Original Research Article

Mapping Two Decades of Supply Chain Efficiency Research: A Bibliometric and Structured Literature Review on Vendor Selection, Risk Mitigation, and Cost Optimization

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Abstract

The study charts the evolution of research on supply chain efficiency, vendor selection, cost optimization, and risk mitigation from 2005 to 2025. It undertakes a combined bibliometric analysis and structured literature review (SLR) on a dataset of 289 Scopus-indexed articles. Using performance indicators, science mapping, and the TCCM framework (theory, context, characteristics, methodology), the study inquiries into publication trends, eminently visited journals, most cited works, and emerging research themes. The study shows a paradigm shift from a cost approach that is narrower to a multidimensional approach that integrates sustainability, resilience, and digital transformation. Among other key enablers which document the approach include blockchain, big data analytics, AI, and Industry 4.0 technologies. China and the United States are leading countries with respect to research outputs and citation impacts, but India is emerging as a developing contributor in procurement and vendor selection, especially since the power and energy sector remains underexplored. Furthermore, the study highlights the predominant use of a cross-sectional quantitative approach and calls for longitudinal and mixed-method approaches. The paper contributes to the literature by charting the intellectual evolution of SCM efficiency research, unearthing sectoral and methodological gaps, and providing actionable recommendations for industrial players and policymakers.

Keywords: Supply Chain Efficiency; Vendor Selection; Cost Optimization; Risk Mitigation; Bibliometric Analysis; TCCM Framework; Sustainability; Digital Transformation; Indian Power Sector.

1. INTRODUCTION

In the course of the past two decades, Supply Chain Management witnessed a paradigm shift mercurially witnessed, with the scholarship being increasingly shifted away from cost-centric operational models to those of sustainability, resilience, and digital integration (Kristal, Huang, & Roth, 2010; Lee, Kim, & Choi, 2012). Out of this transformation is the globalization, technological disruptions, and crises such as the COVID pandemic which laid bare the systemic vulnerabilities within global supply networks (Li *et al.,* 2023). In such times, mechanisms for vendor selection and their role in de-risking and cost optimization assume critical importance within industries subject to regulation and resource dependence, such as the Indian power sector.

Bibliometric studies provide a strong and data-driven means of mapping the intellectual evolution of SCM research. The advent of GSCM has been particularly important in this respect, with empirical studies showing positive relations between environmental practices and organizational performance (Lee *et al.,* 2012; Garza-Reyes *et al.,* 2016). On the

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contrary, studies with cost optimization and environmental effects in the background show how design in infrastructure and logistics is probably going to affect both efficiency and sustainability outcomes (Harris *et al.,* 2011). Lately, Industry 4.0 technologies such as RFID, blockchain, and augmented reality have further been explicated in support of digitalized and data-driven supply chains (Ngai *et al.,* 2008; Rejeb, Simske, Keogh, & Treiblmaier, 2021; Lu, Zhao, & Liu, 2024).

Another branch of research points to the strategic collaboration and ambidexterity in supply chains. Kristal, Huang, and Roth (2010) stress that ambidextrous strategies that balance efficiency and innovation tend to enhance firm performance, while Revilla and Knoppen (2015) stress how important trust and knowledge integration are in buyer-supplier relations. Ni and Li (2012) apply game-theoretic modelling to demonstrate how CSR practices could be a source of competitive advantage under cooperative supply chain structures. So, these mechanisms lay first emphasis on efficient processes and then strategic innovation-oriented processes for building resilient and competitive supply networks.

These macrogeographic areas of contribution have a fertilizing effect on the literature. Harris *et al.,* (2011), in their studies, gave a continental perspective to cost-optimized logistics working from the European automotive industry, whereas Jayawardena *et al.,* (2020) dealt with apparel supply chains in Sri Lanka to examine how supply chain integration affects operational efficiency in emerging markets. Asian and Middle Eastern perspectives continue to reinforce the global concerto of SCM scholarship (Al Hussaini, 2019; Deng, 2023). Regional perspectives put emphasis on contextual differences that must be observed when applying vendor selection mechanisms in different socio-economic and industrial settings.

This said, existing literature shows certain research gaps while addressing vendor-performance issues. At some level, the enquiries are concentrated in specialized industries such as manufacturing and electronics (Lee *et al.,* 2012; Garza-Reyes *et al.,* 2016), while they underexplore energy supply-chain environments or SMEs in developing economies. From a methodological standpoint, cross-sectional surveys or single-case-study designs tend to dominate much of the literature, thus constraining the generalizability of findings (Avrahami, 2013; Nabelsi, 2012). Leakage of blockchain and big data analytics to vendor selection, risk mitigation, and procurement performance on the long-term drawback situation has not yet been evidenced (Purwaningsih *et al.,* 2024; Deng, 2023).

Given the research background, this study undertakes a bibliometric analysis of 289 articles indexed in Scopus for the period of 2005-2025 to map the evolving contours of the study of efficiency in supply chains. Through the performance indicators (such as citation analysis and journal productivity) and science mapping techniques (keyword co-occurrence, citation, and co-citation networks), supported by the TCCM (Theory, Context, Characteristics, Methodology) framework, the study systematically identifies the major themes, emerging technologies, and gaps in research in the field. Situating these insights in the Indian power sector, the intention is also to build on these insights to contribute to theoretical development in SCM and to offer policy-level recommendations for a vendor selection strategy that harmonizes cost parameter optimization with resilience within a highly regulated, resource-intensive sphere.

2. LITERATURE REVIEW
2.1. Evolution of Supply Chain Efficiency Research
The literature on supply chain efficiency (SCE) has grown faster over the last two decades as the increasing complexity and dynamism characterizes global markets. Originally, studies were mostly based on transaction cost economics and operational models, focusing on procurement, inventory management, and cost diminution (Harris *et al.,* 2011). With the emergence of globalization and technological disruptions, the supply chains have metamorphosed to work as strategic levers for resilience, competitiveness, and sustainability. Recent contributions talk about how digital technologies and data-driven modelling can bolster efficiency. For instance, Rezki and Mansouri (2024) developed deep learning hybrid models with better predictive power for supply chain networks, thus proceeding from purely descriptive analytics to intelligent prescriptive analytics. In the same vein, Dharmalingam and Vadlamaani (2024) proposed an intelligent agent system with machine learning algorithms to support supplier evaluation, thus showing how artificial intelligence (AI) redefines the decision-making process in supplier selection.

This transition from older frameworks to technologically empowered approaches stand for a significant intellectual resurgence. While older models were to an extent deterministic, newer approaches acknowledge uncertainty, resilience, sustainability, and a host of other parameters that would depict the real-world scenario of global supply chains (Kristal, Huang, & Roth, 2010; Li *et al.,* 2023).

2.2. Vendor selection and supplier evaluation
Apparently, male selection--or supplier selection, more generally--remains at the core of supply chain efficiency. Scholars argue that decisions on one's suppliers positively or negatively affect cost structures, risk exposure, agility in operations, and anything from time to just executing some order (Ni & Li, 2012; Ramos *et al.,* 2024). The Business Systems Research published by Ramos *et al.,* (2024) explores the impact of demand variability on supplier selection. They show that supplier evaluation needs to go beyond pure price considerations to embrace flexibility, reliability, and responsiveness.

Their work adds to the growing literature that views supplier evaluation as an MCDM exercise rather than a matter of pure transaction.

For supplier evaluation, the traditional MCDM methods AHP and TOPSIS have always been given greater consideration. More recent studies have called for the use of hybrid methods utilizing fuzzy logic, AI, and simulation models (Fallahpour *et al.,* 2021). These methods tackle the uncertainty in global sourcing, where geopolitical risks, demand fluctuations, and sustainability pressures are forces of disruption for a linear decision model. For instance, Avrahami *et al.,* (2013) described RFID-enabled management systems in the printing industry, exemplifying how real-time data can be used to assess vendors and enhance cost efficiency. Together, these studies emphasize the importance of vendor evaluation in joining efficiency with risk mitigation.

2.3. Critical Success Factors and Resilience
By the analysis of the literature, recurring themes are the identification of critical success factors allowing companies to achieve sustainable efficiency. Bambrick *et al.,* (2025) in Production Planning and Control, propose a multidimensional view of the supply chain drivers through their 7Vs-framework: vision, value, velocity, variability, visibility, volume, and virtuosity. Their conclusions echo those of Kristal, Huang, and Roth (2010), who have empirically shown that ambidextrous supply chain strategies, balancing exploration (innovation) with exploitation (efficiency), foster competitive capabilities in quality, cost, flexibility, and delivery.

Resilience is another important feature. Li *et al.,* (2023) examined how firms operated during the disruptions caused by COVID-19 and found that a firm's resilience arises by aligning internal competences, such as product diversity and operational stability, to external network resources like structural holes or centrality. Operation resilience is certainly enhanced by this found alignment, but it forces firms to embrace heterogeneous resource strategies rather than strategies that are homogenous. Such insights underscore that modern supply-chain efficiency is not just about cutting costs but also about creating resilience against shocks.

2.4 Digital Transformation and Simulation Approaches
Another major development in the literature is an integration between digital technologies and simulation models for supply chain design. Krynke (2024) highlights virtual simulation modelling as a major component of Industry 4.0, wherein companies can test decision scenarios and identify bottlenecks in real time. Deng (2023) confirms that big data analytics (BDA) and enterprise application integration (EAI) help improve supply chain performance in Chinese SMEs, especially in terms of visibility and coordination of decisions.

Earlier, Ngai, Suk, and Lo (2008) praised RFID-based systems to enhance operational efficiency in retail food services while Rejeb *et al.,* (2021) stressed the transformative power of AR in logistics and warehousing. These two studies establish a viewpoint that supply chain efficiency studies related to construction have translocated into digitally enabled, data-rich, and supply chain technology integration.

2. 5. Sustainability and Green Supply Chains
Sustainability stands today as an indispensable element in ensuring supply chain efficiency. Lee, Kim, and Choi (2012) found that green supply chain management (GSCM) practices foster operational and relational efficiency, showing the synergy between environmental and economic ends. Harris *et al.,* (2011) also illustrated how cost reduction in infrastructure logistics may reduce CO_2 emissions, demonstrating the role that efficiency plays in the financial and environmental performance arenas.

Furthering this debate, contemporary works aim to infuse sustainability considerations into the digitalized supplier selection frameworks. Fallahpour *et al.,* (2021) developed a hybrid model that applied fuzzy set theory to Industry 4.0 tools to identify how green and digital supplier selection can assist in developing long-term competitiveness. In a similar fashion, Rejeb and Rejeb (2020, 2021) maintain that blockchain offers visibility and tracking for sustainable supply chains thereby rendering sustainability quantifiable and enforceable. Together, these studies argue that ecological and social indicators cannot be dissociated from modern supply chain efficiency.

2.6. Emerging Trends and Research Gaps
The bibliometric map reveals a number of emerging trends. To begin with, there is a growing realization that AI, blockchain, augmented reality, and big data analytics act as agents of efficiency and resilience (Deng, 2023; Purwaningsih *et al.,* 2024). Resilience and risk management are, second, increasingly affirmed as at the core of efficiency-Unlearning from the lessons brought by the pandemic (Li *et al.,* 2023). Third, sustainability is no longer a distant objective but an explicit priority to be considered in supplier selection, logistics, and operational systems (Lee *et al.,* 2012; Fallahpour *et al.,* 2021).

Sizable gaps continue to persist. Research is limitedly focused on sectors such as energy, utilities, and public infrastructure that are vitally important to emergent economies like India, with most studies concentrating on the manufacturing and logistics sectors. Methodologically, an emphasis has remained on cross-sectional surveys and single case studies (Avraham *et al.,* 2013; Jayawardena *et al.,* 2020), with the consequence of limited generalizability and lack of longitudinal insights. While blockchain and AI are increasingly being mentioned, empirical validation does not yet exist on

how they actually influence long-term vendor selection and cost optimization (Purwaningsih *et al.,* 2024).

Moreover, literature presents a clear progression: from the models of cost efficiency-based transaction economics to strategic, technology-based, and sustainability-led supply chains. Vendor selection ceases to be a mere linear procurement activity; rather, it becomes a crucial junction where risk management, sustainability, and digitalization intermingle. In contrast, application domain specification (e.g., power and utilities in India), methodological diversion, and empirical validation of burgeoning technologies remain unaddressed. Once addressed, these will offer opportunities for theorists and practitioners to build supply chains resilient enough, sustainable enough, and well-integrated with technology, so they can address global concerns such as net-zero emissions and digital transformation.

3.METHODOLOGY

3.1 Research Design

This study uses a two-pronged methodological approach by combining Bibliometric Analysis with the SLR. This twin strategy ensures that breadth and depth are offered while exploring intellectual foundations, the evolution of the research, and thematic normalcy of supply chain efficiency, with the primary reason to focus on vendor selection, risk mitigation, and cost factors in the Indian power sector.

3.2 Bibliometric Analysis

As a quantitative approach, bibliometric analysis has been used to map the scientific landscape and systematize the appraisal of scholarly contributions. Bibliometrics enable the study of publication patterns, citation impact, co-authorship linkages, and keyword co-occurrences to unveil the intellectual scaffolds of a discipline, following the methodology of Pritchard (1969).

- **Database Selection:** The selected database was Scopus, which has vast coverage of journals, conference proceedings, and review papers in management, business, and social sciences.
- **Search Strategy:** Using the Boolean search query given below, articles published between the years 2005 and 2025 were retrieved:

TITLE-ABS-KEY ("Supply Chain Efficiency" OR "Supply Chain Management" OR "Supplier Performance" OR "Vendor Performance" OR "Supplier Evaluation" OR "Vendor Evaluation" OR "Vendor Selection" OR "Supplier Selection") AND TITLE-ABS-KEY ("Cost Optimization Approach" OR "Operational Efficiency").

Filters were applied to restrict the results to journal articles and reviews that are published in English.

- **Sample:** A final sample set of 289 articles was selected from the filtered records after screening through the inclusion–exclusion criteria to check the fitment of these articles on the theme of vendor selection, cost optimization, and risk mitigation.
- **Tools and Techniques:** VOSviewer and R-Based Bibliometrix are used to clean and analyse the bibliometric data. The performance indicators considered publication trends, citations, and journal productivity and were complemented by science mapping techniques (co-citation analysis, bibliographic coupling, co-authorship networks, and keyword co-occurrence). This permitted identifying research clusters, thematic hotspots, and evolutionary trajectories in the field.

3.3 Structured Literature Review (SLR)

To complement the objectivity of bibliometrics, SLR provided qualitative depth and critical insight into the selected body of work. This approach maintains the guidelines laid down by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

- **Screening Process:** After collecting bibliometric data, articles were screened systematically for direct relevance to supply chain efficiency, vendor selection mechanisms, and respective performance outcomes. Titles, abstracts, and full texts were evaluated against criteria for conceptual and contextual relevance.
- **Framework for Review:** The TCCM framework (Theory, Context, Characteristics, Methodology) was adopted to structure the synthesis. This framework enabled researchers to classify studies on the basis of their theoretical underpinnings (e.g., RBV, game theory, institutional theory), contextual realms (industries, geographies), primary constructs (sustainability, technology adoption, resilience), and methodological dimensions (surveys, simulations, case studies).
- **Integration with Bibliometrics:** The bibliometric clusters' findings were verified by readings of selected papers to have both a macro perspective and micro insights. For instance, with bibliometric mapping, sustainability and digitalization were determined to be emerging hotspots and further taken apart by the SLR through conceptual analysis of seminal work (Lee, Kim, & Choi, 2012; Kristal, Huang, & Roth, 2010; Fallahpour *et al.,* 2021).

3.4 Justification for Combined Approach

While providing a trajectory for objectivity, reproducibility, and scalability in the analysis of large datasets, bibliometric analysis also needs critical interpretation and contextual richness provided by the SLR. With that integration, one counters the drawbacks that each method has-the bibliometrics uniquely affords citation counts, whereas the SLR has an interpretive component and is quite subjective. Yet, the systematic

mapping in bibliometrics lessens the subjectivity in SLR. Thus, they offer a thorough and triangulated understanding of supply chain efficiency research.

distributions, keyword co-occurrences, and thematic clusters on the basis of a set of 289 articles indexed by Scopus for the period 2005–2025.

4. Results of Bibliometric Analysis

The bibliometric study has attempted to throw a panoramic kind of view on how the scholarship on supply chain efficiency has evolved, with special attention given to vendor selection, risk mitigation, and cost optimization. Performance indicators and science-mapping methodologies were used to analyse publication trends, top journals and authors, and their geographic

4.1 Tracking Publication Trends

In this period, the 18-year trajectory of publication shows steady growth beginning 2005, fairly after 2015, and sharp upward trends during 2023–2025. This is indicative of supply chain resilience and sustainability gaining higher importance in the wake of global disruptions brought upon through the COVID-19 pandemic and geopolitical instabilities.
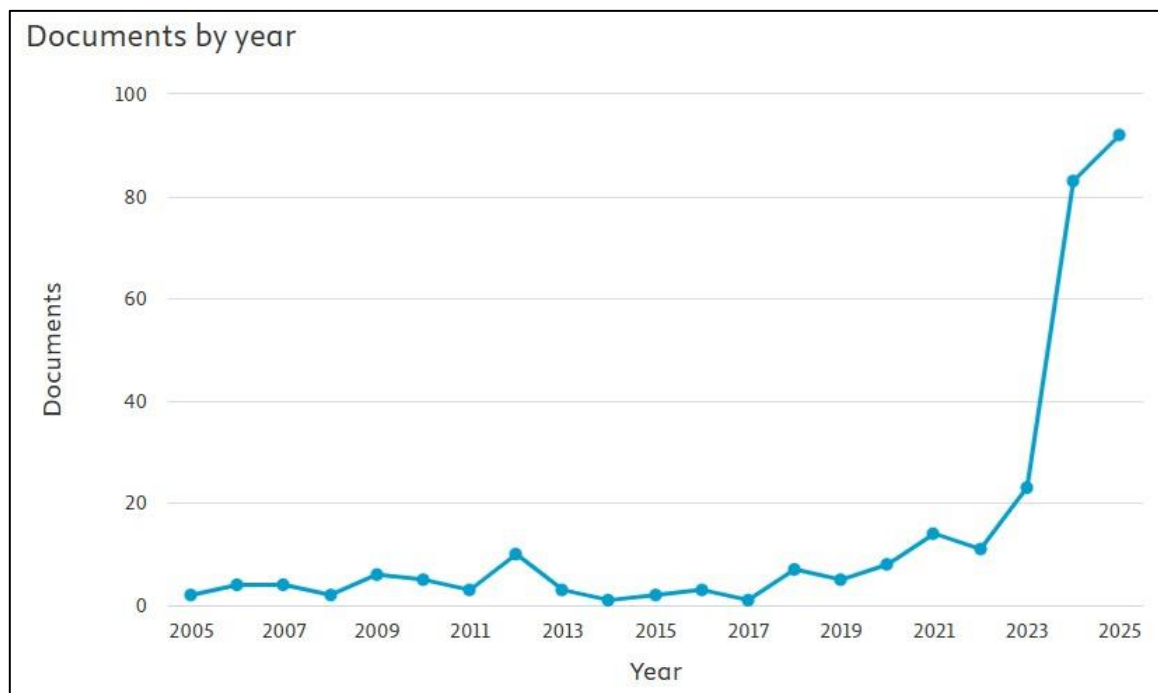

Fig. 1: Key Research Trends in Supply Chain Management (2005-2025)

4.1.1. The Leading Journals

Table 1 showcases the top journals ranked by number of publications (NP) and total citations (TC). Sustainability (Switzerland) becomes the most prolific outlet, with 30 publications; conversely, journals such as

Journal of Operations Management and International Journal of Production Economics register very high citation counts, almost equally contributing toward their productive and influential presence.

Table 1: Most Influential Journals (2005–2025)

SL No	Journal	NP	TC
1	Sustainability (Switzerland)	30	205
2	International Journal of Production Economics	7	492
3	Production Planning and Control	6	225
4	Industrial Management and Data Systems	5	228
5	International Journal of Production Research	5	176
6	Journal of Operations Management	5	525

Note: NP = Number of Publications, TC = Total Citations

4.1.2. Highly Cited Articles

An examination of the most-cited works reveals a panel of classics. Kristal, Huang, and Roth's (2010) work on ambidextrous supply chain strategies leads with 403 citations, while Lee, Kim, and Choi's (2012) green

supply chain management study follows with 315 citations. The studies consider efficiency versus sustainability as the two main building blocks of modern-day SCM research.

Table 2: Most Influential Articles in Total Citations (2005–2025)

Serial No	Authors	Title	Year	TC
1	Kristal, M. M.; Huang, X.; Roth, A. V.	The effect of an ambidextrous supply chain strategy on combinative competitive capabilities and business performance	2010	403
2	Lee, S. M.; Kim, S. T.; Choi, D.	Green supply chain management and organizational performance	2012	315
3	Harris, I.; Naim, M.; Palmer, A.; Potter, A.; Mumford, C.	Assessing the impact of cost optimization based on infrastructure modelling on CO_2 emissions	2011	172

4.1.3. Influential Institutions

Each of the top 10 institutions published a single publishable document, yet their work gained significant citations. Clemson University, Miami University, and York University each garnered a sum of 403 citations, whereas Cardiff and Cranfield universities carry the medium-level impact with around 172 citations.

Table 3 Most Influential Institutions (2005–2025)

SL No	Institution	NP	TC
1	Clemson University (USA)	1	403
2	Miami University (USA)	1	403
3	York University (Canada)	1	403
4	SolBridge International School of Business (South Korea)	1	315
5	University Of Nebraska-Lincoln, Lincoln, Nebraska, United States	1	315

4.1.4 Geographical Contributions

The geographical analysis shows that these countries were the top three contributors to SCM literature: China, the United States, and India. China leads in publications (35), while the U.S. dominates in citations (1,029), which is seen as its global influence. India accounted for 24 articles, thus asserting its presence strongly in emerging market contexts.

Table 4. Most Influential Countries (2005–2025)

Country	NP	TC
China	35	626
United States	29	1,029
India	24	165
United Kingdom	18	613
Canada	14	645

4.1.5 Keyword Co-Occurrence and Research Hotspots

Thematic analysis of keywords could give a glimpse into the skeleton of the domain. Among the keywords, supply chain management yields the highest frequency of occurrence across studies (148), followed by sustainability (31), operational efficiency (25), and industry 4.0 (12). Rapid adoption of digitalization within supply chain territory could be seen with emergent topics such as artificial intelligence (13) and blockchain (8).

Table 5: Top Keywords and Their Occurrences (2005–2025)

SL No	Keyword	Occurrences
1	Supply chain management	148
2	Sustainability	31
3	Operational efficiency	25
4	Operational efficiencies	24
5	Efficiency	23
6	Artificial intelligence	13
7	Industry 4.0	12
8	Blockchain	8

4.2 TCCM Framework for Supply Chain Efficiency Research (2005–2025)

The TCCM framework (Theory, Context, Characteristics, Methodology) finds its broad application in systematized reviews to arrange and synthesize scholarly contributions in structured ways. It allows researchers to examine whether and how theories are applied; under which contexts theories are subjected to tests; the constructs and variables that are studied; and lastly, the methodologies used for such studies. Within

the supply chain management (SCM) context, the TCCM offers a 360-degree view that encapsulates the intellectual progression of SCM from cost-efficiency approaches to sustainability- and technology-driven initiatives. By applying this framework to the bibliometric dataset of 289 Scopus-indexed articles (2005–2025), it is possible to somehow uncover the theoretical origins, empirical contexts, dominant constructs, and methodological approaches dominating supply chain efficiency, vendor selections, risk mitigation, and cost optimization discourses.

Table 6: TCCM Analysis of Supply Chain Efficiency Literature (2005–2025)

Dimension	Focus Areas	Representative Studies	Key Insights
Theory (T)	- Resource-Based View (RBV) for competitive advantage - Institutional & Stakeholder Theories in GSCM - Game Theory & Prospect Theory for CSR, risk, and finance - Technology Adoption Models (TAM, DOI) for RFID, blockchain, AR - Dynamic Capability Theory for Industry 4.0 and Circular Economy integration	Kristal *et al.,*(2010); Lee *et al.,*(2012); Garza-Reyes *et al.,*(2016); Ni & Li (2012); Lee (2019); Ngai *et al.,*(2008); Rejeb *et al.,* (2021); Lu *et al.,* (2024)	Theories have evolved from classical efficiency models to interdisciplinary frameworks that integrate sustainability, resilience, and digitalization.
Context (C)	- Industries: manufacturing, automotive, apparel, logistics, retail, healthcare, public utilities - Geographies: → *China*: resilience, Industry 4.0, big data → *USA*: ambidexterity, strategic SCM → *India*: procurement efficiency, vendor selection → *Europe*: sustainability and logistics efficiency	Deng (2023); Li *et al.,*(2023); Kristal *et al.,*(2010); Harris *et al.,* (2011)	While manufacturing and logistics dominate, underexplored contexts include the Indian power sector and SMEs in developing economies, offering significant scope for contextual enrichment.
Characteristics (C)	- Efficiency constructs: operational efficiency, cost optimization, procurement performance - Sustainability constructs: CO_2 reduction, green purchasing, closed-loop supply chains - Technology constructs: RFID, blockchain, AR, AI, big data, simulation models - Behavioural constructs: ambidexterity, resilience, trust, CSR adoption	Kristal *et al.,*(2010); Lee *et al.,*(2012); Harris *et al.,*(2011); Ni & Li (2012); Garza-Reyes *et al.,*(2016); Rejeb *et al.,* (2021); Bambrick *et al.,* (2025)	Constructs now extend beyond efficiency to incorporate sustainability, resilience, and technology adoption, showing SCM's evolution into a multidimensional field.
Methodology (M)	- Quantitative: surveys with SEM, regression, econometrics, simulations - Qualitative: case studies, interviews, action research - Hybrid: fuzzy models + multi-objective optimization; PCA for CSFs - Review-based: bibliometric analysis, SLR	Lee *et al.,*(2012); Li *et al.,*(2023); Al Hussaini (2019); Harris *et al.,*(2011); Nabelsi (2012); Avrahami *et al.,*(2013); Fallahpour *et al.,*(2021); Bambrick *et al.,*(2025); Zhang (2020); Rejeb *et al.,*(2021)	Research is dominated by cross-sectional quantitative designs and single-case studies. There is a methodological gap in longitudinal, experimental, and mixed-method approaches.

4.2.1 Description of TCCM Analysis
Theory (T)

A paradigm shift has occurred in this research field of SCM efficiency. Before, transaction cost economics, operational models, and efficiency theories stressed procurement and logistics. As time elapsed, theories such as RBV, Institutional Theory, and Stakeholder Theory were increasingly introduced in their attempts to explain how firms achieve sustainability-based efficiency. Game Theory and Prospect Theory enabled a much-needed leap in enhancing the modelling of supplier behaviour and risks arising from CSR adoption. Owing to Industry 4.0, blockchain, and AI being prominent in the transformation of supply chains, the recent shift has occurred in favour of Dynamic Capability Theory and Technology Adoption Models.

Context (C)

The contextual landscape sprawls across various industries and geographies. Manufacturing and logistics have remained centre-stage in the discourse, while niche contexts of studies include apparel (Jayawardena *et al.,* 2020), food logistics (Ngai *et al.,* 2008), and healthcare (Nabelsi, 2012). Geographically, China leads in research production, especially on resilience and digital transformation, while the United States seems to dominate citation impact, having been inclined toward ambidexterity and strategic SCM. India is fast emerging but restricting itself mainly to procurement and vendor selection, leaving power and energy unexplored. Therefore, it should remain a key opportunity for contextual research in future.

Characteristics (C)

Four broad constructs can be identified through the reviewed literature: efficiency, sustainability,

technology, and behavioural/strategic factors. Earlier studies mostly considered cost and operational efficiency, while more recent work considers sustainability (green SCM, closed-loop systems), digital technologies (RFID, blockchain, AI, AR), and resilience (ambidexterity, CSR, trust in buyer-supplier relations). This diversification is a reflection of SCM advancing into a multidimensional area blending performance, resilience, and ethical responsibility.

Methodology (M)

A methodological review shows a quantitative dominance, attempting to make use of surveys, SEM, regression, and simulations. Although more informative, qualitative case studies and interviews remain few. Some authors propose novel hybrid methods-along fuzzy set theory and multi-objective decision-making model-to be increasingly recognized by supplier selection and sustainability. Yet, bibliometric reviews and SLRs grow in importance by offering structured syntheses of fragmented knowledge. While there exists a glaring methodological gap: a lack of longitudinal, mixed-method, and experimental designs capable of studying the dynamic nature of supply chain processes over time.

The theoretical evolution from 2005 to 2025 within supply chain efficiency research can be viewed using the TCCM framework. While these theories have grown and now account for sustainability and digitalization, the contexts remain industry- and geography-specific, with an under-focus on sectors such as energy, utilities, and SMEs in developing economies. Constructs have diversified and moved from cost efficiency into a triad of sustainability, resilience, and digitalization. Methods, simultaneously growing in sophistication, are still predominately cross-sectional quantitative in nature. Hence, future research must integrate multiple theories, apply them to broader contexts, and use dynamic methodological designs to strengthen the academic and practical relevance.

4.3. Thematic Clusters

Cluster analysis further categorizes the literature into seven themes from sustainability and green supply chain practices to technology adoption (RFID, AR, blockchain), resilience, and ambidexterity. These clusters capture historical priorities as well as emerging trajectories such as digital transformation, closed-loop supply chains, and psychological aspects of AI adoption.

Table 7: Thematic Clusters of Supply Chain Research

Cluster	Focus Area	Representative Studies	Key Themes	Methodologies	Implications
1	Sustainability & Environmental Impact	Moon (2008); Rejeb (2020); Cox (2007); Hameri (2005)	Cost optimization, CO_2 emissions, blockchain for sustainability, lean initiatives	Case studies, simulations, action research	Firms must balance cost efficiency with explicit environmental goals; policymakers should support sustainable practices.
2	Technological Adoption & Operational Efficiency	Ngai (2008); Lu (2024); Angeles (2009); Fosso Wamba (2012); Tai (2010)	RFID, web-based e-procurement, process integration, real-time data	Case studies, surveys, longitudinal analysis	Technology adoption enhances efficiency but requires training and compatibility; retail and food sectors gain competitive advantage.
3	Innovations & Emerging Technologies	Revilla (2015); Zhang (2020); Rejeb (2021); Lu (2024)	Knowledge integration, augmented reality, blockchain, Industry 4.0	Systematic reviews, machine learning, surveys	Firms should embrace emerging technologies and build dynamic capabilities; future research should focus on sustainability–Industry 4.0 nexus.
4	Ambidexterity & Resilience	Kristal (2010); Lee (2012); Harris (2011)	Balancing exploration & exploitation, knowledge integration, resilience during disruptions	SEM, case analysis, matching theory	Ambidextrous strategies and trust-building strengthen resilience; firms must align internal and external resources.
5	Green Supply Chain Management (GSCM)	Ni (2012); Famiyeh (2018); Rejeb (2021)	Green purchasing, environmental management systems, SME competitiveness	Surveys, SEM	GSCM enhances operational efficiency; effects vary by industry; SMEs need support from large buyers to develop green capabilities.
6	Performance Assessment in Waste Management	Rodrigues (2018)	Sustainable municipal waste management, governance efficiency	MCDA-C (case study)	Municipalities should adopt structured performance assessment models; adaptable for benchmarking and policy guidance.
7	CSR & Ethical Dimensions in Supply Chains	Garza-Reyes (2016)	Game-theoretic analysis of CSR adoption in supply chains	Game-theoretic modelling	CSR adoption improves when consumer benefits and operational efficiencies align; sequential commitments yield better cooperation.

4.3.1 Description of Clusters
Cluster 1: Sustainability and Environmental Effect

This denotes the cluster of studies that link cost efficiency with environmental consciousness. Researchers have studied various issues, such as the effect of optimization models on CO_2 emissions in a single manufacturer-supplier-limited transportation problem (Moon, 2008), the implication of blockchain in developing sustainable supply chains (Rejeb, 2020), or lean practises in agro-food systems (Cox, 2007). Central-efficiency, therefore, there are also findings of conflicts with sustainability goals, which emphasize the need for important environmental criteria.

Cluster 2: Technological Adoption and Operational Efficiency

Technology-driven efficiency ranks at the centre of this cluster. RFID adoption (Ngai, 2008; Lu, 2024) and web-based e-procurement (Tai, 2010) illustrate how digital solutions enhance inventory management, partner relations, and responsiveness. Both are further supported by case studies from retail and food segments, where barriers such as costs and compatibility issues finally kick in.

Cluster 3: Innovation and Emerging Technologies

This cluster portrays Industry 4.0 tools-blockchain, augmented reality, and knowledge integration-as strategic levers for supply chain competitiveness. Revilla (2015) stresses trust in buyer-supplier relationships, while Zhang (2020) sheds light on evolving patterns within operations management. Together, these studies are witness to the transition into digitalized, innovation-based supply chains.

Cluster 4: Ambidexterity and Resilience

This group of scholars believe that, to be resilient, one needs to find a balance between efficiency and innovation. Kristal (2010) explains how ambidextrous supply chain strategies enhance competitive power, whereas Harris (2011) looks at resilience frameworks developing during pandemics. Trust and strategic alignment between internal and external resources become enablers for resilience.

Cluster 5: Green Supply Chain Management (GSCM)

Considering the operationalization of sustainability, the cluster studies how green purchasing, environmental management systems, and sustainability practices affect firm performance. Insight (Ni, 2012; Famiyeh, 2018) proves that GSCM boosts efficiency and competitiveness, but results showed that differences exist across industries. SMEs particularly need institutional support for building capacity.

Cluster 6: Performance Assessment in Waste Management

Rodriges (2018) introduced a model for sustainable solid waste management-related performance measurement. The study with MCDA-C shows how municipalities track governance and operational efficiency to produce frameworks that are policy- and benchmark-replicable.

Cluster 7: CSR and Ethical Dimensions in Supply Chains

By this cluster, CSR is viewed as a determining factor of ethical supply chains. Garza-Reyes (2016) adopts a game-theoretic model to demonstrate that CSR depends on consumer benefits and operational efficiencies. Sequential commitments to CSR were found to further the spirit of cooperation among partners, implying that ethical issues can be a cause of profitability and sustainability.

Thus, the cast of seven clusters we have presented emphasize the multi-dimensional nature of SCM scholarship: from cost- and efficiency-centric models (Clusters 1 & 2), through techno-centric and innovation paradigms (Clusters 3 & 4), to sustainability-centered and ethical frameworks (Clusters 5 – 7). Together, they depict a field that has grown to include digitalization, resilience, and responsibility as the fundamental pillars of contemporary supply chain research.

5. FINDINGS

A bibliometric analysis and structured literature review of 289 Scopus-indexed articles spanning two decades bring forth several vital findings regarding the evolution, thematic orientation, and methodological development of research germane to supply chain efficiency, vendor selection, cost optimization, and risk mitigation.

5.1. Growth of Literature Over Time

The yearly publication trend alleges a steady rise in publications from 2005 onwards. It follows three distinct phases:

- 2005–2010: Building works centred on operational efficiency and traditional logistics.
- 2011–2020: Expansion into sustainability and more technology-driven frameworks including RFID, e-procurement, and green supply chain management.
- 2021–2025: Emphasis on resilience, Industry 4.0, blockchain, and big data analytics, with a psychological bent to technology adoption.

This trajectory suggests a clear intellectual shift: from cost-centric efficiency models to multidimensional paradigms combining sustainability, resilience, and digital transformation.

5. 2. Influential Journals and Knowledge Outlets

Sustainability (Switzerland) remains the most productive outlet, with 30 papers published there; the Journal of Operations Management and the International Journal of Production Economics, however, have had

more citation impact, with 525 and 492 citations, respectively. This implies that while journals oriented toward sustainability in operations dominate in terms of publication numbers, journals in strategic operations are more intellectually sober.

5.3. Seminal Contributions
Highly cited articles identify thematic anchors of the field.
- Kristal, Huang, and Roth (2010) affirm ambidextrous supply chain strategies balancing efficiency and innovation (403 citations).
- Lee, Kim, and Choi (2012) bring an interesting perspective into the green supply chain management, associating environmental practices with organizational performance (315 citations).
- According to Harris *et al.,* (2011), optimization models for infrastructure costs have influence on both efficiency and CO_2 emissions (172 citations).

Thus, these works together signal that the field slowly pivots toward anchoring efficiency with resilience and sustainability.

5.4. Location and Institutional Contributions
China, United States, and India are thus ranked among the top three contributors.
- China manages in terms of volume of research (35 publications), with such studies involving resilience and Industry 4.0.
- However, the United States overtakes in citation influence (1,029 citations), especially in strategic SCM and ambidexterity.
- India has 24 publications mainly focused on vendor selection and procurement efficiency. However, a notable gap exists in the literature in relation to the Indian power sector, although it is an important aspect from the perspective of economic growth and regulatory oversight.

Institutional analysis shows leading contributions from Clemson University, Miami University, and York University (all three with 403 citations), though the number of publications per institution is low, pointing to concentrated yet impactful research nodes.

5.5. Trending Themes Extracted from Keyword Analysis
Keyword co-occurrence mapping points at dominant and emerging research areas:
- **Core Keywords-Planned Business Operations:** "Supply chain management" (148 occurrences), "sustainability" (31), and "operational efficiency" (25).
- **Emerging Keywords-Among Topics Gaining Traction:** "Artificial intelligence" (13), "Industry 4.0" (12), and "blockchain" (8).

This is testimony to the view of digital technologies being enablers for sustainable and resilient supply chains that has become more prevalent in recent years, moving away from the prior cost-optimization discourse.

5.6. Research Thematic Clusters
Seven major clusters were identified and this cluster contents capture the consideration given to sustainable-a-techno-ethical intersection in the supply chain. On one side, sustainability-related issues focus on CO_2 emissions, blockchain-enabled transparency, lean strategies, and green practices for SMEs and developing economies, ensuring environmentally responsible operations. Parallelly, technology adoption includes RFID, e-procurement, and automation for efficiency gains while innovation through AR, blockchain, and knowledge integration refashions value creation. A trade-off exists between efficiency and innovation, inasmuch as resilience frameworks fortify supply chains against disruptions. Governance mechanisms and sustainability indices then come to bear in drawing the framework for performance assessment, especially concerning waste management. Eventually, ethical concerns come into view with CSR adoption, where game-theoretic modelling peeks into the behaviour of corporations under pressures from stakeholders and society. In synthesis, this cluster shows that the sustainability, technology, resilience, and ethical realms meet in modern supply chains.

These clusters validate the evolution of SCM as a multidisciplinary field to include sustainability, technology adoption, resilience, and ethical considerations.

5.7. TCCM Framework Insights
Insights from applying the TCCM framework articulate:
- **Theory:** Shift from operations and cost models to RBV, Institutional Theory, Game Theory, and Dynamic Capabilities as an outcome of interdisciplinary focus.
- **Context:** Emphasis on manufacturing and logistics, whereas energy, utilities, and SME in developing economies are under-researched.
- **Characteristics:** Expansion of constructs beyond efficiency toward sustainability, digitalization, and resilience.
- **Methodology:** Observed trends lean largely toward quantitative methods (SEM, regression, simulation), while longitudinal, mixed-method, and experimental methods are rare; thus, this renders a stunted view of dynamics.

5.8. Research Gaps and Opportunities
The combination of bibliometric and SLR approaches accentuates the following gaps:
- **Sectoral Gaps:** Restricted supply chain efficiency research in energy and power sectors, especially in India.

- **Methodological Gaps:** Compared to cross-sectional surveys and case studies, there is much less longitudinal and mixed-method research.
- **Theoretical Gaps:** There needs to be a rapprochement of perspectives of behavioural operations, resilience theory, and frameworks of digital transformation.
- **Geographic Gaps:** Underrepresentation of Africa, Latin America, and smaller Asian economies in the global SCM discourse.

The findings point out that research on supply chain efficiency has grown into a multidisciplinary field. While the earliest works dealt with efficiency, the current domain includes topics such as sustainability, digitalization, and resilience after being forged through global disruptions and technological advancements. Still, significant gaps remain in unexplored industries and in the methodological environment, which can thus emerge as promising opportunities for researchers along the line.

6. CONCLUSION

With such a huge topic and research scope, the bulk of articles deal with vendor efficiency, supply chain risk avoidance, and cost optimization-related concerns. This study is considered to have adopted a combined bibliometric analysis and meticulous literature review, analyzing the 20-year period of research and development in this realm covering the general period of 2005-2025. Analysing 289 articles indexed in Scopus using the TCCM framework (Theory, Context, Characteristics, Methodology) has given an enormous volume behind the intellectual, thematic, and methodological trends standing behind this domain.

The findings unequivocally illustrate a smooth transition in the academic focus-from the traditional cost-centred, logistics-based supply chain models toward integrated approaches emphasizing sustainability, resilience, and digital transformation. Seminal contributions on ambidexterity, green supply chain management, and cost optimization form the foundation, while current research increasingly addresses new technologies like blockchain, big data analytics, artificial intelligence, and Industry 4.0 applications. From the thematic clusters emerge the growing importance of sustainability, technology adoption, ambidexterity, and ethical considerations (CSR) in shaping modern supply chain strategies.

In terms of research output, China, India, and the U.S. sit on top of the pile, with the U.S. exerting the greatest citation influence while India supplies a growing but yet less developed body of work on vendor selection and procurement efficiency. High citation impact has so far colonized a select few universities, though limited global collaborations have fueled it. Keyword analysis likewise supports these trends and draws attention to sustainability, operational efficiency, and digital transformation as the dominant and emerging hot areas in the discipline.

The article highlights three takeaways from the analysis: First, the theoretical bases have become more diverse, with RBV, dynamic capability theory, and behavioural models enriching the traditional efficiency concerns-theory bases. Second, the contexts remain unfairly placed and concentrate everything in manufacturing and logistics sectors, leaving crucial sectors such as energy and utilities, especially the Indian power sector, underexplored. Third, the WW constructs have grown to include sustainability, resilience, and digitalization, thus giving expression to the multidimensional aspect of efficiency in a turbulent environment. Fourth, methods are still largely quantitative and cross-sectional; hence, this points toward a sore need for the longitudinal, experimental, and mixed-method application to draw more deeply and reveal the true dynamism of supply chain phenomena.

In summary, the paper makes three major contributions: (i) it charts the intellectual evolution of supply chain efficiency research; (ii) it highlights the interplay of efficiency, sustainability, and digital transformation as the emerging paradigm of the field; and (iii) it identifies major research gaps, namely sectoral (energy and utilities), methodological (longitudinal and mixed designs), and theoretical (integration of resilience and behavioural operations). Addressing these gaps will benefit both scholarly knowledge and practical application.

With procurement inefficiency, volatility in supply, and tariff limitation continuing to plague Indian electricity markets, the insight discussed here holds special relevance. Keeping regulatory supervision and global disruption in context, supplier diversification strategies, digital procurement tools, and sustainability frameworks are a promising route to balancing cost and risk measures.

There has been life into the research on supply chain efficiency, which today is positioned at the nexus of technology, sustainability, and resilience. Henceforth, it is imperative for upcoming research to take a broader contextual growth approach to the study of supply chains. Such an approach should expand methodologies and be theoretical in nature, so supply chain innovation can benefit from its transformative strength across industries, both emerging and traditional, like the Indian power sector.

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