



Sustainable supply chain management and green technologies: a bibliometric review of literature

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Abstract

To attain ecological sustainability and transition to sustainable supply chain management (SSCM), effective technological innovation (TI) and solid waste management (SWM), as likely impending resources, are essential components. From 2000 through 2021, a detailed map of SSCMs in the context of TI and systematic history will be created, highlighting the most significant research themes and trends, primary features, development, and possibly relevant areas for future study. Due to utilizing bibliometric analysis, text mining, and content analytics methodologies, the following concerns were addressed: (1) How has SSCM research progressed over time in the TI domain? (2) Which SSCM research areas and trends receive the most attention in the TI domain? Additionally, (3) what are the research directions for SSCM in the context of TI? As a result, bibliometric networks were developed and examined using 983 journal articles from the Scopus database to highlight the substantial body of literature. As a result, SSCM has been divided into five crucial study themes: (i) transition to TI, (ii) SSCM in closed-loop supply chains, (iii) municipal solid waste management (MSWM), (iv) environmental consequences and life-cycle evaluation, and (v) policymakers and practitioners in SSCM can use the SSCM research landscape and its primary highlight patterns to guide and add in the TI. Considering SSCM research as a way to reduce waste, future study directions are also suggested.

Keywords Sustainable supply chain · Technological innovation · Bibliometric review · Waste management

Introduction

Manufacturing firms are gradually receiving pressure from general public and its stakeholders to be considered responsible for the environmental outcomes that result from

their internal and supplier operations (Koberg and Longoni 2019). For the last two decades, technologies and activities of sustainable supply chain management (SSCM) have been concerned with integrating environmental, economic, and social goals throughout the manufacturing process of firm's

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supply chain operations and strategies to promote sustainability (Khan et al. 2021a, 2021b). With unique concentrations on sustainable supply chain operations, the technological innovations has significantly reduced its burden on the world ecological system, encouraging zero waste and a sustainable environment (Ranjbari et al. 2021). The proper management of sustainable supply chain operations plays an undeniable role in environmental sustainability and positively impacts societies (Manavalan and Jayakrishna 2019). They were adequately designing and managing the sustainable flow of products and services from raw material to finished goods is considered significant in the circular economy (Waqas et al. 2021; Khan et al. 2020; Ali et al. 2022). In recent years, literature review confirmed that plenty of research articles had been published by researchers on SSCM corresponding to the green technological innovations (Wangsa et al. 2022). Some researchers included it but not restricted to establishing the green technological innovations indicators for SSCM (Hussain and Malik 2020), examined and explored sustainable supply chain barriers and drivers and practices (Govindan and Hasanagic 2018), classified and filed the barriers hierarchy index to SSCM in the Chinese and Pakistani manufacturing industry (Jin et al. 2022; Waqas et al. 2018) and enabler of sustainable supply chain operations in Pakistani manufacturing industry (Hussain et al. 2021). The bibliometric analysis has provided directions to scholars, who are managing plenty of research publications in the field of SSCM considering technological innovation. The research teams have found lesser investigated and introduced the new trends and developments in SSCM, such as from raw material sourcing to production (Gedik and Avinc 2020), raw material storage (Baars et al. 2021), sustainable product delivery system (Soleimani et al. 2018; Khan et al. 2022c), worked on sustainable supply chain networks (Abdi et al. 2020) and green reverse logistics. Unfortunately, some are activities still blurred regarding green technological and IT innovation in the literature in the field of SSCM, such as ambiguity in perceiving sustainable ideology, shortage of experts, and trust deficit of manufacturing firms in the adoption of SSCM (Wangsa et al. 2022; Seman et al. 2012; Khan et al. 2021a, 2021b) that is challenging supply chain, procurement managers, and practitioners. Apparently, the roadmap of SSCM research trends linked with technological innovation perspective still has vacuums in the literature review.

The fundamental objective of this research is to introduce a clear picture of recent trends, developments, research gaps, and future research direction in the field of SSCM aligned with the technological innovations over the last two decades since 2001–2021. The selected analysis can provide guidance and a base for future research directions in this field. To accomplish the desired objective of current research, a mixed-method methodology has been employed, including

content analysis, bibliometric analysis, and text mining to answer the below queries.

Q1: What has been the evolution of SSCM research in the TI domain?

Q2: What are the most pressing concerns and developments in SSCM research in TI?

Q3: Based on the findings from the completed bibliometric, text mining, and qualitative content analyses. What future directions might SSCM research pursue in light of the move to technological innovation?

According to the author's best knowledge, current study is the first inclusive research in the literature that introduced bibliometric analysis, content analysis, and text mining in SSCM. Thus, current research is enormously predicted to contribute toward the systematic background of SSCM in a technological innovation context and identify and verify its recent trends in the last two decades. Secondly, accumulate the wide-range literature of SSCM and prominent research patterns that support supply chain managers of the different industries across the globe toward a green technological innovations. Thirdly, suggesting the future research directions in the field of SSCM that still need further investigations to reshape the technological innovation practices.

Sustainable supply chain management technological innovations: guidelines towards challenges and opportunities

Sustainable supply chain practices refer to those actions and activities that deal with the environmental, financial, and social aspects of manufacturing firms (Waqas et al. 2020). The optimization of SSCM activities decreased the demand for reverse logistics, predominately minimizing waste generation, promoting sustainable transportation, and recycling and reusing the waste material that is the foundation for the circular economy (Lee et al. 2014; Ranjbari et al. 2021). Pinegar and Smith (2019) reported that an appropriate waste management system promoted the actions of recalling, recycling, discarding the end-of-life (EOL) products to minimize their burden on the world ecological system. Unfortunately, the field of SSCM is still in its infancy phases due to little adoption by manufacturing industries in emerging economies (Gandhi and Vasudevan 2019; Khan et al. 2021a, 2021b). Jum'a et al. (2022) suggested the adoption of green supply chain practices directed to supply chain experts and managers to decrease the consumption of natural resources. Thus, plenty of scholars and academics have emphasized on eco-friendly production and highlighted the greening concept in supply chain operations (Croom et al. 2018; Green et al. 2019; Kumar et al. 2022). Therefore, considering the severity of environmental

conditions, many researchers have found in literature who manifested the importance of SSCM technological innovation which is the main pillar of a circular economy (Ciliberto et al. 2021; Haleem et al. 2021; Shayganmehr et al. 2021). Rehman Khan et al. (2021) found that reducing pollution and waste by promoting innovations green transportation is the key indicator for sustainable development.

Touboullic and Walker (2015) examined the relationships of different theories with the conceptualization of practices of SSCM. However, their recommendations positively work for the upgradation of the SSCM field. Khan et al. (2021a, 2021b) published state-of-the-art review-based research article in which they filed the recently emerged themes and trends in this field. Similarly, Rajeev et al. (2017) established the review on the design of SSCM networks and incorporated the different techniques that positively works for the upgradation of the green supply chain management field. Their study results focused on the significance of strategic decisions and their impact on sustainable firm performance. Büyüközkan and Göçer (2018) discussed the advantages of greening in digital technology supply chain operations and practices. Their results confirmed that sustainability and supply chain management are treated as separate entities, but a lower percentage of literature researchers interpret them in an integrated approach. Thus, the focus of SSCM studies has shifted from traditional measurement to economic and environmental performance (Seman et al. 2019). Beske-Janssen et al. (2015) demonstrated the performance measurement system in SSCM operations in the manufacturing industry context.

Research methodology

Current research employed is the mixed methodology of qualitative and quantitative but mainly focused on the quantitative method that have been applied to examining the literature related to SSCM technological innovations.

Data sampling, data gathering, data investigating, and data cleaning

To confirm the collection of sufficient research publications related to this study field, Web of Science is the main source of collection; as one of comprehensive and top sources, scientific literature was chosen to collect relevant data for this study. Following keywords (green* supply chain* or sustainable* supply chain*, green* supply chain practices* or sustainable* supply chain practices* and sustainable* supply chain management* or green* supply chain management*) were used to examine in the title of a research article, abstract, and in keywords. The initial screening phase of relevant research articles of this study was started in February 2022 and was published in different well-known

peer-reviewed English language journals from 2001 to 2021. As the results of this extensive search, 983 papers meet the criteria of selection of papers for further analysis. However, after screening, filtering, and selecting published papers, the final cleaning dataset technique was employed before applying the bibliometric and text mining data analysis technique as per recommendations of Ranjbari et al. (2021).

Data analysis

Investigating the structure and evolution of current study field, the combination of three analytical research techniques, including bibliometric, content analysis, and text mining, has been applied.

Bibliometric analysis

Bibliometric analysis of the literature review is the most famous and strong quantitative statistics technique used by different research teams who are dealing with high quantity of research publications and literature mapping in different field such as SSCM (Khan et al. 2021a, 2021b), waste management (Ranjbari et al. 2021) and reverse logistics (He et al. 2020), sustainable development (Du et al. 2021), and technological innovations (Lee et al. 2014). However, bibliometric analysis is very efficient in suggesting and guiding the future research direction of any field by providing a comprehensive evaluation of identified relationships among different factors of the area in publications, journals, citations, and co-citations (Ranjbari et al. 2021). Thus, meeting the requirement of this research, 1.6.16 version of VOSviewer was applied as per recommendations of Waltman et al. (2010) to conduct bibliometric analysis. Following are the bibliometric parameters, trends and theme evolutions in the specific field over time, authors and citation analysis for leading publications, collaboration and co-authorship analysis for institutions and countries, coupling bibliometric networks analysis for a dataset. Lastly, co-word analysis was used for classifying and verifying the different hotspots that were shown in this research to statistically measure the bibliometric evidence of selected publications in the field of SSCM regarding green technological innovation context from 2001 to 2021.

Content analysis

In the same direction Haq (2021) and Schöggel et al. (2020) who conducted their research to analyze the qualitative content of their investigations, which is balancing qualitative technique, were also employed in this study to provide more detailed results related to quantitative results of this research. Considering the situation, the authors applied the data clustering method to selected publications that were clustered according to bibliometric coupling analysis. After that,

qualitative content analysis was employed for each cluster of top 15 publications to examine and verify theoretical orientations in SSCM creating green technological innovations.

Text mining analysis

The text mining method is a useful statistical tool used to screen the required information from a wide range of available publications text by evaluating the themes and trends of a specific field (Amado et al. 2018). However, text mining is specially used to capture the semantic summity phrase patterns appropriate to demonstrating text data’s massive quantity. Similarly, version 1.6.16 of VOSviewer has been utilized to calculate the co-occurrence algorithm on abstract and titles of selected research publications. Thus, the results of applying the texting mining technique to blurred trends and themes of technological innovations in SSCM literature were identified (Fig. 1).

Discussion of findings

To guarantee that our study’s research issues are addressed clearly, the findings are divided into sections 1.1, 1.2, and 1.3 that correlate to the study’s primary research subjects.

Extant studies’ bibliometric mapping

This part discusses the bibliometric analysis indicators in detail in order to directly address the research question posed in the first section.

RQ1. What has been the evolution of SSCM research in the technological innovation (TI) domain?

Evolution of publications: a descriptive study

From 2000 to 2021, Fig. 2 depicts the trend in SSCM-related research publications published in the TI. The majority (713 out of 983) of papers were published afterward in 2017, accounting for more than 73% of the dataset in total. 2018 to 2021 appear to be the most productive years in terms of articles published and academic engagement in SSCM leading up to a TI. The significant increase (de Sousa et al. 2018) in scholarly works over the last 4 years suggests that a variety of sources, including SSCM, have increased their focus on technological innovation establishment. A total of 983 papers on SSCM biotechnology innovation were published between 2000 and 2021.

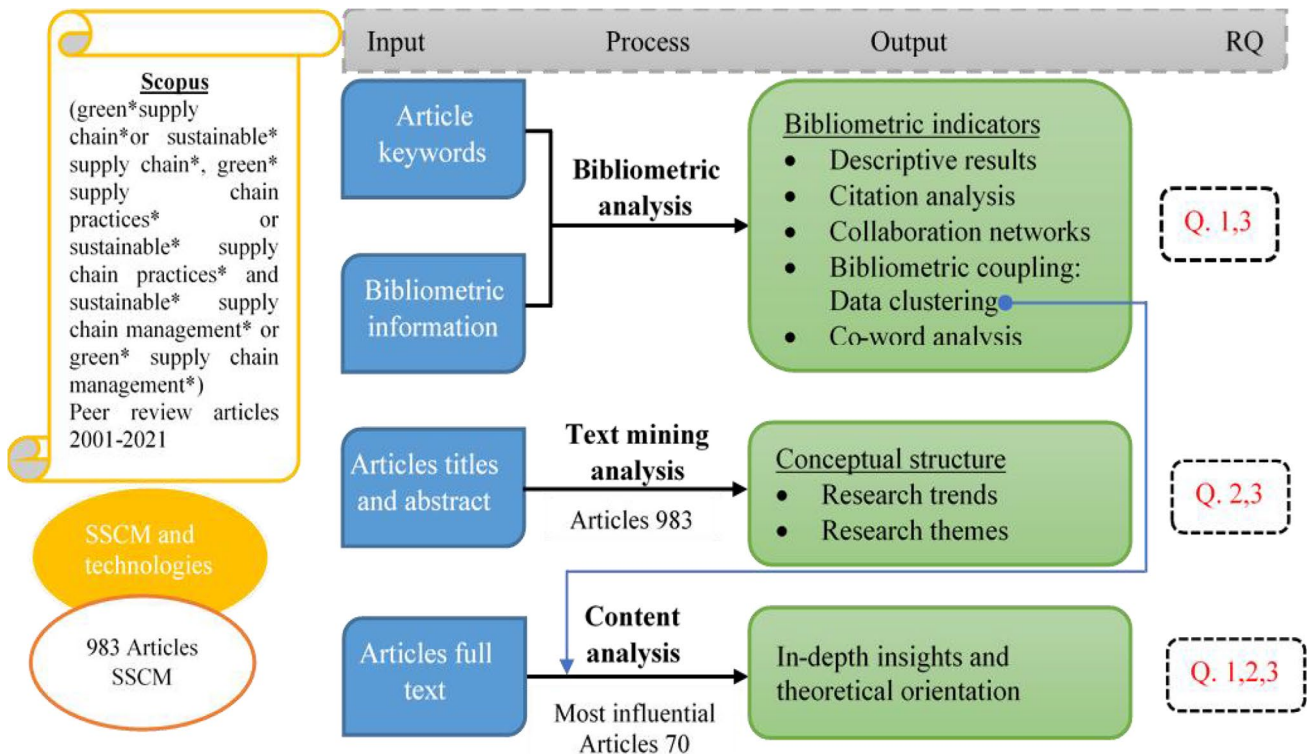
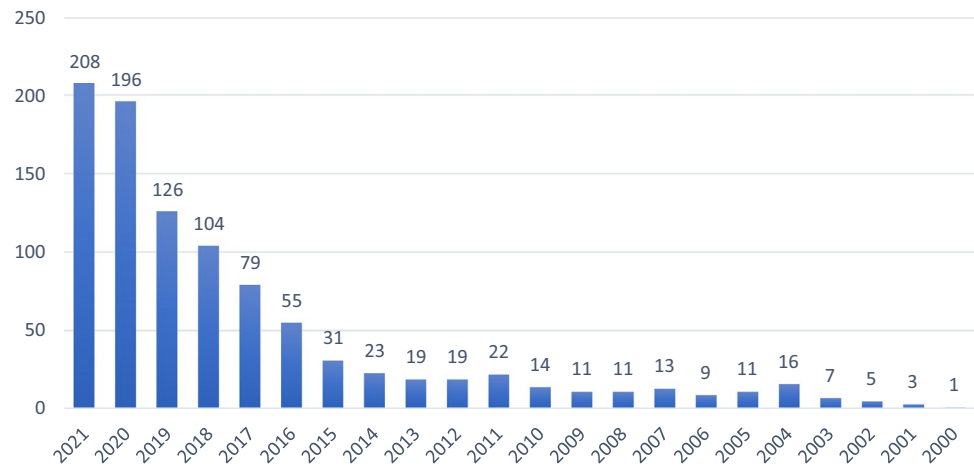


Fig. 1 Step by step study framework

Fig. 2 Publications evolution over time from 2000 to 2021.**Table 1** The top 15 most cited articles in SSCM research pertaining to the TI.

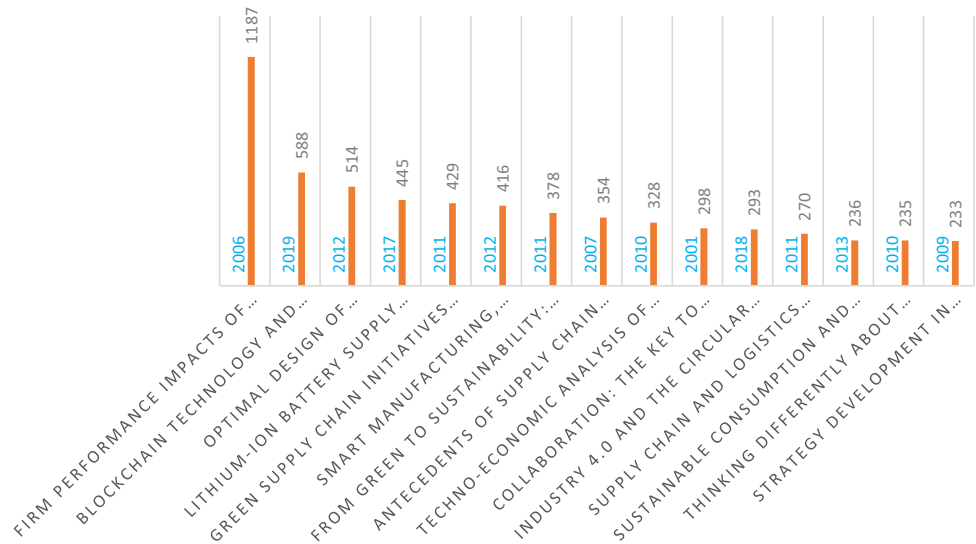
S. no.	Article titles	Year	Source title	Cited by
1	Firm performance impacts of digitally enabled supply chain integration capabilities	2006	MIS Quarterly: Management Information Systems	1187
2	Blockchain technology and its relationships to sustainable supply chain management	2019	International Journal of Production Research	588
3	Optimal design of sustainable cellulosic biofuel supply chains: Multiobjective optimization coupled with life cycle assessment and input-output analysis	2012	AIChE Journal	514
4	Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals	2017	Joule	445
5	Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes	2011	Resources, Conservation and Recycling	429
6	Smart manufacturing, manufacturing intelligence and demand-dynamic performance	2012	Computers and Chemical Engineering	416
7	From green to sustainability: Information Technology and an integrated sustainability framework	2011	Journal of Strategic Information Systems	378
8	Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective	2007	Journal of Operations Management	354
9	Techno-economic analysis of lignocellulosic ethanol: A review	2010	Bioresource Technology	328
10	Collaboration: The key to value creation in supply chain management	2001	Supply Chain Management: An International Journal	298
11	Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations	2018	Annals of Operations Research	293
12	Supply chain and logistics issues of bio-energy production	2011	Journal of Cleaner Production	270
13	Sustainable consumption and production for Asia: Sustainability through green design and practice	2013	Journal of Cleaner Production	236
14	Thinking differently about purchasing portfolios: An assessment of sustainable sourcing	2010	Journal of Supply Chain Management	235
15	Strategy development in small and medium-sized enterprises for sustainability and increased value creation	2009	Journal of Cleaner Production	233

Analysis of citations: key articles, journals, and authors

The number of citations an article receives can indicate its importance. The table 1 below outlines our database's fifteen most cited articles. Management Information

Systems Quarterly is a highly cited research article, proving the journal's strong influence on the technological innovation movement. According to the Scopus database, the most often cited work is Rai and Patnayakuni (2006), firm performance impact of digitally enabled supply chain

Fig. 3 The most often cited publication in the SSCM research on the TI.



integration capabilities, which has had 1187 citations as of November 2021. Optimal supply chains for sustainable cellulosic biofuels: (Saber et al. 2019; Snyder et al. 2011), assessed the Optimal design of sustainable cellulosic biofuel supply chains: Multi-objective optimization combined with life cycle assessment input-output analysis. The most cited articles are reviews on technological innovation’s perspectives and applications (Dao and Langella 2011; Davis et al. 2015; Eltayeb and Zailani 2010; Olivetti et al. 2017; Sapsanganboon et al. 2007) in this study area. This may be due to one of two reasons. Experts have emphasized the need for technical innovation to transition in recent years due to the possible benefits for economic and environmental regimes. Second, politicians struggle

with putting technological innovation into practice, while operational practitioners lack clear standards.

Figure 3 summarizes the productivity (number of publications) and influence of notable authors in technological innovation who contribute to SSCM research. Sarkis, Mangla, and Cerchione had the most significant citations with 2162, 190, and 161. On the other hand, Sarkis, Mangla, and Cerchione were the research’s most prolific authors, producing 13 articles, 11 articles, and 8 articles, respectively, over the study period. Sarkis is included on both lists of the top ten most influential and effective writers, showing that he is a significant contribution to sustainable supply chain management and technical innovation (Fig. 4).

Fig. 4 The most productive and prominent authors in SSCM research directed against the TI.

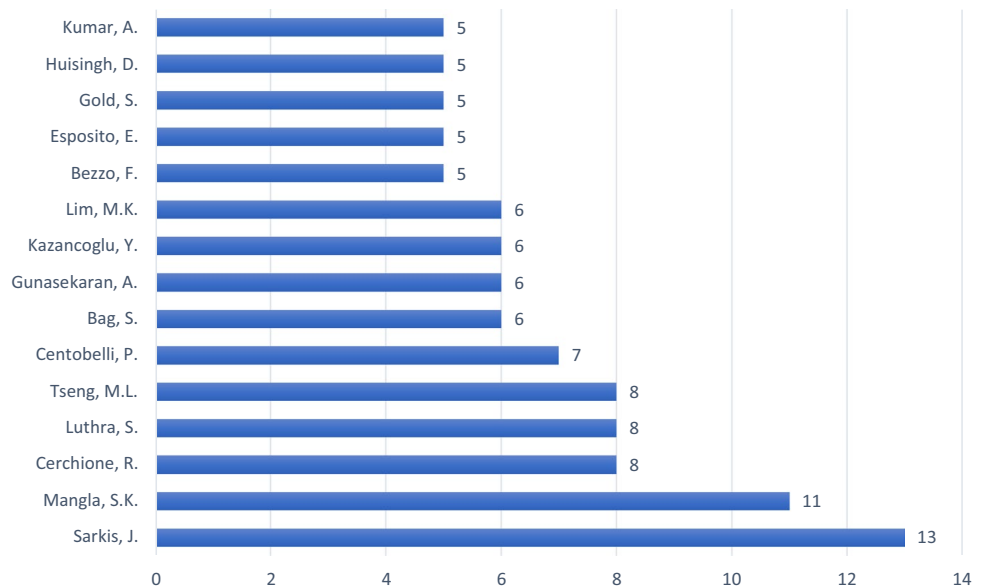
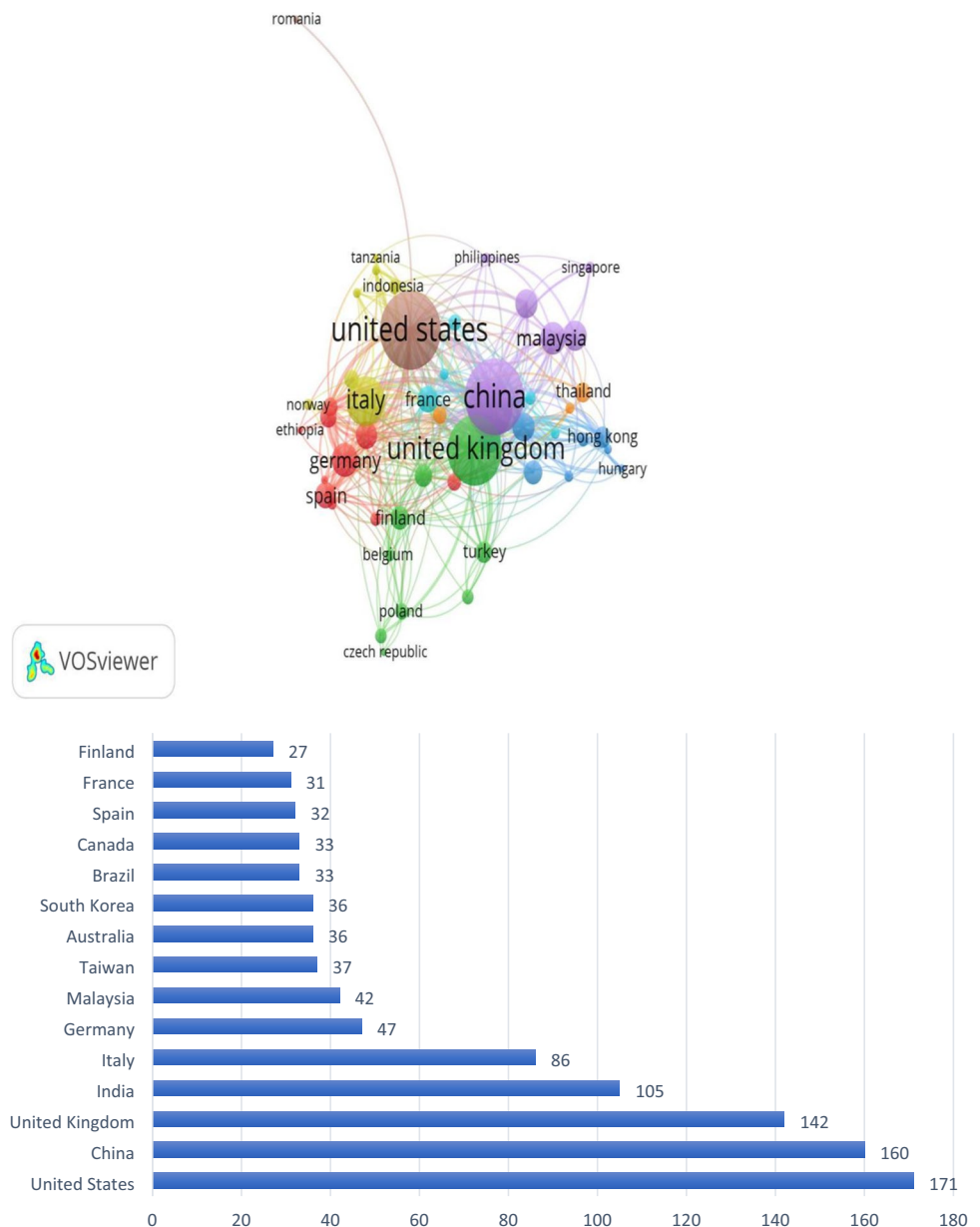


Fig. 5 Countries and institutions working together on SSCM research for the TI.



Analysis of institutions and countries

Figure 5 depicts the countries and institutions that contributed most to the issue out of our sample's 88 nations and 1248 organizations. Each bar in the chart reflects the number of papers possessed by a certain country. Additionally, the more tightly coupled processes are, the higher the potential for collaboration. The USA, China, the UK, India, and Italy lead technological innovation in SSCM research, with 171, 160, 142, 105, and 86 publications.

Because of the proliferation of universities included in this research ($n = 1248$), only those with at least nine publications were included in Fig. 6 to visualize the most significant institutions. At the same time, if we consider

countries' contributions to publications, Romania and Tanzania are not among the top 15 contributors. Università Degli Studi di Padova, Wageningen University & Research, Dalian University of Technology, Università Degli Studi di Napoli Federico II, University of Plymouth, Indian Institute of Technology Delhi, Plymouth Business School all with below 10 publications, while Politecnico di Milano, Tsinghua University, the University of Cambridge equally with 10 publications. The University of Hong Kong and Hong Kong Polytechnic University have 11 and Worcester Polytechnic Institute and the Parthenope University of Naples with 12 publications. In contrast, Imperial College London is the most active institute with 13 publications.

connections between them, the more frequently they occur in conjunction.

Our dataset's ten most frequently used keywords are sustainability, digital transformation, sustainable supply chain management, innovation, sustainable supply chain, technological innovation, supply chain performance, artificial intelligence, logistics, multi-objective optimization, sustainable performance, and game theory. Furthermore, these ten keywords have the greatest number of cross-references to other phrases in the dataset. As illustrated in Fig. 7, the average year of publication for concepts such as sustainable supply chain management, digitization, recycling, and artificial intelligence is longer. On the other hand (Herczeg and Akkerman 2017), experts have emphasized the significance of concepts such as sustainable supply chain management, technological innovation, and sustainable supply chain in recent years. Researchers will find the most potential research frontiers and topics of inquiry in this discipline by identifying the most recent active keywords in the SSCM study domain related to technological innovation (Dong et al. 2021).

Results of text mining: identifying major study themes and trends

The answers to the second question are directly addressed in this section:

RQ2: What are the most pressing concerns and developments in SSCM research in TI?

The findings of text mining indicate that there is currently existing SSCM research in the technological innovation sector organized around eight core study themes. This field (Meherishi and Narayana 2019) encompasses sustainable supply chain management, technological innovation transition, e-sustainable SCM, municipal-solid-waste (MSW), ecological influences and lifecycle evaluation, plastic SSCM, and construction and demolition SCM.

As a result of technological advancement (Mensah et al. 2019; Saurabh 2021), TI has emerged as a critical area of SSCM research. Food-borne SSCM is a significant impediment to technological advancement in this field. This study theme is largely concerned with the valorization of food supply networks and their transformation into value-added resources and bioproducts, as well as their contribution to the innovation (Ahmadi et al. 2020; Mensah et al. 2019), by optimizing energy output from food SSCMs using novel anaerobic biorefinery processes in a long-term food supply chain. Biochar is created by pyrolyzing waste biomass from agriculture and livestock. It is used to determine the lifetime of bioplastic-based food packaging and the sustainability of the food supply chain.

Due to the absence of a standardized mechanism (Abdel-Basset et al. 2020; Kumar et al. 2021; Wei 2021), for collecting, classifying, and sharing information about sustainable supply chains, the second theme focuses on technical innovation and SSCM practices and activities. For example, Mardani, Kannan, Hooker, production, et al. (Mardani et al. 2020) implemented measurement and index systems that promote industrial symbiosis and synergies by substituting raw materials from sustainable supply chain sub-products or recycled materials for end-of-life mismanagement. Its catastrophic adverse environmental repercussions in the research, key SSCM constraints (Ciccullo et al. 2018; Herczeg and Akkerman 2017; Hong and Zhang 2018; Mensah et al. 2019), to adoption of a TI have been highlighted as the discursive framing of technical innovation policies and energy recovery via sustainable supply chains.

With increased worldwide demand for electronic and electrical products (Bechtsis et al. 2018; Meherishi and Narayana 2019; Silvestre 2018), developing and emerging countries, particularly those through technological innovation transitions, have prioritized e-Sustainable SCM. One of the most perplexing issues (Saberi et al. 2019) confronting policymakers in SSCM is an insufficient amount of e-sustainable supply chain treatment and recycling (Geissdoerfer and Morioka 2018; Hussain 2020; Nilsson 2021; Zhou and Govindan 2020), which can have a substantial influence on the environment and human health. The research theme of the e-sustainable supply chains is to identify significant hurdles and strategies for installing formalized supply chain management systems and novel sustainable business models to lower the e-sustainable supply chain (Gnansounou 2010). The critical importance of amending e-sustainable supply chain directions and guiding principles to account for all lifecycle influences, as well as the development of appropriate indicators for e-sustainable supply chains, reverse logistics solutions, and inducements to the sustainable supply chain hierarchy rather than recycling (Saberi et al. 2019).

As a result of the world's growing population and rising living standards, creating a sustainable supply chain has accelerated in recent years (Mahroof et al. 2021). For example (Tseng and Tan 2013), global MSW production will reach 2.01 billion tonnes in 2016. By 2050, it is predicted to reach 3.40 billion tonnes, posing a global threat. The majority of researches on the MSW theme tune focuses on influencing citizens' behavior through the implementation of 3Rs practices, the proposal of inducements for public engagement in MSW management, the provision of practical solutions for technological innovation (Yu et al. 2022; Khan et al. 2021f), and the increase in recyclables assortment rates. It assesses the synergy between recycling and heat treatment and the factors affecting municipal recycling collection rates. The lifetime of the solid waste supply chain and supply chain-to-energy technologies that generate electricity

from MSW is being evaluated (Gómez-Luciano 2018; Hong and Zhang 2018; Mensah et al. 2019).

Technical innovation strives (Ciccullo et al. 2018) to maximize resource efficiency and minimize the environmental impact of sustainable supply chain generation by implementing effective SSCM systems. Assessment of the ecological effects (Seman et al. 2016) of SSCM activities has historically been difficult, making it difficult for policymakers to make informed decisions to pursue a clean and sustainable environment. According to our study's text mining research, the environmental impacts and lifetime assessment subject have been identified as a significant area of environmental review within SSCM operations. Wei (2021) highlighted that the different recycling procedures are examined for their environmental impact, including the development of lifespan assessment models for future SSCM scenario environmental assessments and the assessment of potential environmental benefits associated with reuse preparation prior to recycling. Textile recycling and MSW dumping have a detrimental effect on the environment. Environmental expenses (Tebaldi and Bigliardi 2018) are associated with composting as a strategy for achieving greater sustainability long-term value addition to the supply chain. There are a lot of important environmental studies in this research theme, but two of the most important are the environmental effects of reusing resources from sustainable food supply chains in technology and the environmental effects of the whole lifecycle of electrical and electronic supply chains that are environmentally friendly (Krishnan and Agarwal 2020; Soni et al. 2021).

SSCM has met a plethora of problems and environmental issues (Yadav et al. 2020; Zhang et al. 2019), due to plastic's broad use in industry and urban life, ranging from coastal contamination to limited recycling. Among other things, our research on the plastic sustainable supply chain (Tyan et al. 2020; Yadav and Singh 2020) focuses on closed-loop polymer recycling, how stakeholders in the plastics value chain work together to implement technological innovation, how to define a new economy in agriculture (Fatorachian 2021), with plastics, extended producer responsibility for plastic packaging, and single-use plastic reduction challenges and opportunities, as well as how to reduce the amount of plastic waste in the world's oceans. Identifying important barriers to plastic reprocessing in the local plastic value chain, looking into pollution in reprocessing and the quality of recycled plastic, and looking at options for a sustainable residential plastics supply chain—this is what the project is about (Zimon and Tyan 2019).

Finally, the study's final SSCM research theme was determined using text mining analysis as the decisions for construction (C&D) sustainable supply chain progressed throughout the construction cycle (Mardani et al. 2020; Panigrahi et al. 2019; Shibin et al. 2020). C&D's sustainable supply chain, which is regarded as one of the most major

sustainable supply chain streams, has developed due to the world's expanding urbanization. Sustainable treatment of C&D supply chains should be a critical social, environmental, and economic challenge on a global scale. The researchers concentrated (Khalid and Seuring 2019; Panigrahi et al. 2019; Saeed 2019) their efforts on developing strategies for managing C&D supply chains that are founded on the concepts of technological innovation and information technologies in C&D. SSCM emphasizes the importance of overcoming barriers to technological innovation in research and development. SSCM utilizes sewage sludge ash in the building industry to promote technological innovation and positive community attitudes about C&D waste recycling (Neutzling and Land 2018; Khan et al. 2022b; Tseng et al. 2019).

By text-mining of publications in our dataset, we were able to track the evolution of SSCM subject categories across time how often they write or publish. Figure 6 shows the expansion of important study concerns and SSCM subject parts in the technological innovation environment during the last 5 years. Compared to material cycles, closed-loop systems, single-use plastics, biochar, Organic Fraction of Municipal Solid Waste (OFMSW), plastic, construction and demolition, food, and biofuels supply chains have recently attracted attention.

Clusters of qualitative content analysis: more detailed outcomes

This section looks at the fifteen most important articles in each of the groups that were identified. They include perspectives on a sustainable supply chain hierarchy based on technological innovation, how to think about and implement technological innovation, how to use SSCM in closed-loop supply chains, and how to use technology to improve plastics SSCM.

Conceptualization and implementation of TI

The bulk of publications and literature reviews (Olivetti et al. 2017; Rai and Patnayakuni 2006; Saberi et al. 2019; Snyder et al. 2011) conceptualize and clarify technological innovation. Historically and geographically, a more advanced and integrated SSCM system is desired and necessary. According to SSCM's research (Dao and Langella 2011; Davis et al. 2015; Eltayeb and Zailani 2010), the most significant sub-concept of TI originated relatively recently. This section discusses the factors that contribute to and impede increased sustainability through eco-innovation. Dao and Langella (2011) has looked at managing a sustainable supply chain via technological innovation.

The second set of articles (Gnansounou 2010; Horvath 2001; de Sousa et al. 2018; Sapsanguanboon et al. 2007) examines the application of technological innovation principles in a variety of critical industries, including construction (both construction and demolition phases), manufacturing (industrial symbiosis), and the sustainable supply chain to energy supply chain for augmented technological innovation systems. Business-specific best practices (Kotsemir 2013; Ramsdal and Bjørkquist 2020), such as those found in the construction industry, are highly regarded. This business is particularly interested in managing supply chains in the construction and demolition industries during technological innovation cycles. Finally, researchers and practitioners value the insights gained through SSCM systems (Kwon 1990) that incorporate technological innovation concepts. Additionally, it is worth mentioning that the management of a long-term plastic supply chain, a monumental challenge, has not been addressed.

SSCM in closed-loop supply chains

While ineffective sustainable supply chain management can result in serious environmental problems (Kuhnle and Lanza 2019), environmental issues such as marine litter and pollution of the environment's air, soil, and water, as well as dangerous supply chain leakage, technological innovation can assist developing economies in strengthening their existing solid sustainable supply chain management activities through compelling, long-term supply chain valuation and recycling (Kuhnle and Lanza 2019). It is imperative that a number of supply chain barriers be overcome in order to maximize the efficiency of materials and reduce the volume of raw materials and industrial supply chains throughout the transition to technological innovation (Brandenburg et al. 2018).

The advantage of an integrated SSCM system for reverse logistics is a closed-loop supply chain. Closed-loop supply networks connect (Russo et al. 2019), forward and change supply chains, emphasizing environmentally sustainable end-of-life product disposal. Gold (2010) emphasized how important it is for products to be designed in a way that allows for sustainable supply chain functions like modularity, repairability, and recycling in the closed-loop structure of the supply chain (Ashby 2018). Module reuse was found to be the best way to get things back in this situation, followed by material recycling and thermal disposal. Supply chain management is a big problem when it comes to making sure that chemical processes are long-term and efficient. Supply networks (Kalverkamp 2019), with a focus on energy efficiency and SSCM, minimize supply chain and energy requirements over the long run. Tseng and Tan (2013) closed-loop supply chains may also benefit the environment and improve resource efficiency by properly controlling returns at certain stages and throughout the product's

lifecycle. It is believed that using online mobile platforms to organize on-site sustainable supply chain gathering is acceptable for the overall environmental performance of SSCM systems.

In an uncertain environment, establishing successful closed-loop supply chains (Holgado and Design 2019) is challenging and time-consuming, owing to the interdependence of multiple variables such as product variety, short product lifecycles, and increasing outsourcing opportunities and organizational internationalization. Afum et al. (2021) created an optimization model to lower total reverse logistics costs and increase the effectiveness of product return collection stations, consequently increasing logistics efficiency and supporting proper recycling on an economic and environmental level. Furthermore, reverse activities including shredding, recycling, disassembly, and landfilling were built into closed-loop supply networks to reintegrate reverse material flows into forwarding supply chains (Tsai et al. 2021).

Due to the significant adverse environmental and human health implications (Lejarza 2020), of e-waste, SSCM systems have recently been challenged to build a sustainable supply chain as one of the critical end-of-life commodities within closed-loop supply chains. Policymakers and practitioners (Brandenburg et al. 2018), working on e-sustainable supply chains, should examine all disposal choices holistically inside the design of a closed loop supply chain network. Despite mounting legal pressure on legislation governing e-sustainable supply chain treatment, efficient e-sustainable supply chain management remains in its infancy due to a lack of a solid collecting mechanism, public participation, and regulatory enforcement (Kuhnle and Lanza 2019).

A TI approach to sustainable supply chain management

Concerns over plastic pollution in the natural environment have spurred politicians to seek sustainable solutions (Ebula De Oliveira et al. 2018). The European Commission has helped to control the manufacturing and consumption of the whole plastics value chain, from manufacturers to hoarders and recyclers at the end of the chain (Farooque et al. 2019). Also, the EU's TI strategy emphasizes increasing plastic recycling rates for packaging and domestically generated plastic (Kumar et al. 2021; Yadav et al. 2020). An innovative economy based on technical innovation principles has received momentum to combat plastic's negative environmental and wildlife impacts. Technological innovation aims to prevent plastic leakage into the atmosphere before it becomes a supply chain hazard (Dong et al. 2021). Manufacturers can cut down on their carbon footprint and use less resources by making bioplastics that are more environmentally friendly than fossil-based plastics. Regarding (Snyder et al. 2011) biodegradable plastics such as polylactic acid,

it has been stressed that chemical recycling is preferable to mechanical recycling. Their research on plastic recycling found a direct link between the unique qualities of plastic sustainable supply networks and recycling, revealing that “High Quality” plastic sustainable supply chains were 12–35% more recyclable than “Low Quality” applications. The recent Chinese prohibition on low-quality recycling imports has hampered SSCM systems that prioritize resource quality across the materials, components, and product life cycle (late 2017). Setting recycling targets for plastic packaging that are proportional to the actual output of the recycling process and assuring the quality of the end product is crucial. Plastic recycling is a relatively new technological breakthrough. SSCM initiatives (Cancino 2018) should reduce material degradation during mechanical operations by improving product design and technology.

Nilsson (2021) emphasized the crucial importance of government officials and material manufacturers coordinating the standardization of classification and categorization instructions for SSCM of bio-based plastics in order to accelerate the transition to technical innovation. While technological innovation and proper recycling have been lauded as effective tools for managing the plastic sustainable supply chain (Jin et al. 2019), more than half of the plastic sustainable supply chain has been exported to hundreds of countries worldwide, indicating the need for new policies to address plastic sustainable supply chain importation and exportation. Additionally (Semana et al. 2016), the hazardous sustainable supply chain demands enhanced managerial attention to resource circulation and efficiency in order to foster technological innovation that minimizes the hazardous supply chain and converts it into a resource (Khan et al. 2021c; Nilsson 2021).

Implications for research: future research directions

This section discusses the implications for future research in response to our third research question:

RQ3: These conclusions are based on the results of the conducted bibliometric investigation, text mining, and qualitative contented assessments. What future directions might SSCM research pursue in light of the move to technological innovation?

It was determined that four research topics were potential study gaps, with recommendations for future studies, in order to further integrate the SSCM research plan with perspectives on technological innovation, environmental sustainability, and human well-being, among others.

Technical innovation

Most developed countries can now employ information technology to help clean up the environment and move to more sustainable technological innovation. Using IoT devices to screen human behavior and inform SSCM hubs to take suitable action are two instances of integrating IoT-based solutions into current SSCM systems (Mastos et al. 2021). But this field of inquiry is fairly new, and we are still working on establishing an inclusive, sustainable, and intelligent SSCM mechanism using IT and IoT. (Nilsson 2021). To achieve long-term environmental, social, and economic sustainability, we are encouraging SSCM activities and practices like reprocessing to mitigate the effects of climate change (Khan et al. 2021d; Bag et al. 2021). As shown in Fig. 6, contemporary SSCM research has focused on two key areas. First, the biosphere component of technological innovation (Hong et al. 2019) provides significant research issues that must be solved, if a zero sustainable agri-food ecology is reached. Plastic SSCM and, more lately, the problem of single-use plastic have attracted substantial attention (Silvestre 2018). Researchers have ignored or failed to resolve such transactions. Reverse supply chains must be resilient to pandemic-induced interruptions and shortages in this climate. The COVID-19 situation (Ranjbari et al. 2021) has led to an unsustainable supply chain management system and numerous supply chain issues. However, while some authors explored the COVID-19 crises’ lessons on SSCM, more research is necessary (J Amankwah-Amoah 2020).

Environmental sustainability

Because healthcare is contagious and destructive, ensuring a sustainable supply chain is critical for the environment, health, and well-being. It necessitates considerably more consistent and long-term management. According to Tsai et al. (2021), it is uncertain that the existing healthcare SSCM will fully embrace the paradigm of digital innovation. It would be difficult to implement technology innovation to manage multiple brooks of healthcare supply chains, like pharmaceuticals, clinical, and medical. Increased effort and engagement on the part of multidisciplinary sectors would be required. This is primarily because the reuse, recycling, and recovery of materials in this industry involve infectious, poisonous, and hazardous materials, posing health hazards to the general public. According to the study’s findings (Khan et al. 2021a, 2021b), there is an absence of credible and comprehensive research on implementing technological innovation strategies in the healthcare sector in the SSCM literature. The majority of current research (Choudhary 2019; Khan et al. 2022a; Khan et al. 2021e; Lahane and Kant 2020; Mardani, Kannan, Hooker, production, et al.,

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