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ORIGINAL PAPER

# BLOCKCHAIN TECHNOLOGY AND SUPPLY CHAIN RESILIENCE: A BIBLIOMETRIC AND VISUALIZATION ANALYSIS

Yasser El Ouarrak, Aziz Hmioui

National School of Business and Management, Sidi Mohamed Ben Abdellah University, Fez, **Morocco**

**ABSTRACT. Background:** Recently, global supply chains have been heavily disrupted by severe events (e.g., the COVID-19 pandemic, the Russo-Ukrainian War, and recent natural disasters), prompting both practitioners and academics to find innovative responses to improve supply chain resilience in the face of unexpected disruptive turbulence. Blockchain technology (BCT) has emerged as one such response. As a result, the literature has witnessed a significant growth in studies focusing on supply chain resilience research from the BCT perspective. This paper presents a bibliometric and visualization analysis of research at the nexus of BCT and supply chain resilience.

**Methods:** To carry out our analysis, we adopted a structured methodology, starting with the determination of relevant keywords to build up our search string, moving on to the selection of a scientific database, and finally to the application of inclusion criteria to retain only relevant articles. The analysis was performed using VOSviewer software.

**Results:** As analysis results, we found that Sarkis Joseph, Kumar Anil, Helms Marilyn, Hervani Aref Aghaei, and Nandi Santosh are the most highly productive authors and that *Sustainability* is the principal journal with the most significant number of articles. Regarding country contributions, India, England, China, the USA, and Australia were found to be the top contributors. Finally, "BCT for secure supply chain management", "BCT and sustainability", "BCT, an Industry 4.0 technology, and supply chain resilience", and "BCT within supply chains in the COVID-19 era" were identified as four main research clusters at the nexus of BCT and supply chain resilience.

**Conclusions:** The results of our bibliometric analysis indicate that research at the intersection of BCT and supply chain resilience has attracted considerable interest from the scientific community, particularly in recent years. The network analysis uncovers four relevant research streams that underline the potential of BCT to contribute to improving the resilience of supply chains worldwide. This study provides meaningful insights into supply chain resilience research from the perspective of BCT, constituting an essential milestone for future developments.

**Keywords:** Blockchain technology, supply chain resilience, disruptions, bibliometric analysis

## INTRODUCTION

Supply chain resilience (SCRES) is defined as "*the adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost-effective recovery, and therefore progress to a post-disruption state of operations – ideally, a better state than prior to the disruption*" [Tukamuhabwa et al. 2015]. Academics consider resilience to have multidimensional capabilities [Hsu et al. 2022]. Through a literature review, Marinagi et al. [2023] listed supply chain configuration/ supply chain network design, redundancy, flexibility, visibility, collaboration, agility, situation awareness, information sharing, supply chain risk management culture, security, robustness, risk management, knowledge management, and velocity as the most critical building blocks of SCRES. In addition, Soni et al. [2014] suggested ten SCRES facilitators: agility, actor collaboration, information sharing, supply chain sustainability, risk and revenue sharing, actor trust, supply chain visibility, risk management culture, adaptive capability, and supply chain structure. Over the last few years, marked by an increase in disruptive events, the resilience of supply chains has been very negatively affected, spurring practitioners and academics to reflect on how to improve it to cope with the various disruptions that can compromise activity continuity and consequently deteriorate



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performance. One stream of such practitioners and scholars has been thinking about strengthening the technological infrastructure of global supply chains by implementing powerful emerging technologies, one of which is blockchain technology (BCT). The idea of blockchain (BC) was introduced by Nakamoto [2008], who developed a system of peer-to-peer electronic payments called Bitcoin, removing the role of intermediaries from financial entities. Many definitions have been given to BC. Seebacher and Schüritz [2017] defined it as follows: "*A blockchain is a distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks, holding timestamped transactions that are secured by public-key cryptography and verified by the network community. Once an element is appended to the blockchain, it can not be altered, turning a blockchain into an immutable record of past activity.*" According to Krajka et al. [2022], there are three main types of BC concerning openness and access to data: private BC (with permission), public BC (without permission), and consortium BC (between public and private BC, incorporating elements of both). Within supply chains, BC can be leveraged for data storage and data exchange with other involved actors or for matching incoming data against other node data or external data, with a view to verification [Bumblauskas et al. 2020]. Figure 1 displays a representative data flow in a manufacturing supply chain and logistics backed by different data collection systems and BCT [Raja Santhi and Muthuswamy 2022]. In their bibliometric review of the literature from 2016 to January 2020, Müßigmann et al. [2020] found that the area of BCT in logistics and supply chain management (SCM) is showing a significant increase.

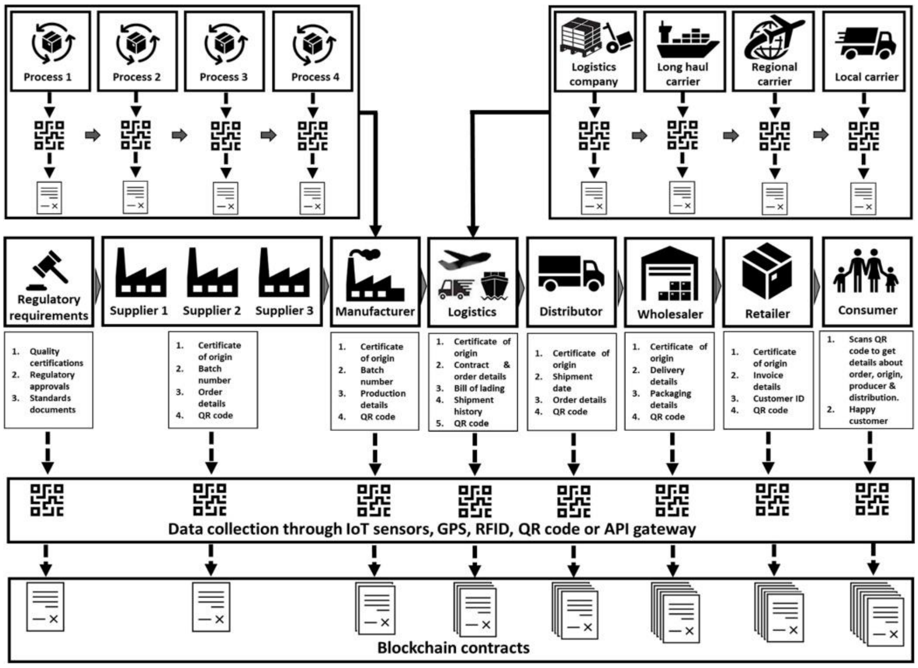

Fig. 1. BCT in a manufacturing supply chain and logistics [Raja Santhi and Muthuswamy 2022]

About the resilience of supply chains, a significant number of papers have been published in recent years investigating the role of BCT for SCRES [e.g. Lohmer et al. 2020, Li et al. 2022, Qader et al. 2022, Cai et al. 2023, Datta et al. 2023, Pandey et al. 2023, Chen et al. 2023, Alvarenga et al. 2023, Pattanayak et al. 2023]. Given the increasing number of articles, the need to conduct reviews of the existing literature at the intersection of BCT and SCRES has become imperative. Some authors have responded to this need, including Bayramova et al. [2021], Taqui et al. [2022], Beck et al. [2023], Chelh and Ababou [2023], and Singh et al. [2023]. However, to the best of our knowledge, there remains a lack of purely bibliometric analyses that map the research landscape and structure at the nexus of BCT and SCRES without positioning from a distinguished perspective. Thus, this study aims to conduct a bibliometric and visualization analysis to map the existing literature at the nexus mentioned above, answering the following research questions:

1. Who and which researchers and journals have contributed most to the literature on the BCT-SCRES nexus?
2. What countries have enormously contributed to the literature on the relationship between BCT and SCRES?
3. What are the primary research clusters in the literature addressing the BCT-SCRES nexus?

The rest of the paper is structured as follows. Following the introduction, section 2 describes the research methodology used. Section 3 then presents an in-depth analysis using rigorous bibliometric tools. Section 4 concludes the paper with a summary of the analysis findings, a presentation of the study's contributions and limitations, and recommendations for future bibliometric analyses.

## RESEARCH METHODOLOGY

In answering our research questions, we followed a structured methodology based on the construction of search string, the choice of scientific database, and the application of inclusion criteria.

### Search string building

To conduct our bibliometric analysis, we first identified the keywords making up our search string. Some previous bibliometric studies were examined to select relevant keywords. Starting with the BC-related side, Moosavi et al. [2021] used the keywords “blockchain” and “block chain” to span the part of their search string related to BC. Müßigmann et al. [2020] included another keyword in addition to “blockchain” and “block chain”, namely “distributed ledger technology”. For the SCRES side, Castillo [2023] used the following search string: “supply chain” AND “resilience” OR “SCRES” OR “SC resilience” OR “resilient” OR “resilien*”, and in a bibliometric study on SCRES in the food industry, Ababou et al. [2023] used the following combination of keywords: “food” AND “industry” AND “supply” AND “chain” AND “resilience” OR “resilient”.

Based on the above keywords and in line with the research objectives of our study, the search string we used was: *(“blockchain*” OR “block chain*” OR “distributed ledger technology”) AND “supply chain*” AND “resilien*”.*

### Database selection

Past bibliometric analyses often relied on Web of Science (WoS) and Scopus, the leading international scientific databases. These continue to be the two main sources of publication metadata and impact indicators, even if bibliographic data sources and metrics have increased considerably over the last ten years [Pranckutė 2021]. Data was collected on the WoS core collection database for our bibliometric study.

### Inclusion criteria application

We performed our search string in the "topic" field in the WoS core collection database, which yielded 193 documents published in English before 02/11/2023. Over 80% of these documents are journal articles (Figure 2).

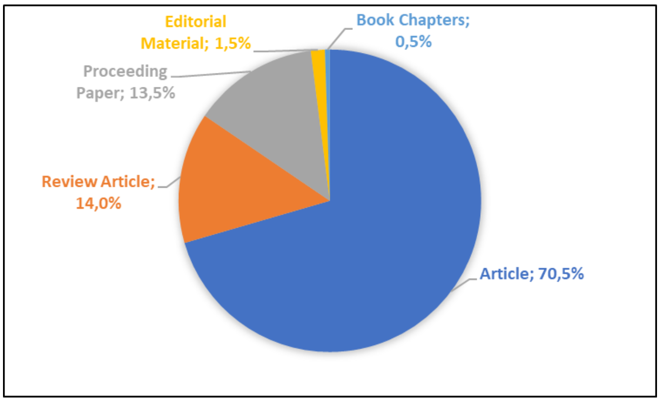


Fig. 2. Publication types

For this study, we only retained journal articles ("review articles" included), thus reducing the number of documents from 193 to 163. To exclude irrelevant articles, we filtered the titles and abstracts (and "full text" in some cases) of the retained papers, resulting, at the end of the screening process, in 136 relevant journal articles published between 2019 and 2023 (up to 02/11/2023). The distribution of these articles (by number of publications and citations) over time is shown in Figure 3.

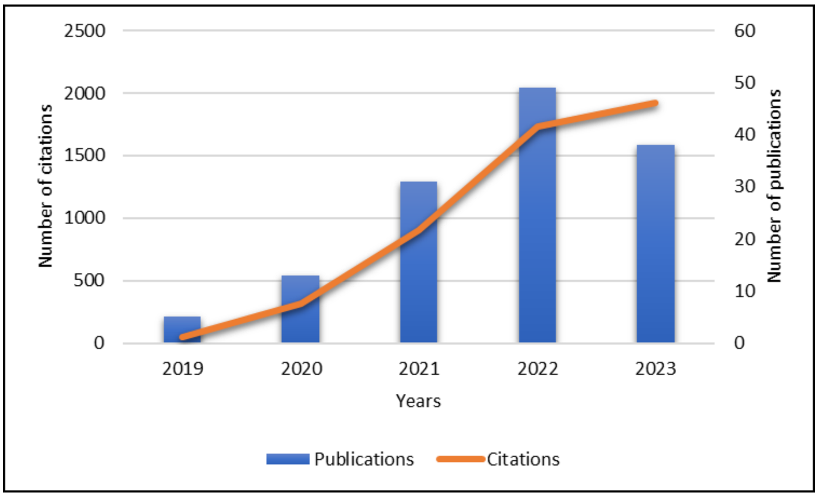


Fig. 3. Times cited and publications over time (based on the WoS database)

The 136 journal articles selected were extracted in a tab-delimited format to be analyzed with the bibliometric software VOSviewer. This is a free software tool for constructing and visualizing bibliometric maps [Van Eck and Waltman 2010].

## BIBLIOMETRIC ANALYSIS

Bibliometric analysis is defined by Kamran et al. [2020] as " *the statistical analysis of books, articles, or other publications to measure the output of individuals/research teams, institutions, and countries, to identify national and international networks, and to map the development of new multi-disciplinary fields of science and technology*." After extracting the 136 relevant English journal articles from the WoS core collection database, we imported them into the VOSviewer software.

VOSviewer can be deployed to build academic publications, academic journals, scholars, research organizations, countries, keywords, or term networks [Van Eck and Waltman 2023]. For our bibliometric study, we used VOSviewer to analyze the scientific production of researchers, journals, and countries and to analyze keyword co-occurrence.

### Influential authors

We assessed the authors' scientific production and found that 478 authors contributed to our corpus of articles at the nexus of BCT and SCRES. Of the 478 authors identified in the set of articles, only 13 have published at least 3. Table 1 presents the authors' names, the number of articles they authored or co-authored, and the number of times these authors were cited. As the table shows, the most prolific authors in terms of the number of papers published are Sarkis Joseph (5 documents) and Kumar Anil (5 documents), followed by Helms Marilyn (4 documents), Hervani Aref Aghaei (4 documents) and Nandi Santosh (4 documents).

In terms of citations, we found that the author Ivanov Dmitry is the author who received the highest number of citations (803 citations), and this is thanks to his article "The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics" [Ivanov et al. 2019] being cited 682 times, which is co-authored with Dolgui Alexandre and Sokolov Boris. The second most cited author is Sarkis Joseph (465 citations), followed by Helms Marilyn, Hervani Aref Aghaei, and Nandi Santosh, with the same number of citations (361 citations).

It is essential to know who the main authors are in the area of research under study, as this provides direction to scholars interested in conducting studies in that area. Carefully reading and following the scientific output of leading authors would be a reasonable basis for future developments, as it highlights existing research gaps and suggests avenues for further research.

Table 1. The top 13 influential authors based on the number of published articles

| Authors | Number of articles | Number of citations |
|---|---|---|
| Sarkis, Joseph | 5 | 465 |
| Kumar, Anil | 5 | 47 |
| Helms, Marilyn | 4 | 361 |
| Hervani, Aref Aghaei | 4 | 361 |
| Nandi, Santosh | 4 | 361 |
| Ivanov, Dmitry | 3 | 803 |
| Lotfi, Reza | 3 | 53 |
| Luthra, Sunil | 3 | 45 |
| Iranmanesh, Mohammad | 3 | 41 |
| Jayaraman, Raja | 3 | 39 |
| Salah, Khaled | 3 | 39 |
| Yin, Weili | 3 | 22 |
| Gupta, Shivam | 3 | 11 |

**Influential journals**

Turning to the leading contributing journals, we found that the 136 articles analyzed were published in 83 different sources. Table 2 lists the names of the leading ten contributing journals, the number of articles they published, and the number of citations they received. The table shows that the journal *Sustainability* leads the list with 11 papers, followed by *Annals of Operations Research* journal with eight papers, and *Computers & Industrial Engineering* journal with seven papers. The other journals in the table have fewer than six papers each. These statistics highlight the considerable interest of peer-reviewed scientific journals in the research at the nexus of BCT and SCRES.

Regarding citations, the *International Journal of Production Research* received the highest number of citations (1063 citations), even though it only contributed five papers. The two essential documents published by this journal, which got the highest share of 1063 citations, are: “The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics” [Ivanov et al. 2019] cited 682 times and “Blockchain technology for enhancing swift-trust, collaboration and resilience within a humanitarian supply chain setting” [Dubey et al. 2020] cited 255 times.

Identifying important journals is helpful for researchers who intend to publish their future work, as it enables them to find their way around the prominent journals that accept the publication of studies on the subject under consideration.

Table 2. The top 10 influential journals based on the number of published articles

| Journals | Number of articles | Number of citations |
|---|---|---|
| Sustainability | 11 | 184 |
| Annals of Operations Research | 8 | 74 |
| Computers & Industrial Engineering | 7 | 143 |
| International Journal of Production Research | 5 | 1063 |
| IEEE Transactions on Engineering Management | 5 | 40 |
| International Journal of Production Economics | 4 | 209 |
| Operations Management Research | 4 | 141 |
| Business Strategy and the Environment | 3 | 40 |
| Benchmarking-an International Journal | 3 | 22 |
| Frontiers of Engineering Management | 3 | 11 |

The considerable number of authors and journals indicates that research at the intersection of BCT and SCRES is significantly prominent to the scientific community. Moreover, the diversity of research areas of the leading journals reflects the multidisciplinarity and interdisciplinary character of the research at the BCT-SCRES nexus.

A comparison of the number of authors and journals with the recentness of the topic (Figure 3) indicates the growing level of academic interest in studying the role of BCT for SCRES in a context marked by a high number of disruptive events. The volume of articles can be expected to rise in the coming years because of the various disruptions that global supply chains are experiencing and the growing awareness among academics and practitioners of the importance of emerging technologies in strengthening SCRES.

**Influential countries**

To gain an overview of the various collaborative relationships existing between the different countries of the various scholars in our article corpus, we created a co-authorship network on VOSviewer, choosing "countries" as the unit of analysis to generate a country collaboration network. The article corpus includes 58 countries. To display the central countries in the pool, we chose the default value of 5, giving 14 countries with at least five publications.

Table 3 lists the top fourteen contributing countries. As indicated in the table, India (31 papers), England (27 papers), China (26 papers), USA (20 papers), and Australia (16 papers) are the five leading contributors among the top fourteen.

Table 3. The top 14 contributing countries

| Countries | Number of articles |
|---|---|
| India | 31 |
| England | 27 |
| China | 26 |
| USA | 20 |
| Australia | 16 |
| France | 10 |
| Germany | 9 |
| Italy | 8 |
| Iran | 8 |
| Sweden | 7 |
| United Arab Emirates | 6 |
| Finland | 6 |
| Malaysia | 5 |
| Turkey | 5 |

VOSviewer classified the countries into four clusters varying from six to two items. Figure 4 reveals several collaborations that occurred between the first 14 contributing countries. According to the number of links, England ranks first, collaborating with 12 different countries; Australia second, collaborating with 11 other countries; then the USA third, collaborating with nine countries; then India and Italy in the same order with eight collaborations each.

The results of the cross-country collaboration analysis illustrate the importance of worldwide collaboration in the output of publications on the subject under study. The number of influential countries from different regions and the various collaborations between them indicate that research at the nexus of BCT and SCRES is global in scope. However, countries from specific areas, such as Africa and South America, are not represented in the list of major contributing countries. The absence of these countries may be due to the weak productivity of scientific organizations, weak collaboration among authors, lack of funding sources, insufficient awareness of the importance and benefits of BCTs in supply chains, or/and the absence of BCT infrastructure.

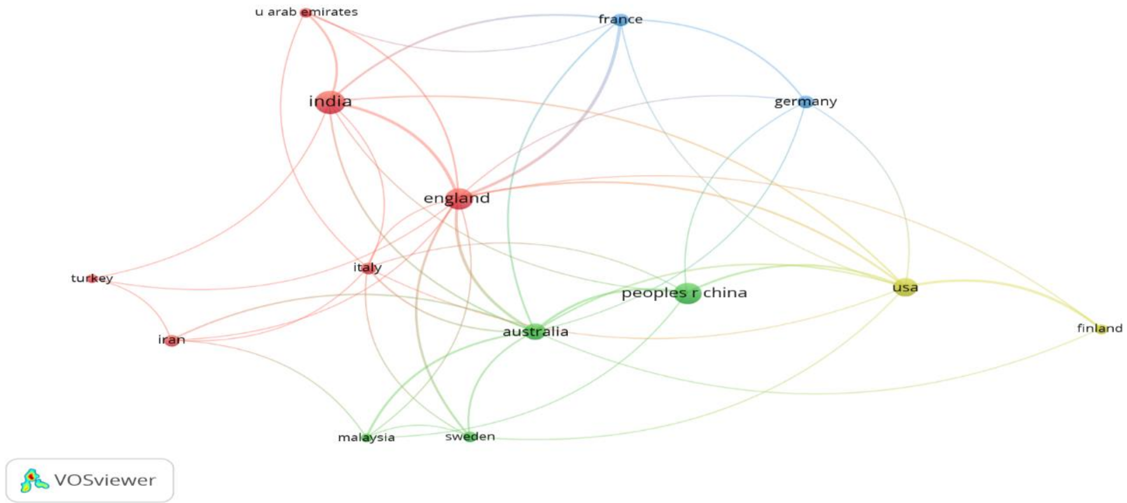


Fig. 4. Collaboration network among the central contributing countries based on the number of publications
Note: A threshold of 5 was applied for the minimum number of publications by a country. Of the 58 countries, 14 meet the threshold.

## Keyword co-occurrence analysis

We created a keyword co-occurrence network using VOSviewer software to cluster the pertinent literature. Within the software, we selected "author keywords" as the unit of analysis and then set the minimum number of occurrences to four. We also used a thesaurus file to clean up the data [Van Eck and Waltman 2023, pp. 43]. Figure 5 shows the visualization of our keyword co-occurrence network.  As can be seen, VOSviewer has grouped the keywords into four clusters of distinct colors.

### *Cluster 1: BCT for secure SCM*

Cluster 1 is colored green. Based on the main keywords in cluster 1, we labeled it "BCT for secure SCM". BCT is seen as a tool for securing SCM. Queiroz et al. [2019] studied BC's current state of application in SCM. In their categorization of BC research, they found that applications of BC to increase security were a widely represented domain. In a recent study, Liu et al. [2023] proposed a secure SCM framework built on BC and illustrated the achievability of deploying BCT for SCM security reinforcement. From a broader scope, Asante et al. [2023] investigated the contribution of distributed ledger technologies, like BC, to managing supply chain security. They outlined distributed ledger technology integrated frameworks and solutions suggested in the literature, conceived for surmounting today's supply chain security management challenges.

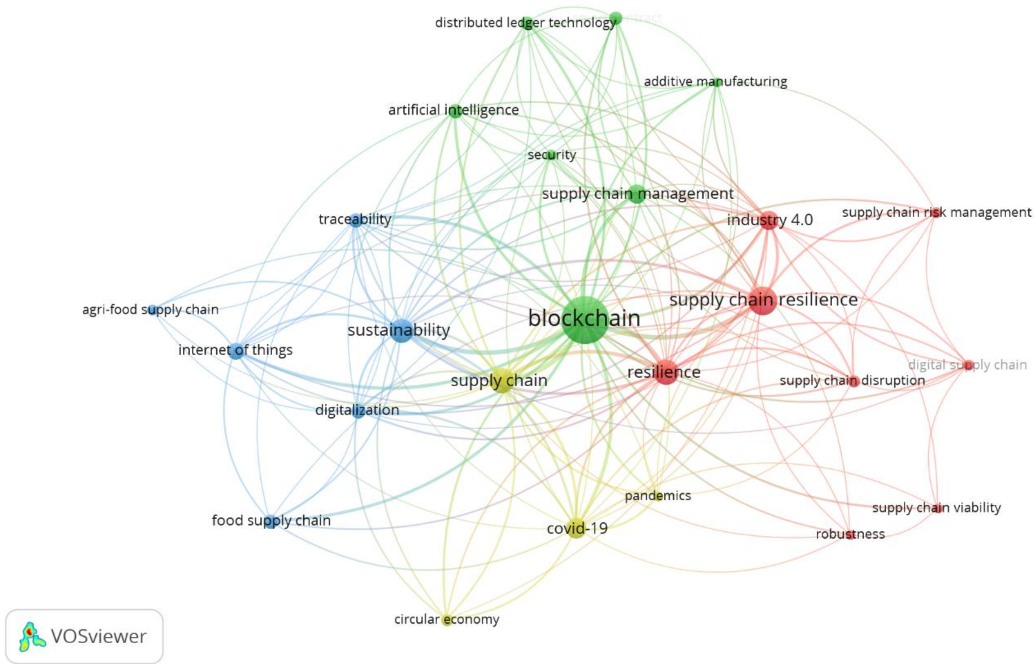


Fig. 5. Keyword co-occurrence network.

Note: A thesaurus file was used for keyword cleaning.

More specifically, cybersecurity has emerged as one of the main contributions of BCT. According to Min [2019], BCT is able to eliminate single-point-of-failure risk thanks to its end-to-end encryption, visibility, and privacy, and represents a prime means to attenuate cybercrime and piracy risk. In a recent systematic literature review, Singh et al. [2023] found that the BCT and cyber-secure supply chain association has been the subject of a broad body of research. In their study, Bayramova et al. [2021] indicated that cybersecurity is one of the key features of BCT within supply chains. Meanwhile, Bechtsis et al. [2022] noted that BCT and cybersecurity are directly linked and suggested a resilient data-driven supply chain framework comprising three levels and integrating three layers. The BC layer constitutes the second layer, which provides secure data storage to preserve data integrity, which is vital for the sustainability and reliability of the network.

The security aspect of the supply chain is seen as one of the critical elements in creating a resilient supply chain. BC helps to improve this aspect by offering a secure peer-to-peer (P2P) exchange platform between supply chain actors. Recently, cyber-attacks have been multiplying and have become a significant threat to supply chains, which can result in disruption of supply chain activities, leading to delays, downtime, financial losses, loss of productivity and competitiveness, and loss of partner confidence. Future research should increasingly focus on proposing effective BCT-based security mechanisms leveraging this technology's immutability, auditability, and redundancy features to reduce supply chains' vulnerability to cyber-attacks.

***Cluster 2: BCT and sustainability***

Cluster 2 is the blue cluster. We titled it "BCT and sustainability" based on the main keywords in the cluster. Several researchers examined the role of BCT for both sustainability and SCRES, putting sustainability and resilience on the same axis. For instance, Shukla and Shyam [2023] evaluated BC's contribution to improving SCRES and sustainability in e-commerce channels for additive manufacturing (ECAM). Al Azmi et al. [2022] explored the deployment of BC to support SCRES and sustainability in the Saudi Arabian construction industry. Pandey et al. [2023] looked at how the resilience and sustainability of the supply chain can be realized by leveraging BC-based technologies. They pinpointed 21 BCT-based critical success factors for resilience and sustainability in the supply chain. Hervani et al. [2022] introduced a performance measurement framework for socially sustainable and resilient supply chains in another study. Their framework incorporates (1) the environmental goods valuation to assess social sustainability and (2) BCT-enabled digitalization to improve the sustainability and resilience of the supply chain process. Patidar et al. [2023], for their part, determined the key performance indicators (KPIs) for building a resilient supply chain and assessed them from industry 4.0 (I4.0) and sustainability angles. According to them, "*Blockchain, Big Data and Cyber-physical systems enhance KPI's value and, in turn, foster economic, environmental and social sustainability of the SC and help in better decision making in terms of smart contracts, better forecasting and enhanced real-time information sharing*". Indeed, the achievement of resilience leads to the realization of sustainability goals, while the implementation of sustainable practices leads to strengthening the ability of supply chains to cope with disruptions. Scholars should pay more attention to this relationship, empirically examining how BCT could help improve SCRES while meeting the objectives of the triple bottom line of sustainability (economic, social, and environmental).

In the studied cluster, we note the inclusion of the "Internet of Things", suggesting that the literature backs the combination of BCT and the Internet of Things (IoT) as holding considerable promise for sustainability and resilience within supply chains. Based on their review, Amentae and Gebresenbet [2021] identified traceability and sustainability as key concepts covered by digital technologies (BC and IoT included) throughout food chains so that these technologies help to ensure traceability and can serve as catalysts for sustainable transformation in the food system. Indeed, integrating contemporary technologies like IoT, BC, and Geographic Information System (GIS) into agri-food businesses is critical to achieving food supply chain sustainability [Rejeb, Rejeb, Abdollahi et al. 2022]. In terms of resilience, IT infrastructures, including new technologies such as cloud-based solutions, BC, and IoT, are able to sustain the resilience of the supply chain by enabling the exchange of real-time data, providing situational awareness, delivering scalable meals, backing cooperative practices, and easing decision-making [Kopanaki 2022]. In the context of the pharmaceutical supply chain (PSC), Chen et al. [2023] also emphasized how IoT and BCT can improve resilience in the supply chain. Qader et al. [2022] further supported the position that IoT, BCT, and Machine Learning have a positive impact on SCRES. The joint implementation of BCT and IoT along supply chains contributes to improved visibility, traceability, transparency, collaboration, and trust between the actors involved in the supply chain. All these capabilities are enablers of SCRES. However, the joint integration of these two emerging technologies requires a high cost and may entail certain technological risks. Thus, future research could investigate the trade-off between the resilience benefits of integrating BCT and IoT and such integration's financial and technological constraints. In addition, further studies may propose practical guidelines for managers in successfully exploiting BC and IoT technologies to derive maximum benefit from the integrated combination of both.

The "food supply chain" and "agri-food supply chain" inclusion in this cluster indicates that the "food system" can be considered as a leading supply chain area that can leverage BCT to attain its sustainability [Amentae and Gebresenbet 2021, Rejeb, Rejeb, Appolloni et al. 2022, Wünsche and Fernqvist 2022, Rejeb, Rejeb, Abdollahi et al. 2022, Agnusdei and Coluccia 2022].

***Cluster 3: BCT, an Industry 4.0 technology, and SCRES***

Cluster 3 is the red cluster. Taking the main keywords in the cluster into account, we labeled it "BCT, an Industry 4.0 technology, and SCRES". The importance of BCT for SCRES, as a relevant component of I4.0, has been covered in numerous papers. Based on a systematic literature review, Spieske and Birkel [2021] provided an overview of I4.0 enabler technologies ("BC" included) underpinning SCRES. They presented a framework that outlines the relationships between these technologies, SCRES antecedents, and SCRES phases. Relatedly, Kopanaki [2022] indicated that in the I4.0 age, SCRES could be sustained by modern technologies like cloud-based solutions, BC, and IoT. Similarly, Marinagi et al. [2023] identified I4.0 technologies (BC included) that can contribute to enhancing the KPIs involved in building a resilient supply chain 4.0. In a similar vein, Patidar et al. [2023] addressed the question of how and which I4.0 technologies contribute to KPIs enhancement for SCRES. They indicated that BC, Big Data, and Cyber-physical systems increase the value of KPIs. Furthermore, Qader et al. [2022] found that I4.0 boosts SCRES and that the latter acts as a mediator for the relationship between I4.0 and supply chain performance. They also revealed that supply chain visibility enhances the I4.0 impact on SCRES. Only IoT, BCT, and Machine learning technologies were included in this study as I4.0 technologies. In a nutshell, BCT forms a prominent technology among the I4.0 technologies that positively impact SCRES. The more supply chains implement I4.0 technologies tailored to their needs, the more effectively they can improve their resilience. Which I4.0 technologies can be implemented with BCT to achieve greater resilience at the lowest investment cost is a fruitful future research avenue.

The inclusion of "supply chain disruption" in the considered cluster marks the value of BCT in managing disruptions to achieve SCRES. Etemadi et al. [2021] performed a systematic literature network analysis to identify the key trends and the recent research streams in BC-enabled supply chain cyber and disruption risk management. The authors pinpointed two principal streams: one dedicated to supply chain capabilities and strategies for implementing BC as a critical element of cyber supply chain risk management; the second relates to a supply chain disruption risk management perspective, looking at how BCT can be blended with other digital technologies and how intelligent operations can handle and predict disruptions and drive resilience and robustness in the supply chain. Importantly, BCT can enable tracking down the roots of disruptions and observing their spread (i.e., the ripple effect) [Ivanov et al. 2019]. In the context of the COVID-19 crisis, Pattanayak et al. [2023] explored the contribution of BCT to mitigating supply chain disruptions' adverse impact, focusing on those associated with the pandemic crisis, and increasing the resilience of the supply chain.

### *Cluster 4: BCT within supply chains in the COVID-19 era*

Cluster 4 is colored yellow. It revolves around the use of BCT in supply chains in the COVID-19 era. BCT emerged as one of the main ways to improve SCRES in the context of the COVID-19 crisis. As shown in Figure 3, the number of publications and citations in the literature at the nexus of BCT and SCRES has grown very significantly since 2020, the year of COVID-19's global spread. Since then, the role of BCT in dealing with supply chain issues and challenges in the era of COVID-19 has been addressed significantly in the literature. For instance, Pattanayak et al. [2023] determined 17 issues that arose during the COVID-19 epidemic and identified how the BC-based supply chain could alleviate such issues. Against the same backdrop, Sultana et al. [2022] examined the intention of various industries to embrace disruptive technologies (BC included) to meet challenges resulting from the supply chain disruptions brought about by the COVID-19 crisis.

The healthcare system is considered to be the central sector affected by the COVID-19 pandemic. Some authors have tried to propose BC-enabled solutions to the healthcare system-related challenges posed by the COVID-19 pandemic. For instance, Verma et al. [2022] suggested a generic VaCoChain scheme, merging BC and unmanned aerial vehicles (UAVs) underpinning fifth-generation (5G) communication services for the timely distribution of vaccines in the course of the COVID-19 outbreak and future pandemics. For their part, Chen et al. [2023] looked at the challenges confronting PSC in the post-COVID-19 era. They put forward an IoT-BC-integrated hospital-side led PSC management model. According to the authors, this model helps improve PSC visibility, flexibility, and rapid response and contributes to the alignment of medicine supply and demand. In addition to the healthcare sector, the food sector was severely affected by COVID-19. A number of researchers have conducted studies examining

BCT's role in the resilience of the food supply chain during the pandemic. Among them, Sengupta et al. [2022] highlighted the contribution that BC and satellite imagery can make to increasing fish SCRES in the wake of the COVID-19 pandemic. Further, Sharma et al. [2021] assessed the resilient strategies of BCT-based food supply chains attenuating the disruption effect over the course of the pandemic. They found that "improving flexibility" is the most critical resilient strategy.

The COVID-19 pandemic caused considerable disruption to global supply chains. The scientific community should draw on the COVID-19 experience to propose BCT-based solutions to prepare supply chains for potential future pandemics, covering all sectors likely to be affected. Furthermore, increasing attention needs to be paid to "smart contracts" stored and executed on BCTs, which provide significant advantages compared to traditional contracts, especially during times of crisis such as the COVID-19 pandemic. One of these advantages is the automated execution of diverse processes across the supply chain, including ordering, invoicing, and payments. This automation minimizes dependence on human intervention.

The results of our bibliometric analysis underline the growing interest in studying the role of BCT in improving SCRES. This role has been highlighted in the literature in several different spheres. Firstly, BCT helps to strengthen the security of SCM. Security has been recognized as a critical benefit that BCT offers in SCM. BCT's decentralization, immutability, auditability, and cryptographic features provide security for transactions between supply chain actors, making a direct and vital contribution to improving resilience. Secondly, BCT has been considered a catalyst for supply chain sustainability. Implementing this technology helps supply chain actors achieve the objectives of the triple bottom line of sustainability. Economically, BCT helps to minimize costs and improve efficiency within supply chains. Environmentally, BCT could ensure sustainable sourcing by verifying that materials come from sustainable sources and that environmentally-friendly practices are applied in procurement processes. On the social front, BCT's transparency makes it possible to monitor respect for employee rights throughout the supply chain and to ensure that supply chain actors are committed to their communities through corporate social responsibility initiatives. These represent some of the benefits of BCT for sustainability and, at the same time, for resilience. Indeed, implementing practices aimed at achieving sustainability automatically improves the supply chain's resilience and prepares it for any potential disruption. In turn, the pursuit of resilience reinforces the achievement of sustainability objectives. The role of BCT in SCRES enhancement can be strengthened if this technology is integrated with other I4.0 technologies (e.g., IoT). The increasing number of disruptions that global supply chains have suffered has significantly raised managers' awareness of the importance of I4.0 technologies and highlighted the need to integrate these technologies to guarantee process visibility, transparency, traceability, security and flexibility, and to ensure collaboration, coordination, and trust among supply chain actors, ultimately leading to improved SCRES. In the era of COVID-19, BCT has demonstrated its importance in mitigating the adverse effects generated by the disruption of the pandemic crisis, and the scientific community has proposed many BCT-based solutions to address the challenges of the crisis in various affected sectors, such as healthcare and food.

## CONCLUSION

The central objective of this article is to map the research landscape and structure at the intersection of BCT and SCRES. To this purpose, we performed a bibliometric analysis to pinpoint the leading authors, journals, countries, and principal research clusters. Bibliographic data were retrieved from the WoS core collection database, and 136 relevant journal articles were selected after screening for analysis using VOSviewer software.

The results showed that Sarkis Joseph, Kumar Anil, Helms Marilyn, Hervani Aref Aghaei, and Nandi Santosh are the authors with the highest productivity and that *Sustainability* is the journal that published the largest number of articles. We found that India, England, China, the USA, and Australia are the most active contributors regarding country coverage. Moreover, the network of collaboration between countries gave us an overview of the global dispersion of scientific production at the nexus of BCT and SCRES. Lastly, the keyword co-occurrence analysis revealed four major research clusters at this nexus.

Our study provides valuable insights for researchers investigating the potential benefits of BCT in the field of SCM in general and for SCRES in particular. Identifying primary authors and journals provides a reference for academics seeking to publish articles on the subject under study, and the visualization of collaborations between contributing countries can serve as a basis for future research cooperation. Determining the main research clusters could enable researchers to seize further research opportunities and develop new perspectives.

Despite its interesting contributions, this study has certain limitations. Firstly, a few papers were included in the analysis due to the choice of a single database for data collection, the restricted search string used, and the inclusion of only journal articles may have led to omitting some relevant documents that could have enriched our analysis. Secondly, the identified research clusters require further analysis to reveal research gaps and suggest more future research directions. Thirdly, our bibliometric analysis was not followed by either a citation analysis, a bibliographic coupling analysis, or a co-citation analysis.

Based on the above limitations, further bibliometric analyses could be carried out to extend the results of our study by (1) selecting more than a single scientific database, (2) broadening the search string by adding more keywords on BCT and SCRES, and (3) including other document types, such as conference papers and book chapters. In addition, future bibliometric studies could provide an in-depth analysis of the research clusters found and adopt various network analyses (citation, bibliographic coupling, and co-citation analyses).

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Yasser El Ouarrak ORCID ID: https://orcid.org/0000-0002-2724-4705
National School of Business and Management,
Sidi Mohamed Ben Abdellah University, Fez, Morocco
e-mail: yasser.elouarrak@usmba.ac.ma

Aziz Hmioui ORCID ID: https://orcid.org/0000-0002-9032-4978
National School of Business and Management,
Sidi Mohamed Ben Abdellah University, Fez, Morocco
e-mail: hmioui.aziz@yahoo.fr