

Review

A Systematic Review of Strategic Supply Chain Challenges and Teaching Strategies

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Abstract: *Background:* This study provides a comprehensive overview of current supply chain challenges and how they are taught within university circles or among supply chain professionals to simulate reality. *Methods:* The study applied a systematic literature review, using bibliometric co-citation and concept-centered content analysis for a comprehensive review of 118 relevant articles, leading to the identification of critical challenges in modern supply chain management. *Results:* These challenges include supplier selection and quality, supply chain networks, and sustainable supply chains. Supply chain educators are encouraged to use games that mirror real-world scenarios to teach these challenges. Results from this review underscore that existing games covered supply chain concepts such as the bullwhip effect, collaboration, networks, supplier selection, quality management, humanitarian logistics, sustainability, lean supply chain, Supply Chain 4.0, and perishable goods supply. *Conclusions:* The study's contribution is to assist in selecting games tailored to the supply chain specific aspects and to guide developers in creating realistic games that address recent challenges in supply chain management. It recommends a holistic approach to enhance new supply chain game development, drawing from methodologies such as problem-based learning and Lego Serious Play. This multifaceted approach imparts practical knowledge and comprehensive skills for addressing supply chain intricacies in modern business settings.

Keywords: strategic supply chain challenges; business simulations; serious games; supply chain teaching effectiveness



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1. Introduction

Strategic supply chain management is vital in today's competitive global landscape, efficiently aiding companies in anticipating and meeting consumer demands [1,2]. However, uncertainties from disruptive technologies, demand fluctuations, pandemics, and environmental turbulence challenge the supply chain decision-making [3–5]. To that effect, the traditional theoretical teaching approach may leave future managers ill-equipped to handle real-world problems, termed the “enigma of professionalism.” [6] Practical skills development is crucial to address the above challenges, especially in disciplines such as supply chain management. Business simulations and game-based learning have proven effective, providing an engaging and interactive environment where learners can make genuine decisions and enhance creativity [7,8].

Previous studies have utilized games such as *the Beer Game* to illustrate concepts like supply chain coordination [9–12]. Other games have tackled various supply chain concepts, such as the closed-loop supply chain [13], demand forecast, production plan, supplier selection based on cost and lead times, and inventory management [14,15].

While some games address specific supply chain challenges, research suggests a need for more educational tools and models, especially in the era of Supply Chain 4.0 [16].

Current games focus on technical stability rather than learning capabilities, necessitating a broader perspective on real-world challenges. One of the reasons for this could be the need for increased access to a more recent survey of the challenges in this field, as most prior reviews have focused on strategic supply chain issues individually. For instance, numerous literature reviews have delved into specific facets of green supply chain management, including performance measurement, supplier selection/evaluation, and analytical modeling efforts [17,18]. This makes it difficult for them to see the big picture of severe challenges that may affect the supply chain and need consideration. Efforts to consider recent challenges and uncertainties in the strategic supply chain still need to be apparent in existing games and simulations. Many games focus on the same familiar concept or challenge, neglecting other potentially newer and more difficult challenges. For instance, more than twelve games concentrate on the bullwhip effect [19], whereas other critical aspects such as reverse supply chain and collaboration in uncertainties are not directly addressed in current games. It is also difficult to clearly state the most- and least-used supply chain aspects or challenges covered in existing games.

This study reviews recent strategic supply chain challenges and educational strategies to bridge this gap. The objective is to offer a thorough overview of current supply chain challenges and illustrate how existing games and simulations cover and address them, thereby aiding their comprehension within university circles or among supply chain professionals. More specifically, this study addresses the following questions: (1) What strategic supply chain management challenges have recent studies addressed? (2) How has strategic supply chain knowledge been conveyed to students, and what are future avenues in teaching strategic supply chain given contemporary challenges and uncertainties?

The review encompasses search methodology, analysis techniques, and results detailing strategic supply chain challenges, pedagogical activities, innovative teaching strategies, future directions, and conclusions.

2. Methodology

This work uses a systematic literature review methodology to identify strategic supply chain management challenges and the state-of-the-art of actual pedagogical strategies to teach these supply chain challenges. This study uses ref. [20]’s protocol for a systematic literature review. The study relies on two queries to search papers. It uses keywords derived from the main research question and joins them using standard Boolean operations [21]. The first query consists of identifying supply chain management challenges. As presented in Table 1, the search scope was limited to Scopus and ABI-Inform, two critical interdisciplinary databases.

Table 1. Number of papers per database for query 1.

Database	Query 1	Number of Papers
ABI-Inform	NOFT (“supply chain management” OR “supply-chain management” OR “strategic suppl*” OR “supply chain network design” OR “Supply chain planning” OR “supply chain coordination” OR “supply chain optimization” OR “supply chain collaboration” OR “supply chain forecasting”) AND (“supplier selection” OR “supplier management”))	358
Scopus	TITLE-ABS-KEY (“supply chain management” OR “supply-chain management” OR “strategic suppl*” OR “supply chain network design” OR “supply chain planning” OR “supply chain coordination” OR “supply chain optimization” OR “supply chain collaboration” OR “supply chain forecasting”) AND TITLE-ABS-KEY (“supplier selection” OR “supplier management”))	1734
Total		2092

The second query investigates pedagogical strategies for teaching supply chain management in higher education. This study utilizes Scopus, ABI-Inform, Business Source

Complete, ACM Digital, and ABSL databases, as suggested [20] (See details in Table 2). ABI-Inform, Business Source Complete, and ACM Digital are vital supply chain and information systems databases, while Scopus offers interdisciplinary coverage. ABSL focuses on simulation publications.

Table 2. Papers per database for query 2.

Database	Query 2	Number of Papers
ABI-Inform	MAIN SUBJECT.EXACT (“supply chains”) AND NOFT (serious game” OR “simulation game” OR “simulation training” OR “megagame” OR “instructional strateg*”)	12
Scopus	TITLE-ABS-KEY (“strategic supply chain” OR “collaborative supply chain” OR “supply chain management”) AND (“serious game” OR “simulation game” OR “simulation training” OR “megagame” OR “instructional strateg*”)	108
ACM-library	[[All: “strategic supply chain”] OR [All: “collaborative supply chain”] OR [All: “supply chain management”]] AND [[All: “serious game”] OR [All: “simulation game”] OR [All: “simulation training”] OR [All: “megagame”] OR [All: “ instructional strateg*”]]	49
Business source complete	TI (“strategic supply chain” OR “collaborative supply chain” OR “supply chain management”) AND TI (“serious game” OR “simulation game” OR “simulation training” OR “megagame” OR “instructional strateg*”)	3
ABSL	Supply chain	22
Total		194

The scope of this study was limited to studies published in the year 2000 and beyond, as 2000 was a year of interactive and collaborative technology development. To ensure the incorporation of pertinent papers in this study, we implemented a two-step process utilizing eligibility criteria. Initially, the articles were filtered based on title, abstract, and keywords after removing duplications. Secondly, the literature was screened by examining the introduction and the conclusion. The last two authors have independently replicated each step of the process to ensure and verify the quality of the selected articles. This study proposes inclusion and exclusion criteria to screen relevant papers. The inclusion criteria are outlined as follows:

- (1) Must be published in peer-reviewed journals or conferences and written in English.
- (2) Publications must reference strategic supply chain management and its teaching strategies in high schools.
- (3) Publications must reference one or more supply chain challenges.
- (4) Papers published after the year 2000 are of interest.

For exclusion, the paper must meet the following criteria:

- (1) Non-English papers.
- (2) Papers that focus on supply chain curricula without any aspect of pedagogy.
- (3) Non-peer-reviewed and review papers.
- (4) Books, thesis, reports, and book chapters.
- (5) Publications with no direct relation to supply chain management challenges and supply chain educational strategies.

The approach applied in this study integrates bibliometric co-citation analysis with concepts-centric content analysis. Bibliometric reviews leverage quantitative methods, combining co-citation analysis and bibliographic coupling for mapping publication networks [17,22]. These techniques form “clusters of thematically related publications” [22]. Co-citation occurs when two papers are both cited by a third paper, indicating a potential relationship between the co-cited papers. Studies suggest that papers frequently cited together by other publications are more likely to be related, implying a shared subject area [17,23]. Co-citation analysis assumes similarity between publications when cited

together, forming classes representing different themes. Bibliometric analysis suits broad reviews with “large datasets due to its efficiency” [24].

With $n_1 = 1905$, co-citation analysis was applied to query one following the initial screening. Grouping co-cited publications revealed distinct themes in the literature. We used VOSviewer_1.6.19 software to run the co-citation analysis. The second evaluation of the papers was conducted based on the results obtained from co-citation analysis. Query 2 papers on teaching strategic supply chain strategies were comparatively fewer ($n_2 = 197$), aligning with [21] recommendations for classic methods requiring fewer papers for review. Figure 1 summarizes the study’s steps and the final number of papers included.

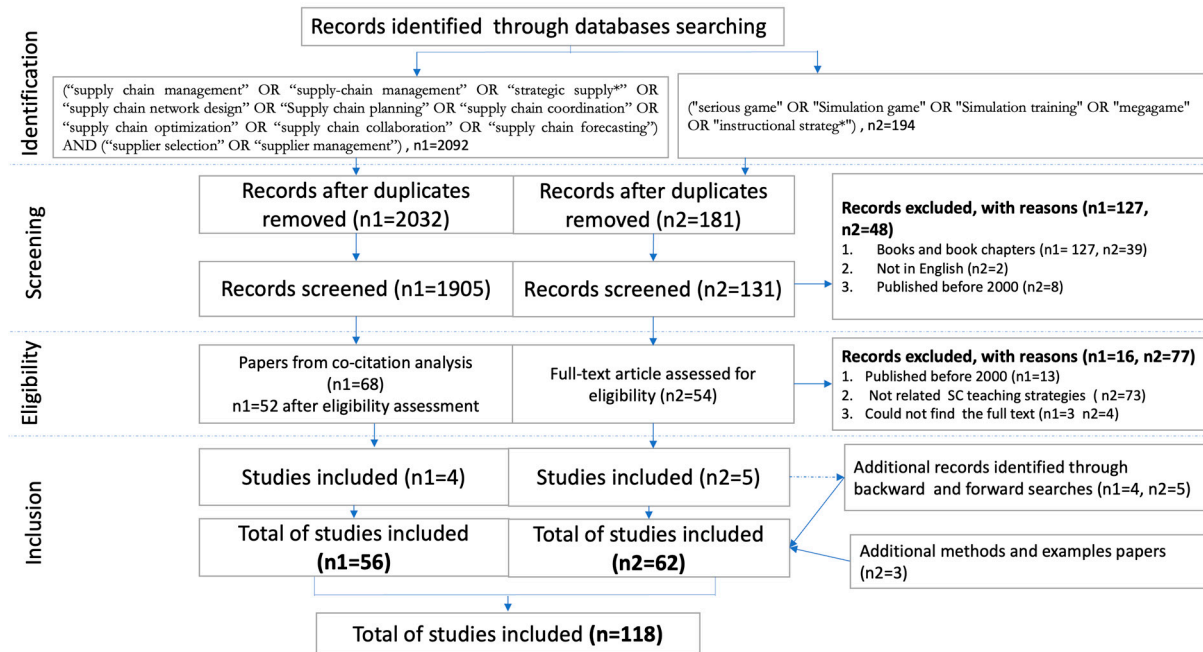


Figure 1. Synthesis of steps and final number of papers included in this study.

Figure 1 summarizes our literature search and paper evaluation. Initially, 68 relevant papers on strategic supply chain challenges were identified through co-citation analysis for query 1. After excluding 16 articles (13 published before 2000 and 3 inaccessible), 52 papers remained. Incorporating the four most recent papers from backward and forward searches and adding 62 from query 2 gave a total of 118 papers for content analysis. Following [25] a concept-centric approach, the study analyzed and synthesized the content of these papers. As in the previous steps, the last two had to double-check the analysis results separately. Concept-centric analysis is the best way to organize and analyze the literature [25]. This approach organizes diverse concepts developed in the literature in a matrix. The concepts matrix makes it easier to identify shared supply chain concepts among authors, along with their conclusions (findings) about these concepts. The other alternative is the author-centric approach, which “essentially presents a summary of relevant articles” instead of analyzing them, as argued in [25]. The next section presents both the co-citation and concepts-based content analysis results.

3. Results

This section presents the findings of this study in three main subsections: (1) topics analysis, (2) strategic supply chain concepts-based content analysis, and (3) strategic supply chain pedagogical activities and teaching innovative strategies from content analysis. All those papers were excluded from the content analysis.

3.1. Thematic Analysis with Co-Citation Analysis

The co-citation technique applied to the database ($n1 = 1905$ papers) revealed three essential themes. The co-citation analysis allowed us to extract classical papers, as shown in Figure 2.

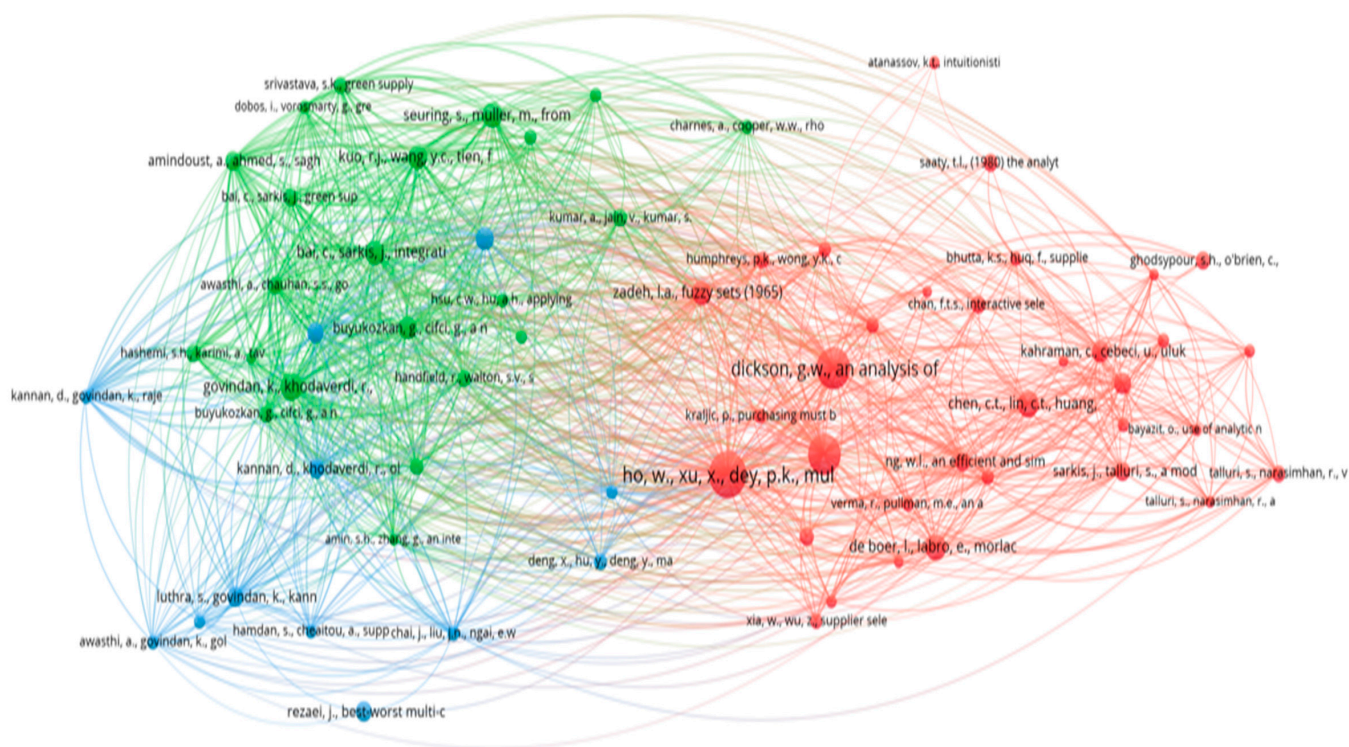


Figure 2. Clusters from co-citation analysis, as produced by VOSviewer1.6.19 software.

Co-citation analysis identified 68 classic articles, initially grouped into three clusters with a minimum co-citation requirement of 20, resulting in 39 articles. Subsequently, the minimum was adjusted to 15 co-citations, maintaining the total at 68 articles across three clusters (first cluster in red, second cluster in green, and third cluster color in blue), as illustrated in Figure 2. VOSviewer did not automatically assign themes, requiring us to identify topics by reviewing titles and abstracts. Co-citation bibliometric analysis (results in Figure 2) highlights three main areas of scholarly focus: (a) information control, supplier evaluation, and selection with 34 papers in this cluster (with example papers in this cluster, [26–28]); (b) green supply chain and sustainability with 22 papers (examples of papers in this cluster [29–31]); (c) decision-making tools for sustainable supply chain management with 12 (examples of papers in this cluster [32–34]). It is essential to note that co-citation analysis may occasionally include papers beyond the intended scope. As was the case in this study with some classic papers before the year 2000, none of these papers were considered for content analysis. Following systematic review guidelines adapted from seminal papers, the following section presents the outcomes of content analysis within the framework outlined by [25].

3.2. Strategic Supply Chain Concepts-Based Content Analysis

The content analysis identified five key challenges in the supply chain: supplier evaluation and supplier quality, supply chain network, and green supply chains. Additional challenges encompassed collaboration, disruptions and resilience, inventory, distribution, and integration of Industry 4.0 and lean management.

The supplier evaluation and selection have been extensively examined in earlier studies [27]. Their analysis reveals that supplier selection and evaluation involve multiple

phases and require well-established criteria to facilitate decision-making. Previous studies often concentrated on the final step of the process—choosing qualified suppliers—with a sole criterion: cost [27,35]. In modern supply chains, effective supplier selection and evaluation necessitate a multicriteria approach encompassing all process steps, prompting recent studies to categorize criteria and devise new selection methods [18,36–38].

The phases of the selection process encompass initial problem definition, formulation of criteria, qualification of potential suppliers, and the final choice among qualified suppliers [35]. Problem definition involves determining the ultimate problem and justifying supplier selection as the optimal solution. This phase addresses why to buy or not, the number of suppliers, and the rationale for replacing the current supplier [35,39]. The formulation of the criteria phase entails identifying suitable suppliers, commonly referred to as factors influencing the selection [40]. While earlier studies focused on the traditional cost-based approach, modern supply chains acknowledge supplier selection as a multicriteria problem [41–43]. Researchers have identified quality, delivery, and cost as critical criteria, with recent considerations incorporating Industry 4.0-related sub-criteria in economic, environmental, and social categories [18,44,45]. Supplier qualification involves reducing the supplier pool to an acceptable set [35], and the final choice occurs in the last phase. Various methods are applied in these stages, differing between traditional and Industry 4.0 supply chains. AHP and TOPSIS emerged as popular methodologies for supplier selection and evaluation, with information control identified as a critical factor in reducing uncertainty [27,46].

Another important aspect of supply evaluation and selection is supplier quality. Quality is pivotal in supplier selection and evaluation decision-making [18,27]. Companies, as noted in [47], should invest in enhancing supplier quality, resulting in a substantial decrease in the cost of quality (COQ) [48]. However, quality cost is integral to the quality management system, with quality cost management representing a crucial aspect of overall system development within a company [47]. Effective management of quality costs allows companies to strategically utilize pricing strategies by considering both quality and price in consumer purchasing decisions [49]. Quality improvement for suppliers entails an increase in quality costs, with supplier performance evaluation playing a vital role in this improvement and assisting suppliers in controlling their quality costs. Previous research identified Six Sigma techniques, outsourcing parts production in supplier selection, and conformance quality as influential factors in reducing quality costs [50,51]. Various factors can impede quality management within organizations, with the scarcity of human resources identified as a central barrier. Ref. [52] identifies leadership issues, ignorance, inadequate human resources, lack of cooperation, insufficient encouragement, absence of information technology, inadequate green practices in production, and limited awareness of global circumstances as significant barriers to effective supplier quality management. These challenges hinder the successful implementation of supplier quality management in various organizations.

The second challenge developed in the literature is the supplier network. The supply chain network is critical in supply chain management. It involves long-term decisions with substantial financial implications [53]. Essential practices within the supply chain network, such as supplier selection, site localization, sizing, and production allocation, are paramount [53,54]. It is not only the regular supply chain network that has attracted studies; the reverse logistics network, described as the closed-loop supply chain network, is now also of interest [55].

This field has gained recognition across various disciplines due to its emergent and rapidly growing nature [56]. It highlights the increasing complexity of supply chains, requiring enhanced collaboration, resilient mechanisms, continuous inventory monitoring, and optimization efforts to reach customers effectively [53].

Supply chain collaboration, as investigated in [57–59], involves companies working together for a competitive advantage and increased profits. This synergistic approach optimizes resources and benefits partners [60], enhancing efficiency and asset utilization,

reducing inventories, and consolidating truck requirements. Outsourcing logistics to service providers, as emphasized in [58], allows businesses to focus on core competencies. Logistics service providers serve as enablers for collaboration between manufacturers and retailers. Careful provider selection is crucial, ensuring active promotion of collaboration over capitalizing on operational inefficiencies [61]. Despite the essential collaboration needed among supply chain actors, the increasing complexity of supply chains brings forth specific threats, notably disruption risks. These risks stem from natural disasters (e.g., earthquakes, tsunamis, and floods) or intentional or unintentional human actions (e.g., strikes, wars, economic crises), with low probabilities but severe consequences, disrupting regular chain operations [53]. Disruption occurrences cause some costs that have been quantified by prior scholars [62,63]. Prior papers on supply chain network design considered disruption and all other risk management practices as processes marked by uncertainties [53]. The costs incurred due to disruption occurrences have been quantified in previous studies [62,63]. Resilient mechanisms are crucial in this uncertain landscape of supply chain network design, aiming to mitigate the damage and costs associated with disruptions.

Resilient supply chain literature explores the interplay between resilience and sustainability in supply chain design. It emphasizes the resilient-green supplier selection criterion [59,64]. Recent studies have delved into resilient strategies pre-disruption, encompassing multiple sourcing, supplier fortification, prepositioned inventory at protected suppliers, and third-party logistics provider (3PL) contracts [65]. Key resilient indicators include responsiveness and facility reinforcement. Meanwhile, sustainability aspects prioritize reliability and quality as the foremost indicators [66]. However, these strategies depend on the maturity of the supply chain. Regarding maturity in humanitarian logistics, a few prerequisites are required. For instance, to comment on the maturity in the context of humanitarian logistics, the phase of the crisis needs to be well known, as do the main processes, in a narrow link to stakeholders and information flows [67]. To handle crises associated with recurrent events, the maturity model for humanitarian logistics systems by [67] includes administering donations, designing distribution networks, and selecting suppliers. The most recent literature introduces the supply chain viability concept, focusing on the dynamic reconfiguration of supply chain structures for long-term survival [68]. Supply chain viability goes beyond traditional resilience mechanisms as it qualifies as an extended resilience perspective. While resilience involves returning to a previous state or restoring planned performance after a disruption, supply chain viability is an adaptive open-system perspective that embraces a “new normal” to endure and thrive in significantly altered internal and external conditions [68].

Regarding monitoring inventory and distribution, information technologies have revolutionized supply chain reliability, reducing costs and enhancing information exchange among actors for better decision-making. Traditional models, managing procurement, production, and distribution independently, incurred high costs and diminished customer satisfaction [69]. Supply chain design involving collaborative specifications and task sharing addresses these challenges. As highlighted in earlier studies [70,71], information technology integrates activities for efficient customer product delivery. Innovations such as RFID, big-data analytics, and blockchain improve performance. RFID enhances distribution systems, improving product dispatch and inventory transit. Big-data analytics tools handle massive data for informed decision-making. RFID enables real-time data sharing, and the Internet of Things enhances warehouse visibility, increasing speed and efficiency [72]. Blockchain directly benefits supply chain revenue, improving visibility, traceability, and sustainability. Blockchain positively influences sustainability through integration, eliminating intermediaries in sourcing, and establishing direct links to suppliers [73].

The third challenge that emerged from the analysis is green supply chain and sustainability. As highlighted earlier, the evaluation and selection of suppliers stand out as a critical and strategic tool for decision-making guidance [43,74]. The emergence of green supply chain management, driven by a growing commitment to environmental protection, has positioned sustainable practices as integral to long-term industry competitiveness [29,75–77].

Factors such as sustainability criteria in supplier selection, environmental policy, and green human resource management contribute to the influence of green supply management [75,78–80]. Recent studies have shifted focus towards strategically choosing green suppliers in supply chains, centering on criteria derived from actual case studies and effective supplier selection methods [81–84]. The coordination and improvement of supply chain information integration for production, technology investment, transportation, and inventory require a joint decision-making [85,86]. Carbon tax emerges as a critical policy that directly sets prices on carbon emissions, significantly impacts supply chain management decision-making, and promotes coordination among supply chain members for economic, environmental, and societal improvements [86].

Another critical aspect highlighted in studies is the importance of Industry 4.0 and lean supply chain management integration. Integrating lean supply chain management (LSCM) with Industry 4.0 (I4.0) is mutually beneficial for companies, sharing the common goal of cost reduction and increased productivity [87,88]. Recent studies indicate that LSCM is a strategic precursor to the I4.0 adoption [89]. I4.0 focuses on automating systems, digitalization, and data exchange in industries, facilitating intraorganizational and inter-organizational process integration [90,91]. This approach meets the growing need for informatization and automatization, enhancing information integration throughout the supply chain and enabling real-time transmission and processing for easier decision-making [92]. In manufacturing, for instance, digitalization aims to connect all actors in value chains [89]. I4.0's application minimizes human interaction, increasing quality, customer satisfaction, and productivity [90,91]. Lean management is a quality method that emphasizes flow by eliminating waste [93]. Within organizations, lean management distinguishes between waste and value [94]. Lean supply chain management integrates upstream and downstream flows to enhance value and reduce costs and waste, meeting customer demands promptly [89]. Implementation yields benefits in cost reduction, shortened throughput time, and improved quality [92,95]. Strategically, LSCM drives I4.0 for sustainability while, at the operational level, I4.0 supports LSCM with advanced tools such as big data, augmented reality, digital products, cloud chains, blockchain, and additive manufacturing [89].

3.3. Strategic Supply Chain Pedagogical Activities and Teaching Innovative Strategies

This subsection outlines supply chain educational strategies. The content from existing papers is organized as follows: (a) theoretical approaches to games and simulation-based learning, (b) technical features of existing games and business simulations, and (c) the addressed supply chain concepts in teaching-based games and simulations.

As far as theories are concerned, two primary theoretical trends guiding the use of games and simulations in supply chain teaching emerge from existing literature: problem-based learning (PBL) and Experimental Learning Theory (ELT). Both emphasize action-based, participatory, and student-centered learning, drawing from concrete experiences and critical reflection in group settings [96–98]. Problem-based learning encourages students to explore new knowledge collaboratively, with the teacher as a facilitator and guide [7,98,99]. Ref. [8] identify several critical elements in the Problem-based learning process. These include the open-ended problem that triggers learning student engagement in independent and collaborative learning. Additionally, teachers' facilitation through continuous scaffolding enables students to develop domain-relevant problem-solving skills, stimulates creativity, and encourages critical thinking [8,100,101].

Simulations have become a tool for revitalizing supply chain courses, utilizing guided experiences to replace or amplify real experiences with positive learning outcomes [98,101,102]. Grounded in Kolb's Experimental Learning Theory, simulations bridge practical skills and theoretical knowledge, enhancing short-term engagement and long-term employability [103,104]. The study highlights the challenge of conveying fundamental supply chain knowledge through theoretical teaching alone, emphasizing the effectiveness of role-playing games, simulations, exercises, and business case studies as complementary approaches [104–108].

The literature defines a game as a paradigm for competitive and cooperative behavior within a structure of rules varying in formality. In contrast, a simulation aims to understand and solve “complex real-life problems” by constructing a simplified version or model [109]. Whether playing individually or in groups, participants pursue goals through action and decision-making in business games or simulations related to the business world [110,111]. The simulation is a simplified, abstract model with rules, enabling participants to harness the dynamics of achieving common goals. Within the simulation environment, gaming allows individuals to witness the effects of different strategies without a human competitor, constituting a sensemaking process [109].

Regarding the existing simulation games’ technical features, the supply chain simulation games literature covers paper-based (for example, the game by [112]) and digital formats, addressing various supply chain and logistics dimensions. Online games “reduce the setup time, make it easier for an instructor to review and present results” [113]. They also reduce the students’ coordination requirements and make the supply chain more realistic [113–115]. Despite these advancements, the industry still predominantly employs paper-based games, with only 37.5% being digital web-based games [19]. Recent games integrate multiple supply chain and logistics dimensions, with examples such as the *Shortfall* and *X-Supply* games incorporating sustainable aspects [19]. However, a limited number of digital web-based games simulate current supply chain challenges, as most remain technically basic and paper-based. This limitation hinders the incorporation of essential settings such as real-time interaction and player numbers. Consequently, there is a need for more realistic games that address modern supply chain challenges dynamically, moving beyond conventional, static knowledge transmission [16]. The existing games’ model realism is low, necessitating a comprehensive framing of real-world supply chain challenges. The subsequent passages elaborate on the various supply chain concepts these games and simulations cover.

However, games have facilitated young students’ acquisition of practical skills in educational settings. Games operate in real-time and continuously simulate the complexities of a global supply chain, involving human players in decision-making processes [116,117]. They have received consistent approval for their effectiveness in teaching students how to manage the challenges of a global supply chain by offering practical insights into the real-world application of supply chain concepts [116–120]. Moreover, game-based learning enhances higher-order thinking skills, promotes teamwork, and facilitates the social construction of knowledge. This approach allows them to interact with others, an essential added value that most companies require [119,121]. More intriguingly, research suggests that learning is often influenced by context. Consequently, the transfer of knowledge from a simulation game to real-life situations is not guaranteed. It all depends on factors such as the student’s level of engagement and metacognitive responses [117].

The study by ref. [19] identified numerous supply chain games and systematically analyzed the complexity of forty of them. Based on their characteristics, we classified them into two main categories. The first category encompasses global supply chain games. This category of games covers several challenges of a global supply chain. This category includes games such as *Fresh Connection*, *SCM GLOBE*, *The Distributor Game*, and *The Cell Phone Game* [19,120,122]. The second category comprises games focusing on a specific global supply chain challenge, such as beer games and many other games developed with the same logic [123,124]. The analyses carried out reveal that all these games in every category cover a range of supply chain concepts, encompassing (1) the bullwhip effect, (2) collaboration and contract, (3) supply chain network, (4) supplier selection and evaluation, (5) quality and risk management, (6) humanitarian logistics, (7) sustainable supply chain, (8) lean supply chain management, Supply Chain 4.0, and (9) perishable goods supply and closed-loop supply chain.

First, the bullwhip effect concept has been a focal point for simulation and game developers in supply chain education. *The Beer Game* and many others have effectively addressed this concept, serving as popular tools for conveying supply chain information

value [9,125–129]. *The Beer Game* can demonstrate the bullwhip effect and swiftly share insights for mitigation [104,130,131]. Over ten existing games, including *The Mortgage Service Game*, *SBELP* “supply chain simulator”, *The SC-Mark Shark Tank Game*, *ECLIPS Game*, *Lean Leap Logistics Game*, *Quebec Wood Supply Game*, *Service Supply Chain Game*, and *Think Log*, support this supply chain phenomenon [14,19,106,132,133]. *The Mortgage Service Game* centers on service-oriented supply chain management (SCM) principles, highlighting cost reduction. It empowers learners to make informed decisions in demand forecasting and inventory management, fostering a more profound comprehension of bullwhip effects and emphasizing the significance of information sharing in the SCM [14,133–135]. However, these actions are often addressed at operational levels, posing challenges in making optimal inventory and demand forecasting decisions amid uncertainties [14].

Second, collaboration and contract concepts have been implemented in existing games. Collaboration is pivotal in the supply chain for building relationships and gaining a competitive edge. Games and simulations are practical tools for teaching this supply chain phenomenon [136]. Examples include *BASE*, the supply chain collaboration business game [10], *The Fresh Connection* [122], *Service Supply Chain*, *Lean Leap Logistics*, and *Chain Game* [19]. Additionally, the *FloraPark* simulation, a newer game focusing on supply chain contracts and collaboration, complements *The Beer Game* [104]. Together with the *B2B* simulation, the *FloraPark* simulation introduces price bargaining, addressing conflicts of interest and competition among supply chain partners in the same market [104,137,138]. Collaboration games aim to impart the significance of inventory control and collaboration between firms throughout their experiences [10,139].

Third, the supply chain network concept is also of interest to game developers in existing games. Production planning is a pivotal element within supply chain management, overseeing the entire production process and holding a critical position in the broader supply chain network. According to [13], a supply chain plan integrates and ensures the smooth operation of every organizational component. Existing research introduces *Logistic Simulator* (LOST) as a game for supply chain production planning, providing students with a playful approach to learning. Another game, *Responsive Learning Technologies*, focuses on critical factors in the supply chain and network design [14]. Through these games, students can make concrete decisions related to demand forecasting, capacity, production planning, inventory management, and logistics network design [14,110,140,141]. As learners play these games, they quickly grasp key decision factors in supply chain management, making capacity, forecasting, and inventory management decisions. They can formulate an efficient logistics network that maximizes supply chain performance, concurrently managing demand and inventory [14,142–146]. By addressing order fulfillment and capacity management, these games aim to reduce costs [133].

Fourth, the supplier selection and evaluation challenge is also implemented in a few existing games. Supplier selection and evaluation pose critical challenges in strategic supply chains. Learners, as stated in [14], can formulate strategies to navigate demand uncertainty while understanding the cost-lead time trade-off. Game-based learning facilitates the development of supply-based management skills, fostering the creation of a profitable and flexible supply chain. Armed with this knowledge, learners find it easier to make informed decisions in supplier selection, production planning, and resource allocation [14]. While there is a scarcity of games addressing supplier selection and evaluation, *The Global Supply Chain Management Simulation*, described by [19], focuses primarily on operations management.

Fifth, quality and risk management supplier chain challenges have been developed in existing games. Quality management is pivotal for robust production networks, emphasizing game-based simulations for effective learning [147]. These simulations enable players to make informed decisions by grasping the fundamental principles of quality management in the production network learning [147]. *The Quality Intelligence Game* and *Beware* support quality and risk management [148]. Ref. [14] asserts the effectiveness of games in raising awareness among supply chain managers about quality issues, illustrating how these issues

permeate the chain network and impact overall supply chain costs. While simulations on quality management are limited, developing concrete skills in quality management is crucial, considering it as a critical factor in supplier selection and evaluation.

Sixth, humanitarian supply chains and logistics, shaped by complex and hazardous events, can be comprehended through games. For instance, ref. [99] proposed a mixed-reality game as an extension of the *Disaster Relief Game*. It is a role-based simulation game that improves understanding of the intricate planning and execution of supply chain management during crises. Notably, it enhances game visualization and simplicity, facilitating easier play compared to its predecessor [8]. Other games dedicated to humanitarian logistics include *The Disaster Relief Game* and *Thing Log* [14,133]. Existing games cover a significant number of aspects of crisis management, such as hostage situations using the *ARLearn Game*, terrorist attacks using *AUGGMED*, and the basic *Disaster Relief Game* (with MR Extension) to introduce players to basic concepts of humanitarian logistics. These games have been developed with recent technologies and can run on devices such as phones and computers with head-mounted displays or can be played with multiple users online. Ref. [149] states that humanitarian logistics exhibit various characteristics and temporal dimensions, including both long-term and short-term actions, whether exceptional or routine. However, not all these specificities are clearly specified within existing games.

Seventh, sustainable supply chain management addresses economic, social, and environmental challenges, as described by *The Crude Palm Oil Management Game* [150]. Games and simulations such as *Shortfall*, the *X-Supply Game*, and *Business on the Move* have enhanced the understanding of sustainable supply chain management [14,151,152]. Ref. [151] introduced *Looper*, a single-player serious game for SSCM to foster awareness and prompt discussions. Recognized as an attractive “teaching tool, *Looper* contributes significantly to raising awareness and comprehension” of sustainable supply chain management [151]. While sustainable supply chain management is getting the most attention from scholars by fashioning recent works on curriculum development and program development in higher education, few games still cover this challenge. For instance, ref. [19] identified only two supply chain games that implement this concept. Sustainable supply chain management refers to several concepts such as “closed-loop supply chains”, “responsible sourcing”, “green logistics”, and “performance measurement”; however, a consistent definition is still needed [153,154]. Usually used for the integration of economic, environmental, and social aspects into supply chain management to increase performance and manage risks from environmental and social practices along the supply chain, the social dimension has received less attention in existing studies [155]. Similarly, sustainable supply chain management has received less attention from professionals who have another understating and definition of this concept compared to scholars. For instance, one of the conclusions of a study by [153] is that the development of sustainable supply chain management frameworks is predominantly led by academics, while practitioners and consultants exhibit limited involvement in the research field. In the same vein, ref. [155] concluded that practitioners show limited awareness of supply chain challenges beyond their firms, emphasizing economic and environmental concerns. They highlight understudied areas in sustainable supply chain management, such as human resources, leadership for sustainability, and ethics, indicating the need for further exploration. For an easier understanding of sustainable supply chain management, ref. [156] concluded that knowledge management practices offer a valuable reference for designing courses for business management students or professionals, especially in the context of supply chain management.

Eighth, the lean supply chain management and Supply Chain 4.0 have been covered by existing games and simulations. Recent methodological developments introduced the Lego Serious Play (LSP) approach as an effective strategy for teaching Supply Chain 4.0 [16]. Although LSP has a history in education, it is a recent addition to supply chain teaching methodologies. LSP employs gamification, allowing students to visualize and articulate their understanding of taught concepts by constructing 3D models [16]. Only two studies have highlighted the significance of LSP in the broader supply chain context [157], specifi-

cally in the Supply Chain Management 4.0 [16]. For lean supply chain management, the *TimeWise* simulation game, developed in 2003, stands out as an exemplary tool [14]. However, enhancements are necessary to address contemporary challenges and uncertainties.

Ninth, the perishable goods supply and closed-loop supply chain are the last supply chain challenges covered by existing games. Ref. [158] emphasize the challenges in managing perishable supply chains, highlighting the need for competent decision-making due to limited shelf life. They introduce *The Blood Supply Chain Game*, a simulation that models the delicate equilibrium between supply and demand in the UK blood supply chain. Players act as distributors, striving to maximize order fulfillment in hospitals. In the context of closed-loop supply chains addressing the Waste of Electronic and Electrical Equipment (WEEE) and simple waste (e.g., [134]'s game), ref. [159] proposes a serious simulation game to teach this complex concept effectively. Closed-loop supply chains, described as the movement of goods from producer to consumer and back for reprocessing, emerge as being crucial for green and sustainable supply chain efforts, mitigating environmental and health issues associated with WEEE.

4. Implications and Further Development

The findings from the analyzed papers emphasize that supply chain management is shaped by contemporary complex challenges, which may hinder the achievement of its goals and disrupt decision-making. Supply chain decision-making challenges arise from disruptive technologies, fluctuations in demand, pandemics, and environmental turbulence [3–5]. Due to their unpredictable and complex nature, these challenges become difficult to convey to young university students. To fulfill the business school's mission of imparting practical supply chain knowledge and connecting theoretical understanding with practical skills [104], a variety of continuously updated teaching strategies must be employed. The use of contemporary and innovative teaching methods and tools, including simulations and games, not only boosts students' short-term engagement but also improves their long-term employability after graduation.

In terms of implications, this study provides a more recent picture of the challenges and some mechanisms to face these challenges in the strategic supply chain management field. The same study describes business simulation games and the different strategic supply chain challenges they cover. Hence, the conclusions of this study are useful for supply chain scholars and managers, as well as for simulation and game developers. For instance, these findings may help supply managers and teachers to choose a suitable game based on the specific aspect of the supply chain in which they want their employees or students to develop practical skills. For simulations and game developers, this study uncovers games' current state of supply chain coverage. Therefore, this study may guide them in developing new games that simulate reality and cover the most recent challenges in supply chain management.

While acknowledging that the conclusions drawn in this study are confined to the studies analyzed in this literature review, further research in this area should be instigated and include additional documents that may yet have to be captured during this literature review. Future research should concentrate on understudied aspects of sustainable supply chain management (e.g., human resources, leadership, and ethics) and develop frameworks for teaching and understanding these areas for students and practitioners. Others should empirically test various sustainable supply chain frameworks and explore the effectiveness of innovative teaching approaches, such as integrating knowledge management practices with supply chain methodologies. Game development efforts should include mobile, computer, or web-based games that can be viable to meet 21st-century technological challenges and other uncertainties rather than physical or paper-based games. Implementing games in newer technologies allows the game to consider and meet several scenarios that are not possible without online or computer-based game versions. Under these conditions, game developers can create more complex exercises, bringing games closer to simulating the complexity of supply chain management as it is in reality [19].

In the realm of future game development, there is a need to integrate the latest technologies, including artificial intelligence, blockchain, and the Internet of Things. Simultaneously, addressing less-explored challenges, such as emphasizing sustainable supplier selection and quality, sustainable supply chain practices, closed-loop and reverse supply chain dynamics, logistic outsourcing, and collaboration in uncertain environments, is crucial for these games. The games should thoroughly consider the strategic supply chain dimensions, including operational, tactical, and strategic levels. Configurability for diverse course levels is essential. Employing approaches such as problem-based learning and Lego Serious Play enhances creativity and dynamic knowledge transfer by bringing the game closer to reality. Designing the game cycle to include multiple rounds will enable the differentiation of operational, tactical, and strategic decisions across various supply chain concepts. Moreover, disasters and emergency situations are inevitable in daily life [160], and teaching practical skills to cope with them is more than critical. Lack of these practical skills for supplier chain managers may cause secondary crises such as economic losses, social disruption, and famine, which can result from poor management or logistical breakdowns. Hence, further research and initiatives in game development should prioritize humanitarian logistics, encompassing diverse aspects such as various characteristics and temporal dimensions. This includes both long-term and short-term actions, whether they are exceptional or routine. Supply chains in the non-profit humanitarian sector, addressing long-term crises or improvements, require distinct management approaches compared to emergency relief actions or post-disaster logistics [161].

5. Conclusions

This study systematically reviewed strategic supply chain challenges and instructional strategies. Using a systematic literature review and a bibliometric co-citation analysis, this study retained 118 essential papers. Their analysis uncovered a predominant emphasis on studies addressing sustainable supplier selection and evaluation challenges within supply chain management. Additionally, they highlighted the effectiveness of business simulation games as a suitable strategy for teaching these challenges. The criteria encompass quality, delivery, technological capabilities, sustainable factors, and cost. Fuzzy AHP and VIKOR emerged as relevant methods for supplier selection. Other literature topics include supply chain networks and sustainable supply chain management.

In educational settings, games and simulations effectively teach supply chain concepts, covering diverse areas such as the bullwhip effect, collaboration, supply chain networks, and sustainable practices. However, to align with the complexities of sustainable Supply Chain 4.0, developers should create more intricate exercises addressing uncertainties, disruptions, and sustainable factors. Integration of blockchain and artificial intelligence models is essential.

Future games should offer extensibility, incorporating recent technologies, less explored challenges (e.g., focus on supplier selection and supplier quality, sustainable supply chain, closed-loop and reverse supply chain, logistic outsourcing, collaboration in uncertainties, humanitarian logistics), and various dimensions of the strategic supply chain (operational, tactical, and strategic levels). Configurability for different course levels is crucial. Adopting approaches such as problem-based learning and Lego Serious Play enhances creativity and dynamism in knowledge transfer. The game cycle should include multiple rounds to differentiate operational, tactical, and strategic decisions across supply chain concepts.

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