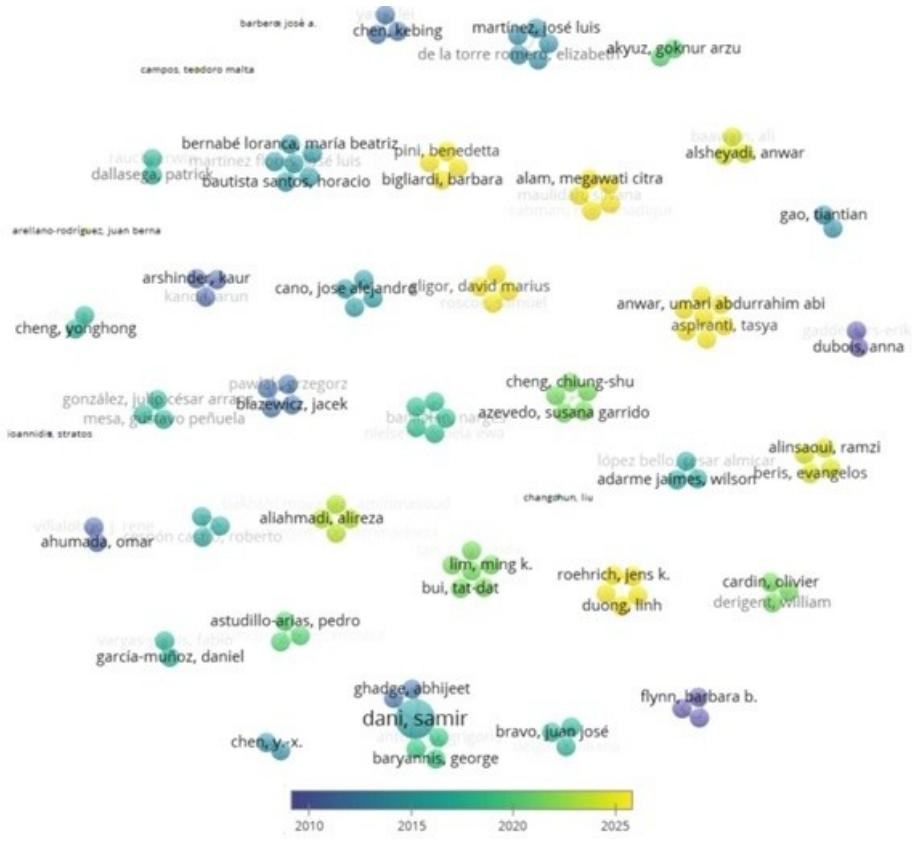

Figure 2. Collaborative networks

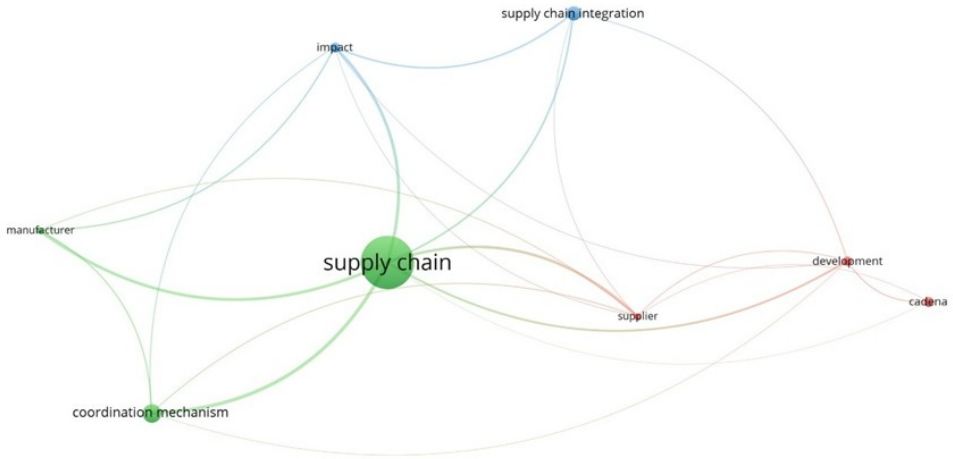

Figure 3. Co-occurrence network

Finally, Table 3 also highlights strategies like "reverse logistics" with a focus on recycling, and "cost-sharing under government subsidies," which aim to maximize profits and promote long-term sustainability. These approaches underscore the importance of cooperation and strategic design in global supply chains.

Strategy/Model (P-O-C)	Supply Chain Purpose: Community/Continent
Joint Inventory Strategy for Coordinating CS under Fuzzy Demand	The supplier-distributor coordination is studied by numerical analysis (Lu & Li, 2010): China/Asia
Collaborative dynamic planning model	A model is proposed for dynamic planning based on the exchange of information and the coordination of production plans that integrate SC to obtain a global solution (Alvarez, 2010): EU
Strategy based on improved planning processes	High-performance production processes are analyzed as a reference for implementing Total Chain strategies (Arango-Serna, Adarme-Jaimes & Zapata-Cortés, 2010): Colombia/Latin America Internal integration serves as the foundation for SC optimization. By aligning departments such as marketing and production, it ensures that manufacturing plans respond to actual demand, thereby eliminating internal inefficiencies (Anwar et al., 2025): China/Asia
Three-stage coordination strategy using an exchange contract	It is shown that effective cooperation in SC is possible if the contract parameter is taken as a reference in a win-win situation (Yi & Jiang, 2010): China/Asia
Coordination strategy by shared wholesale price and revenue-sharing contracts	It is shown that a decision model in a centralized decision framework has benefits for the members of the chain (Wang & Kang, 2011): Germany/EU
Revenue coordination strategy based on lead-time compression	A batch supply model and delivery outsourcing are shown to reduce lead time. Stackelberg leader-follower game models establish optimal costs (Lv et al., 2011): China/Asia
Coordination strategy based on lead-time compression under elastic demand	Optimization under elastic demand in a SC consisting of one supplier and one buyer. The Stackelberg game theory is used to minimize the cost. Simulation shows the variations of the system (Lv, 2012): Shanghai/Asia
Coordination strategy through progressive discount pricing	Demonstrate that using progressive discount pricing is a coordination mechanism between supplier partners and buyers (Liu, 2012): China/Asia
Coordination strategy based on JIT batch splitting applying Stackelberg game theory	Demonstrated that a profit coordination mechanism in SC based on JIT batch splitting is possible. This mechanism uses the Stackelberg leader-follower game to minimize costs (Lv, 2013): China/Asia
Competitive Logistics Reference Model and Value Networks Model	Demonstrated the usefulness of logistics benchmarking models and value networks in a statistically significant sample of companies, enabling strategies for their development to be mapped out (Gómez-Acosta et al., 2013): Cuba/Latin America
Coordination strategy based on supplier-managed inventory control	The supplier-managed inventory coordination mechanism was shown to be better than the traditional SC coordination mechanism under decentralized decision-making conditions (Yang & Zhu, 2013): China/Asia
Strategy based on the synchronization of logistical processes	A methodology is proposed that helps to synchronize operations and decisions in CS through TOC (Marín-Marín & Gutiérrez-Gutiérrez, 2013): Colombia/Latin America Real-time data flow through IoT-based systems enables SC participants to better align production, inventory and logistics with actual demand (Xue et al., 2025): China
Three-level coordination strategy using non-cooperative game theory	A model that shows that when members of a SC participate jointly, their performance levels are better than when efforts are individual, especially in green supply chains (Zhang & Liu, 2013): China/Asia
Three-stage coordination model under a dual mechanism of fuzzy random demand and random rate	It is shown that with a three-stage coordination model (supplier, manufacturer and retailer) in exporting companies, collaboration between manufacturer and supplier improves SC efficiency (Wang et al., 2014): China/Asia
Strategy based on performance indicators	Evaluate the use of indicators in the different SC logistics processes to measure collaboration between members of the chain (Zuluaga-Mazo et al., 2011): Colombia/Latin America
Strategy based on synergies of mutual interest among collaborators.	Compiling a compendium of good practices in logistics for the optimization of operations in the global management of the SC. (Sáenz et al., 2006): Spain/EU

Strategy/Model (P-O-C)	Supply Chain Purpose: Community/Continent
Coordination strategy for a reverse SC based on processing waste	A three-step reverse SC model was studied to maximize profits and achieve mutual benefits. The three-tiered chain is more competitive than the two-tiered chain as the recycling cost increases (Long et al., 2018): China/Asia
Strategy based on assurance of the whole SC	Structure and characterize the different links and actors of the SC to improve their synchronization between members (Cano et al., 2015): Colombia/Latin America
Logistics management model for SMEs	It is demonstrated how a conceptual model of logistics management through the control of inventory, storage, production and distribution policies can improve coordination for an SME (Olivos et al., 2015): Mexico/Latin America
Coordination model with combined contracts for a four-tier CLSC	Game theory simulates CS through combined contracts. Government subsidies strengthen SC (Jun & Dagang, 2016): China/Asia
Mixed integer non-linear multiobjective modeling	Support strategic and tactical decision making such as facility location using mixed integer nonlinear mixed integer modeling, material flow design and selection of means of transport (Feitó-Cespón et al., 2016): Cuba/Latin America
Coordination strategy through production plan adjustment and an enhanced revenue sharing contract.	The supplier and retailer adopt a revenue sharing contract to coordinate the SC that can be adjusted over time (Ji et al., 2019): China/Asia
Group bargaining model with supplier-retailer cooperation	It shows that centralized decisions are better than decentralized ones. The degree of cooperation benefits profits in SC (Liu, Liu & Li, 2020): China/Asia
Pricing strategy and profit sharing under asymmetric decision modes and asymmetric powers	The coordination of a closed-loop control system is studied using the Stackelberg model. Centralized decisions are better; power asymmetry affects prices (Guo et al., 2021): China/Asia
Strategy based on cost-sharing and government subsidies	A three-stage model is presented. It designs a coordination mechanism that considers shared costs (Liu et al., 2022): China/Asia

Table 3. Supplier-Organization-Customer (P-O-C) Chaining Strategy and/or Model (Continued)

Supplier selection is a strategic process of organizations that impacts the benefit of the quality of their operations (Bals et al., 2018). It is a complex multi-objective problem that in the last 25 years has been solved with fuzzy methods, AHP, TOPSIS and linear programming or hybrid models incorporating sustainability criteria (Rashidi et al., 2020).

Chaining Strategy (agro-industrial enterprises)	Purpose in the Supply Chain: Community/Continent
Trusting and cooperative relationships between actors in regional food networks	Improved social relations of trust and cooperation between small producers and agribusiness. Networks are strengthened because of cooperation (Jarosz, 2000): USA/America
Logistics flows: inbound and outbound companies	Analyzes the perception of companies with dyadic vulnerability in logistics flowing to customers, considering time and functional dependencies (Svensson, 2002): Norway/EU
Partnerships between companies	Macro and micro factors are explored in the context of the agri-food industry to identify particularities of collaboration (Matopoulos et al., 2007): Grece/EU Integration with suppliers highlights the importance of forging strategic partnerships with key partners to optimize resources and foster joint innovation (Anwar et al., 2025): China/Asia
Coordination through contract option in biomass SC between "Company and Farmer"	Using Stackelberg theory, a contract model is constructed to coordinate production profit between company and farmer is achieved (Huibo-Gong et al., 2010): China/Asia

Chaining Strategy (agro-industrial enterprises)	Purpose in the Supply Chain: Community/Continent
Quality management of fresh food throughout the SC	Demonstrate how a mixed integer linear programming model that considers the perishable nature of agribusiness helps maximize demand satisfaction (Rong et al., 2011): Finland/EU
Mixed integer programming for harvest planning and distribution.	It seeks to maximize producer income through informed decision-making during the harvest season to determine short-term harvesting and distribution policies (Ahumada & Villalobos, 2011): USA/America
Crop planning using contracts	Provides a planning methodology to determine agricultural areas and planting times annually, to deliver harvests just in time (Tan & Çömden, 2012): Turkey/Asia
Coordination of the fresh produce SC through contracts and disruption	Coordinate the SC through contracts that regulate the pricing and exchange of goods and/or services between independent members (Guohua, 2013): China/Asia
Network approach in food SC with application to fresh produce	A fresh food SC model is developed under conditions of oligopolistic competition and perishability (Yu & Nagurney, 2013): USA/America
Coordination of food CS through trust, information sharing and external environment	Model for building food safety with multiple actors. Trust, information and environment are considered as order parameters (Liu, 2017): China/Asia
Agricultural commodity coordination strategy through contracts	The role of the revenue sharing contract in the coordination of SC is studied with random output and uncertain demand (Cao et al., 2018): China/Asia
Two-tiered agricultural commodity coordination strategy through low carbon	Optimal solutions for both centralised and decentralized agricultural supply chains, with or without low-carbon technology, are analyzed. A low-carbon coordination mechanism is designed to improve the performance of decentralized chains (Changchun, 2017): China/Asia
Contract farming SC coordination strategy with government subsidies	A coordination mechanism for contract farming SC is proposed, where the farmer has price protection. The proposed mechanism makes SC more stable by balancing the interests of both the farmer and the company (Yu et al., 2019): China/Asia

Table 4. Chaining strategies reported in studies of agro-industrial enterprises

Figure 4 shows the proportion of studies reported in the 2010–2025 literature that sought to link the links of the SC: POC, OC, PO. More than half of the work in this research has focused on the coordination of the entire chain, followed by the studies that sought to synchronize the supplier with the organization.

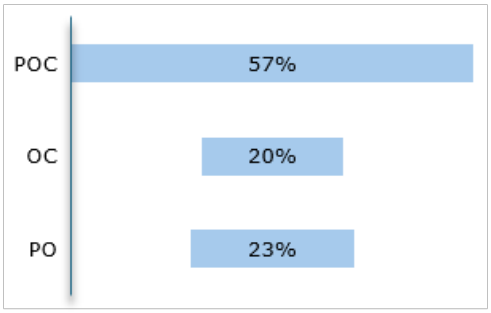

Figure 4. Strategy of chaining entre echelon de la SC

In these studies, 16 fictitious cases have been identified, and 5 studies carried out in the agro-industrial sector. Figure 5 illustrates a word cloud of the most frequently occurring terms identified in the models and strategies reviewed in this study. Terms such as coordination, supplier, contract, and cost emerge as central themes, reflecting the primary concerns in SC integration and management during the study period. These words underscore the strategic focus on optimizing supplier coordination, improving contract mechanisms, and managing costs, reflecting the dominant trends and linkages identified in our systematic review. This knowledge enhances the academic

community's understanding of how SC models and strategies have evolved across regions and sectors, particularly regarding SME integration and the dynamics of global collaboration.

Figure 5. Keyword frequency in SC coordination and strategy 2010–2025

These studies have identified 16 fictitious cases, and 5 studies conducted in the agro-industrial sector. Figure 5 highlights the words with the highest frequency in the models and strategies present in this study period. These words represent the search criteria established in this research. Figure 6, meanwhile, groups the representative models and strategies by continent. This figure suggests that there are different approaches by region to collaboration and coordination in supply chains. While Europe seems to focus on standardization and efficiency, Asia adopts a more flexible and resilient approach, with a strong emphasis on technology and decentralized decision-making. America, on the other hand, seems to prioritize research, the development of collaborative strategies and a more relational and sustained approach.

This analysis allows us to visualize regional trends in the linking of supply chains, highlighting that each continent adopts specific models that respond to its economic and cultural contexts.

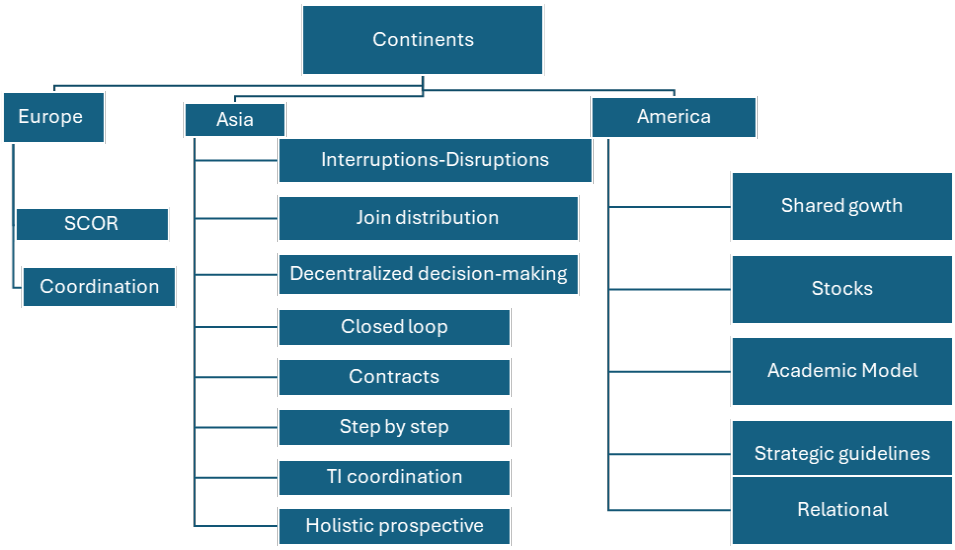

Figure 6. Regional SC Collaboration Strategies by Continent

4.5. Critical Parameters in Synchronization Strategies and Models

This study analyzes 184 articles, identifies key parameters for assessing the effectiveness of the synchronization strategies and models reported during the study period from 2010 to 2025. Beyond descriptive synthesis, these parameters provide a critical evaluation framework to assess the applicability and limitations of existing approaches, particularly in the context of SMEs.

Firstly, there is a strong dependence on the context in which they were developed; it is evident that regional, sectoral and size-related factors influence synchronization strategies (Pezeshki et al., 2013; Rius-Sorolla et al., 2020; Tran et al., 2024), which limits the transferability of approaches across regions and economic sectors, and leads to disparities in SMEs capacity-building. This context dependency represents a structural limitation in the generalization of SC models highlights the need to assess contextual relevance before adopting any integration model.

Secondly, technological feasibility poses a significant challenge. Although technologies such as the Internet of Things (IoT), blockchain and artificial intelligence are transforming SC management, their uptake among SMEs remains limited due to knowledge gaps and uncertainty regarding the return on investment (Baryannis et al., 2019; Bigliardi et al., 2026). This gap between technological potential and actual adoption reveals a critical mismatch between model design and real-world implementation conditions in SMEs. It is therefore necessary to assess whether strategies proposed within digital transformation frameworks are feasible in environments with low digital maturity and limited resources.

A third factor relates to structural and managerial imbalances among the actors in the SC. SMEs lack bargaining power when dealing with large suppliers or customers (Manik, 2022), which makes it difficult to implement collaborative models based on balanced relationships. These asymmetries constitute a critical barrier to equitable integration, limiting the effectiveness of coordination strategies that assume balanced inter-organizational conditions. Any assessment of a strategy must consider whether it incorporates mechanisms to mitigate these structural inequalities and promotes capacity-building within the SC.

Finally, the methodological complexity of many quantitative models limits their practical application, as they require advanced techniques that entail high costs and make it difficult to model processes, particularly non-linear ones (Rius-Sorolla et al., 2020), which limits its adoption of these models in companies with basic analytical capabilities. This highlights the need to balance model sophistication with practical usability, particularly in SME contexts where decision-making relies on accessible tools.

Overall, these critical parameters shift the analysis from a descriptive review toward a critical understanding of the limitations, applicability, and scalability of synchronization strategies in real-world supply chains. These insights provide a basis for further discussion on the relevance, applicability and adaptability of synchronization strategies, particularly within SMEs and agro-industrial sectors.

5. Conclusions and Discussion

This research, grounded in a comprehensive literature review, highlights the need to adopt supply chain management (SCM) models that enhance efficiency, coordination, and resilience in an increasingly dynamic global environment. The findings indicate that while many small and medium-sized enterprises (SMEs) still rely on traditional, empirical practices, the integration of data-driven approaches can create significant competitive advantages, including improved productivity and reduced inventory costs. Notably, as highlighted by Harianto et al. (2024), the adoption of digital technologies not only enhance internal and external operational efficiency but also fosters long-term sustainability. A well-executed digital transformation balances efficiency and environmental responsibility, with emerging digital technologies offering more effective decision-making strategies, particularly in mitigating SC disruptions.

From a systemic perspective, the literature demonstrates that SC synchronization and integration enhance operational efficiency, coordination, and trust among actors, while simultaneously incorporating emerging dimensions such as sustainability and digitalization. These elements collectively facilitate firms' integration into new markets and strengthen their capacity to respond to disruptions. However, despite these benefits, the adoption of such integrative approaches remains uneven across regions and firm sizes, revealing structural and capability-based asymmetries, particularly in SMEs.

The analysis of different geographical contexts further reveals that SC risk management has evolved into a strategic priority. In countries such as China and Colombia, coordination mechanisms focusing on pricing, demand, and production alignment play a critical role in achieving synchronization across the SC. For instance, Chen et al. (2012)

demonstrate that non-linear wholesale pricing schemes enhance operational adaptability under fluctuating market conditions, while Salas-Navarro et al. (2017) highlight the importance of inventory management models in strengthening integration and competitive positioning. These findings indicate that risk management is not a uniform construct but rather a context-dependent capability shaped by institutional, economic, and operational conditions. Recent studies further reinforce this perspective by showing how geopolitical disruptions and structural reconfigurations of supply chains require adaptive and ambidextrous strategies to maintain performance under uncertainty (Moradlou et al., 2025).

At the same time, the growing emphasis on sustainability reflects a paradigmatic shift in SCM, where efficiency objectives are increasingly aligned with environmental and social considerations. Mechanisms such as closed-loop supply chains and sustainable contracting practices, particularly observed in Asian markets, indicate that SCM is evolving toward a more holistic model that integrates economic performance with sustainable development goals (Yazdani et al., 2017; Bui et al., 2021).

Furthermore, this research stresses the importance of incorporating dynamic capabilities into SC management, particularly in Europe, where operational flexibility and quality are essential. Effective coordination among SC actors is linked to enhanced resilience and cost optimization, favoring a holistic approach that considers both adaptability and collaboration. However, in sectors like agro-industry, trust and cooperation are fundamental, yet farmers face barriers in accessing advanced mathematical models. Therefore, technological solutions must be tailored to the capacities of these early-stage SC actors (Selvananthana, 2024). In this regard, recent empirical evidence shows that the alignment between artificial intelligence capabilities and learning processes significantly enhances SC resilience, particularly under unstable conditions (Lu et al., 2025). However, these capabilities are unevenly distributed across SC actors, especially in SMEs. Digital technologies, including artificial intelligence, blockchain, and the Internet of Things—play a transformative role in redefining SC structures and processes. These challenges are particularly pronounced in SMEs, reinforcing the need for adaptive implementation frameworks that consider organizational readiness and contextual limitations, to improving the resilience of companies (Duong et al., 2025; Golgeci et al., 2025; Lu et al., 2025; Moradlou et al., 2025).

Overall, the literature reviewed from 2010 to 2025 indicates that SCM has evolved toward more collaborative, digitally enabled, and sustainability-oriented models. This evolution reflects a shift from linear and efficiency-driven paradigms to more complex, adaptive, and interconnected systems. Emerging research further suggests that supply chains should be understood not only as operational systems but also as socio-political structures shaped by institutional pressures, power dynamics, and global interdependencies (Golgeci et al., 2025). From this perspective, SCM can be conceptualized not only as a coordination mechanism but also as a socio-technical system that integrates actors, technologies, and processes to enhance resilience and competitiveness in volatile environments.

The bibliometric analysis reveals, it has been concluded that there is a fragmentation among research groups, and that research in this field has grown. *Supply chain* is the conceptual core of the field, linking integration, coordination and development, although these connections are still in their infancy. In terms of co-authorship, no research group has yet established itself as a leading authority in the field, due to the diversity of topics; this indicates that there are opportunities to strengthen thematic integration and collaboration at regional and global levels.

From a theoretical perspective, this study contributes to the SCM literature by reinforcing the view of supply chains as dynamic and context-dependent systems, where performance is shaped by the interaction between technological capabilities, organizational structures, and relational dynamics.

Future research should prioritize the development of accessible technologies that integrate smallholder farmers and entrepreneurs, as recent studies demonstrate that their inclusion enhances SC resilience. Additionally, developing hybrid models that balance sustainability and efficiency, as suggested by Rashidi et al., 2020, could reduce operational costs. The formation of regional clusters also presents a valuable area for fostering collaboration and strengthening local economies. These research directions will contribute to the advancement of SCM knowledge, offering the scientific community tools and theoretical frameworks to address contemporary challenges in SC integration. Furthermore, greater attention should be given to the contextual adaptation of SCM strategies, the

development of empirical evaluations on the impact of technologies in agro-industrial SMEs, and the design of tailored digital tools that respond to the specific needs and constraints of these organizations.

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Authors' contributions

Eduardo Fernández-Echeverría: conceptualization, data processing, formal analysis, methodology, writing original draft, review & editing.

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Data availability

Data included in the article itself

Use of Artificial Intelligence

The authors declare that they wrote this article without using artificial intelligence for the writing of the text, data analysis, the creation of graphs, or any of the other activities carried out.

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