



Blockchain Technology for Sustainable Supply Chains: A Bibliometric Study

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Abstract

Purpose: The study is developed in order to describe the trends of scientific production of blockchain technologies for sustainability within the supply chains. **Research design, data and methodology:** This study is developed from the documentary field from the application of bibliometric techniques to analyze the trends of scientific production indexed in the Scopus database, for which processing is carried out in the R and VOS Viewer software. **Results:** The results show a total of 461 documents, of which 58% of the articles, 17% are conference articles and the remaining 25% are made up of other formats. **Conclusions:** 78% of the articles are concentrated in the years 2020, 2021 and 2022. India, United Kingdom, China, United States and Italy are the countries where 70% of all the publications were published. 23% of the articles have been published in four journals: Sustainability (Switzerland), Journal of Cleaner Production, Computers and Industrial Engineering and Business Strategy and the Environment. Sarkis, J. is the author with the most published articles with fifteen publications and, finally, 13% of the total publications were concentrated in: Uttaranchal University, Yasar University, Malaviya National Institute of Technology, Centro Di Ricerca Ingegneria e Trasformazioni Agroalimentari and University of Hong Kong.

Keywords: Supply Chain, Blockchain, SDG's, Digital Assets, Sustainability

JEL Classification Code: E44, F31, F37, G15

1. Introduction

Supply chains are an essential part of the proper development of all commercial activity, from the most local in establishments and small producers to the largest such as multinational industries (Salas-Navarro et al., 2019; Goel et al., 2021). The correct approach to supply chains allows a significant improvement in production processes through control and auditing resulting from the understanding of the entire production chain in each of its links, demonstrated as a logical and sequential order for the transformation of raw materials. until delivery to the final consumer (Arizpe, 2019).

When talking about supply chains, it is important to highlight the great challenges that they currently present as a result of the volatile state of the international context as a result of various events such as armed conflicts, challenges framed in the environmental footprint, the container crisis or even the same COVID 19 pandemic (Craighead et al., 2020; Galanakis, 2023). This context arises from the need for supply chains to be part of the globalization process in order to enter and maintain themselves. competitively within international markets that, even with all these aforementioned challenges, are increasingly demanding for the industry (Koberg & Longoni, 2019; Singh & Kumar, 2020).

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One of the most outstanding demands towards the industry is related to sustainable development, thus recognizing the high environmental footprint generated by the production and distribution processes on the environment and the consumption of non-renewable resources for the operation of all systems and subsystems that coexist in the process of supply chains (Martins & Pato, 2019).

According to various United Nations reports and various studies, supply chains are one of the largest sources of contamination internationally, whether from the use of land, sea and air transport, where a level of gas emissions is observed. greenhouse effect that is increasing more and more and that the risk of the impact generated towards the environment can suppose a point of no return for humanity in the face of climate change (Trevisan & Bordignon, 2020; Farkas, 2021; Kazancoglu et al., 2021).

This problem is currently addressed and adopted based on the Sustainable Development Goals, which are a series of 17 objectives and 167 goals that operationalize the monitoring and measurement of society's actions to achieve sustainability as a global goal (Castro et al., 2022). This leads to a series of demands at the strategic levels of the supply chains at the level who respond effectively to these needs, but without losing the commercial factor and related jobs throughout the process (Jacob-John et al., 2021).

In this way, it is possible to see how supply chains are beginning to no longer see sustainability as a mere objective to be met at the request of interest groups but are beginning to envision opportunities for improvement by adopting this sustainability as an institutional policy. looking for better results, better processes and in turn a direct alignment towards sustainable practices (Djekic et al., 2021; Cammarano et al., 2022).

It is within the framework of this adoption of sustainability as a strategic supply chain policy that is the location of new alternatives and tools that allow achieving a profitable production process that is framed in these paradigms related to the responsibility of the industry with the interest groups (Cai & Choi, 2020). Among several of these tools and alternatives is the implementation of industry 4.0 as a catalyst towards the transformation of conventional processes towards a sustainable supply chain.

Various studies show the high impact of industry 4.0 within the supply chain, where technologies and innovations such as the Internet of Things (IOT), predictive systems, big data, data mining and even blockchain itself are applied; evidencing positive results within the improvement of processes, transparency and agility in everything related to the productive chains (Federico et al., 2020; Zekhnini et al., 2020).

In this sense, blockchain-based technologies stand out as an opportunity to integrate various elements of industry 4.0

under a single integrated system, which allows all interested parties to generate greater confidence in those related to supply chains (Dutta et al., 2020); from the levels of the organizations involved in the process to the same clients or control entities for whom having said information is highly important (Sunny et al., 2020).

However, it is important to explain that the vast majority of these blockchain-based technologies are quite young, which is why there are still various gaps and industry needs to understand each one of them and how they can be effectively applied to processes. productive in order not to fall back on wear and tear resulting from poor implementation or implementing a type of technology that was simply not consistent with the true needs in the context (Monrat, 2019).

It is important to mention that in many cases the blockchain is only associated with commercial transactions of cryptocurrencies or any other type of fungible or non-fungible digital asset, so it is imperative to generate spaces for knowledge and dissemination of the advantages and possible applications of this technology to the industry. Based on this, the present study is developed in order to describe the trends in the scientific production of blockchain technologies for sustainability within supply chains.

From this powerful tool, decisive benefits can be included, which have been the reason why more and more companies and people decide to incorporate blockchain in all their day-to-day activities. For this reason, the factors that have caused the increase in these statistics for the use of the blockchain are analyzed in this paper. The first factor of analysis is the increase in transparency in the ecosystem. Thanks to the blockchain infrastructure, all interested parties can have access to any part of the process, or that a product has had from its origin and authenticity, in its stages or contents, for example, from materials to its production, transportation and distribution (Agrawal et al., 2023).

Another factor is traceability. Access to this information and evidence allows the internal level of the company or any process to find problems, delays and inefficiencies of the processes in its production chain, so when traceability is known, direct solutions can be executed to optimize costs, possible technical risks and errors. Within the supply chain, it is also possible that batches or packages of products can be easily identified if they are contaminated. This by default increases the efficiency and effectiveness of the products, due to the fact that smart contracts automate certain tasks and payments, which allows to eliminate intermediaries and costs associated with the execution of tasks. In this sense, the blockchain infrastructure creates a time stamp, which is encrypted with the previous block and the block that follows it, so if a block is altered, it does not fit into the blockchain and its alteration can be noticed (Sharma et al., 2023).

2. Literature Review

2.1. Supply Chains

To clearly understand the concept of supply chain, it is important to mention to what it attributes its name; understanding that they are a series of interconnected links or phases in a large chain from obtaining that raw material to satisfying the needs of the final consumer (Balza-Franco et al., 2019). The supply chain then requires understanding the logistics processes within the organizations as a whole and observing from a strategic level what exceeds the borders of the same organization, in order to achieve the greatest optimization within the processes and therefore this implies a better relationship with customers in order to increase the results of the same chain (Salas-Navarro et al., 2019). Various authors stipulate that the supply chain involves a series of processes that must be understood and studied from its execution to its relationship with other processes in the chain (Sánchez Suárez et al., 2021).

2.2. Blockchain as a Renewal of Industries

In the first instance, to understand what blockchain is, it is important to go back to the year 2008 where, based on a model based on P2P (people to people), a new digital architecture is proposed in which data record processes based on a principle are developed. called as decentralization. For many experts, this blockchain technology is called the new internet and represents one of the most important innovations of the 21st century (Zhou et al., 2020); which consists of a series of blocks interconnected with each other and in real time record the data immersed in it and the transactions through a key element called the smart contract.

This type of architecture based on the principle of decentralization seeks to offer an opportunity for the same community to make processes independent of conventional server systems, which are exposed to various types of violation and/or manipulation (Chen & Bellavitis, 2020). It is in this process where transparency is one of its greatest qualities to be applied in various industries (Nanayakkara et al., 2019). In this way, the steps involved in the implementation of the blockchain are the following: Networks, Communication, Validation, Check and Confirmation.

In this way, blockchain technology is currently applied to various areas such as art, finance, education and even to the supply chains themselves; showing extremely impressive results in the improvement of processes and generation of transparency towards the interest groups of each of these application sectors (Franceschet et al., 2021; Raimundo & Rosário, 2021; Zheng et al., 2022). More

specifically, the blockchain is used to a large extent within supply chains, among various things, for the process of identification and tracking of processes and assets in an agile and transparent manner, achieving greater transparency in the process. In the supply chain, smart contracts are applied to compliance conditions, payment settlements, dispatch authorization and compliance checks (Agrawal et al., 2023).

2.3. Sustainable Development: Paradigm from the SDGs

For the present study, it is important to be precise regarding the concept of sustainability, which is addressed through the understanding of what is called sustainable development based on the recommendations issued by UNESCO (2015), which stipulates the creation of a responsible, green and global society; where new technologies, science and innovation are the catalyst for the implementation of sustainable actions that make it possible to face climate change and the other challenges of humanity.

From this perspective, sustainable development is understood as a tool for changing society and industry towards practices that lead to an increasingly equal and just society that can coexist harmoniously with the environment (Dantas et al., 2021). This concept of sustainable development conceived from the SDGs arises as a response to the barriers and gaps presented in the materialization of the millennium goals, which through the 2030 agenda seeks to achieve a truly sustainable society from the breadth of the concept (Castro et al., 2022).

3. Research Methods and Materials

The present study is based on a process of bibliometric analysis, which is a subbranch of scientometrics focused on studying and analyzing scientific production in the form of written products such as scientific articles, books, book chapters, among others. In this way, in order to describe the trends of scientific production of blockchain technologies for sustainability within supply chains, a process of scientific observation is applied in the Scopus database on the written scientific production indexed in said base. high impact data. For this research, a series of keywords are proposed that start from the variables under study:

Based on these descriptors, it is mentioned that the review process is carried out in February 2023 under the search equation: (TITLE-ABS-KEY (blockchain) OR TITLE-ABS-KEY (block AND chain) OR TITLE -ABS-KEY (block-chain) AND TITLE-ABS-KEY ("supply chain") AND TITLE-ABS-KEY (sustainability)). The results obtained from the search equation are processed from the Bibliometrix package of the R software and, in turn,

cluster graphing processes and keyword networks are proposed through VOS Viewer. The general information of the published articles is presented in Table 1.

Table 1: Main Information of the Data Obtained from Scopus.

MAIN INFORMATION ABOUT DATA	
Timespan	2004:2023
Sources (Journals, Books, etc)	232
Documents	461
Annual Growth Rate %	21,74
Document Average Age	2,12
Average citations per doc	27,01
References	31153
DOCUMENT CONTENTS	
Keywords Plus (ID)	1961
Author's Keywords (DE)	1146
AUTHORS	
Authors	1318
Authors of single-authored docs	44
AUTHORS COLLABORATION	
Single-authored docs	61
Co-Authors per Doc	3,47
International co-authorships %	39,05
DOCUMENT TYPES	
article	267
book	3
book chapter	33
conference paper	80
conference review	13
note	2
review	62
short survey	1

Source: Ramírez et al. (2023).

Table 1 shows the main information of the documents consulted, in a time interval from 2004 to 2023; In total, 461 documents were analyzed, of which it can be noted that the majority are articles (267), followed by conference articles (80), between the two they cover 75% of all publications.

4. Results

Initially, an analysis of bibliometric productivity is carried out, then different bibliometric indicators were analyzed and finally the analysis of relationships and co-occurrences was carried out.

4.1. Laws of Bibliometric Productivity

The scientific productivity of writers is first described by Lotka's productivity index, sometimes known as the inverse

square rule; On a given topic, around half of the authors make a single contribution, while approximately 60% of the authors make many contributions (Batista et al., 2018).

Table 2 shows compliance with Lotka's law, the largest number of authors (1152) which is equivalent to 87.6% are the ones that make the least contributions with only one article, 9% which is equivalent to 119 authors have made 2 contributions and only 3.5% have made at least 3 contributions. Based on this, it is inferred that most of the publications are made by researchers who carry out a transitory investigation on the subject of study.

Table 2: Lotka's Law

Written documents	No. of Authors	Ratio of authors
1	1152	0,876
2	119	0,09
3	23	0,017
4	14	0,011
5	6	0,004
6	2	0,002
15	1	0,001

Source: Ramírez et al. (2023).

On the other hand, Bradford's law is applied to a set of journals to identify the nucleus of the most productive journals in a given subject, and its representation is done by zones; Table 3 shows that 34% of the articles published are concentrated in the top 12 journals and that these belong to zone 1 of Bradford's law, where a relatively small number of journals are concentrated and are the most productive. Similarly, it allows identifying the most productive journals in a given field (Alvarado, 2016; Sembay et al., 2020).

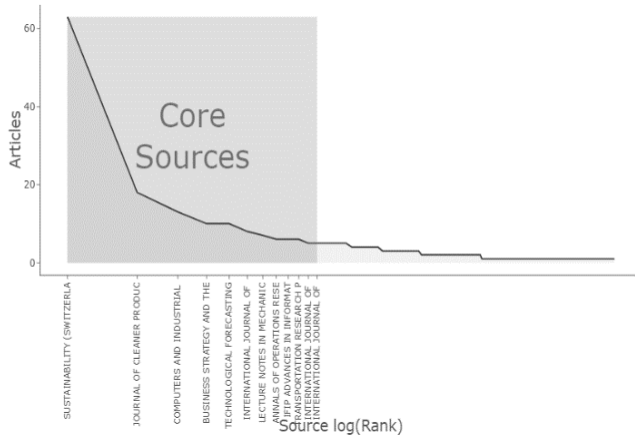
Of these, the first 4 magazines can be highlighted as shown in figure 2, which correspond to 66% of the total publications of the magazines that make up zone 1 of Bradford: Sustainability (Switzerland), Journal of Cleaner Production, Computers and Industrial Engineering and Business Strategy and the Environment.

In this same sense, it is worth highlighting some of the areas of publication of the four journals that concern the subject, such as environmental sciences, sustainability and the environment, engineering and business; emphasizing in its scope the interest in sustainability and sustainable development; to contribute to a more sustainable society.

Table 3: Bradford's Law.

Zone	No. Magazines	No. Titles	Percentages
Zone 1	12	157	34,06%
Zone 2	68	152	32,97%
Zone 3	152	152	32,97%

Source: Ramírez et al. (2023).

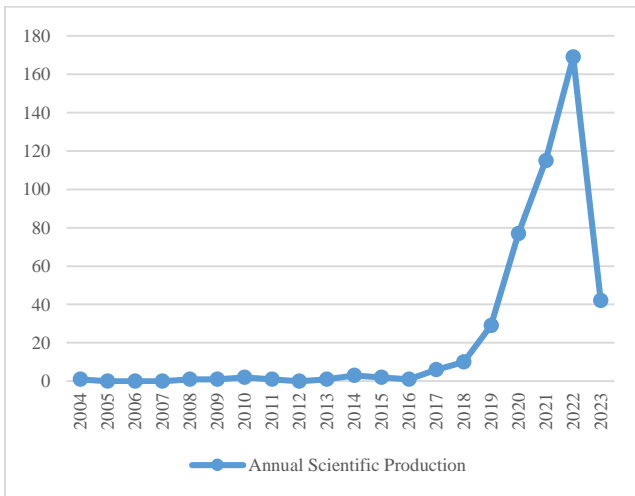


Source: Ramírez et al. (2023).

Figure 1: Bradford's Law

4.2. Bibliometric Indicators

Figure 1 highlights the years 2020(77), 2021(115) and 2022(169), in which there was a notable growth in publications related to the research topic and 78% of the entire publication is concentrated. research carried out, indicating a clear interest in the research topic; It also shows that the annual scientific production related to the research topic is increasing, especially from 2017.



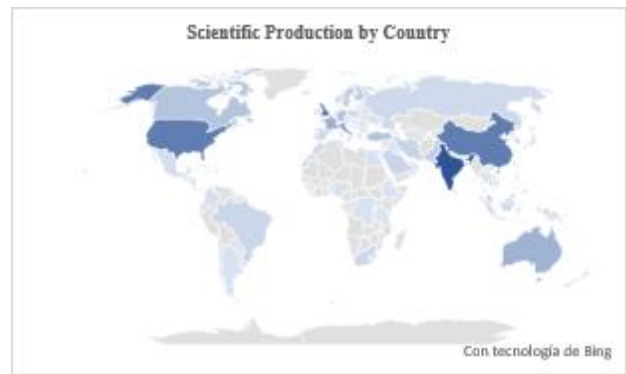
Source: Ramírez et al. (2023)

Figure 2: Annual Scientific Production

A geographical analysis was carried out in order to know the countries in which they have published the most regarding the research topic; Figure 3 shows the map of the countries that make contributions in the field of study, those

in dark blue are the ones that contribute the most, India (84), United Kingdom (70), China (60), United States (60) and Italy (48), these countries contribute 70% of all publications in the field of study.

According to the SCImago Journal Rank, India, the country with the most publications in this area, is the seventh country that publishes the most research and the United Kingdom is the third. At the same time, it should be noted that India, two of its research areas that have carried out the most publications in recent years, are computer science and engineering, within the latter, the field of industrial and manufacturing engineering stands out in relation to the subject.

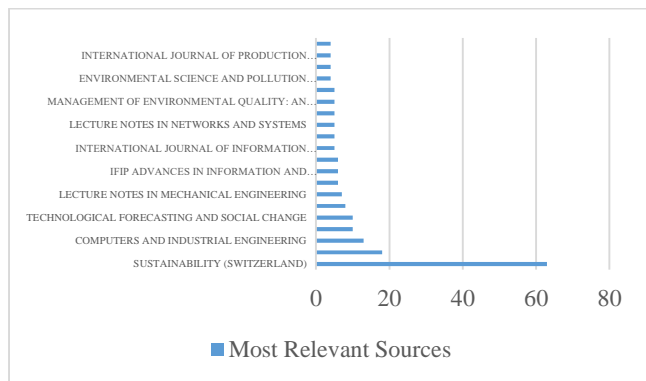


Source: Ramírez et al. (2023)

Figure 3: Scientific Production by Country

India concentrates 18% of all publications; some of his studies are aimed at the use of Blockchain technology in the food supply chain to achieve food security and contribute to the fulfillment of sustainable development goals 2 and 12 in terms of ending hunger and promoting sustainable agriculture through increased production and consumption of fruits and vegetables. Likewise, they address the importance and use of Industry 4.0 technologies for horticulture, including the Internet of Things, cloud computing, artificial intelligence, blockchain and big data, to advance current methods of disease screening, irrigation management, fertilizer management, maturity identification, marketing, supply chain management, soil fertility, and weather patterns in the run-up, during, and post-harvest period (Singh et al., 2022; Saha et al., 2022; Singh & Sharma, 2023; Chandan et al., 2023).

On the other hand, in the United Kingdom some of his research refers to Industry 4.0 and Blockchain technology and how they are transforming circular economy practices and business models; Blockchain technology as a critical enabler to accelerate the transition to a circular economy (Khan et al., 2021; Rejeb et al., 2022).



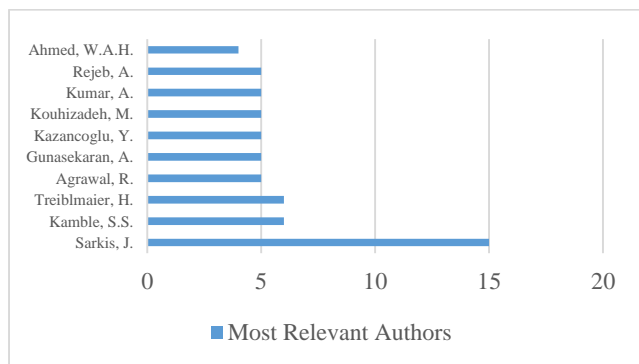
Source: Ramírez et al. (2023)

Figure 4: Most Relevant Sources

On the other hand, an analysis of the most relevant sources on the research topic was carried out; Figure 4 shows that the 4 journals that publish the most on the subject are Sustainability (Switzerland) (63), Journal of Cleaner Production (18), Computers and Industrial Engineering (13) and Business Strategy and the Environment (10).

The second most cited article in Sustainability Magazine (Switzerland) discusses how blockchain technology can influence the efficiency and growth of supply chain partnerships, which can affect performance results. It concludes that blockchain technology features such as information transparency, information immutability, and smart contracts have significant positive effects on the growth of partnerships.

On the other hand, the Journal of Cleaner Production magazine, the second with the most publications, some of its articles are aimed at the use of Blockchain technology and the internet of things in sustainable construction and, in turn, the digitization of the construction supply chain. (Li et al., 2021; Yevu et al., 2021). Production per author is low compared to the number of articles published from 2004 to 2023. As can be seen in figure 5, the author with the most published articles is Sarkis, J. with fifteen publications.

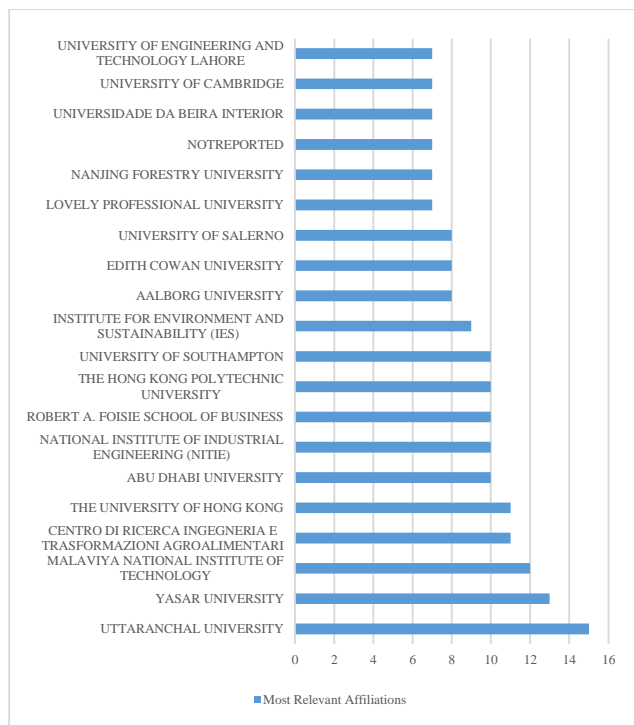


Source: Ramírez et al. (2023)

Figure 5: Most Relevant Authors

One of Sarkis, J. investigations is aimed at the creation of a results measurement framework for socially sustainable supply chains through valuation methods of environmental assets, a performance framework that allows companies to strategically measure social sustainability and the supply chain resilience.

This framework integrates the valuation of environmental assets to assess social sustainability and digitization through blockchain technology to improve the sustainability and resilience of supply chain processes (Hervani et al., 2022). In turn, Figure 6 shows the 20 institutions that have published the most research on the topic of study; Of these, the 5 most important can be highlighted: Uttaranchal University, Yasar University, Malaviya National Institute of Technology, Centro Di Ricerca Ingegneria e Trasformazioni Agroalimentari and The University of Hong Kong.



Source: Ramírez et al. (2023).

Figure 6: Most Relevant Affiliations

Table 4: Most Cited Articles

Articles	DOI	Total Citations
SABERI S, 2019, INT J PROD RES	10.1080/00207543.2018.1533261	1230
KSHETRI N, 2018, INT J INF MANAGE	10.1016/j.ijinfomgt.2017.12.005	846
KAMBLE SS, 2020, INT J INF MANAGE	10.1016/j.ijinfomgt.2019.05.023	363
KOUHIZADEH M, 2021, INT J PROD ECON	10.1016/j.ijpe.2020.107831	341
KAMBLE SS, 2020, INT J PROD ECON	10.1016/j.ijpe.2019.05.022	332
KOUHIZADEH M, 2018, SUSTAINABILITY	10.3390/su10103652	272
HASTIG GM, 2020, PROD OPER MANAGE	10.1111/poms.13147	266
FENG H, 2020, J CLEAN PROD	10.1016/j.jclepro.2020.121031	265
WONG L-W, 2020, INT J INF MANAGE	10.1016/j.ijinfomgt.2019.08.005	246
BAI C, 2020, INT J PROD RES	10.1080/00207543.2019.1708989	244
ESMAELIAN B, 2020, RESOUR CONSERV RECYCL	10.1016/j.resconrec.2020.105064	222
SHARMA R, 2020, COMP OPER RES	10.1016/j.cor.2020.104926	201
NANDI S, 2021, SUSTAIN PROD CONSUM	10.1016/j.spc.2020.10.019	195
CHOI T-M, 2019, TRANSP RES PART E LOGIST TRANSP REV	10.1016/j.tre.2019.09.019	191
GALANAKIS CM, 2021, TRENDS FOOD SCI TECHNOL	10.1016/j.tifs.2021.02.002	187
YADAV S, 2020, RESOUR CONSERV RECYCL	10.1016/j.resconrec.2019.104505	173
ASTILL J, 2019, TRENDS FOOD SCI TECHNOL	10.1016/j.tifs.2019.07.024	164
VENKATESH VG, 2020, ROB COMPUT INTEGR MANUF	10.1016/j.rcim.2019.101896	162
DI VAIO A, 2020, INT J INF MANAGE	10.1016/j.ijinfomgt.2019.09.010	159
UPADHYAY A, 2021, J CLEAN PROD	10.1016/j.jclepro.2021.126130	146

Source: Ramírez et al. (2023)

Table 4 shows the 20 publications with the most citations, the three most representative are SABERI S, 2019, INT J PROD RES, KSHETRI N, 2018, INT J INF

MANAGE and KAMBLE SS, 2020, INT J INF MANAGE; In this same sense, Table 5 contains a description of the ten most cited articles regarding the research topic.

Table 5: Ten most cited articles.

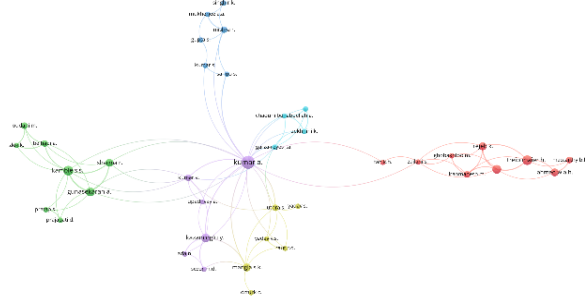
Highlight	Year	Source	Citation
Analysis of blockchain technology and smart contracts with a possible application to supply chain management.	2019	INT J PROD RES	(Saber et al., 2019)
Blockchain is likely to affect key supply chain management objectives such as cost, quality, speed, reliability, risk reduction, sustainability, and flexibility.	2018	INT J INF MANAGE	(Kshetri, 2018)
Taking advantage of the Blockchain to improve the performance of supply chains such as reducing the high number of intermediaries, payment delays and long transaction delivery times.	2020	INT J INF MANAGE	(Kamble et al., 2020)
Using the technology-organization-environment framework and force field theories to investigate barriers to Blockchain adoption for managing sustainable supply chains.	2021	INT J PROD ECON	(Kouhizadeh et al., 2021)
Study on the performance of the sustainable supply chain from the implementation of emerging technologies.	2020	INT J PROD ECON	(Kamble et al., 2020)
Use case of Blockchain technology in the generation of ecological supply chains.	2018	SUSTAINABILITY	(Kouhizadeh & Sarkis, 2018)
Use of the Blockchain to use supply chain traceability systems to identify business requirements and the critical factors of their implementation.	2020	PROD OPER MANAGE	(Hastig & Sodhi, 2020)
Use of Blockchain technology to identify solutions to address food traceability issues, highlight the benefits and challenges of implementing Blockchain-based traceability systems.	2020	J CLEAN PROD	(Feng et al., 2020)
Use of the Technology, Organization and Environment framework that allows investigating the advantages of Blockchain adoption for operations and supply chain management among small and medium-sized companies.	2020	INT J INF MANAGE	(Wong et al., 2020)

Highlight	Year	Source	Citation
Blockchain technology performance measures that incorporate various technical attributes and sustainable supply chain transparency.	2020	INT J PROD RES	(Bai & Sarkis, 2020)

Source: Ramírez et al. (2023)

4.3. Analysis of Relationships and Co-occurrences

The analysis of relationships and co-occurrences is done using the VOSviewer software, taking as a parameter that the author has a minimum of two documents and a minimum of two citations. The co-authorship analysis shows that of 1318 authors, 148 meet the parameters, of these only 39 have works with other authors, this is equivalent to 26%; We can see this in figure 7, in which six clusters can be identified.

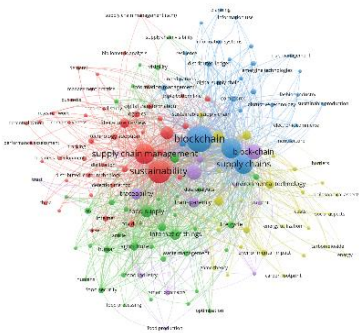


VOSviewer

Source: Ramírez et al. (2023)

Figure 7: Co-authorship Relationship

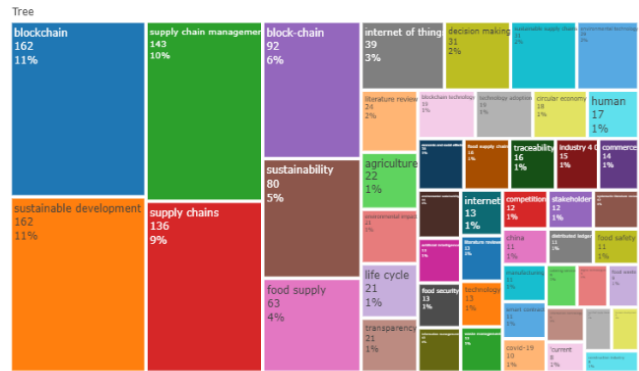
Finally, a keyword co-occurrence analysis was carried out, the parameter was that the minimum number of occurrences of a keyword is 5, out of 2729 words only 150 meet the parameter, this can be evidenced in figure 8 and figure 9 where 5 clusters are identified; The words blockchain, sustainable development, supply chain management, sustainability, food supply, internet of things and decision making can be highlighted.



VOSviewer

Source: Ramírez et al. (2023)

Figure 8: Co-occurrence of Keywords



Source: Ramírez et al. (2023)

Figure 9: Keywords

5. Discussion and Implications

Of the 461 documents analyzed in this bibliometric study carried out based on Scopus information on the Blockchain, it can be concluded that:

58% of the documents consulted are articles, 17% are conference articles and the remaining 25% are made up of other formats. The scientific production analyzed in the period from 2004 to 2023 shows a growing interest in the research topic, the highest peaks of publications occurred in the years 2020, 2021 and 2022 where 78% of the total published articles are concentrated.

India, the United Kingdom, China, the United States and Italy are the countries where 70% of all the publications that were generated in the research topic were published. On the other hand, the journals that publish the most on the subject are Sustainability (Switzerland), Journal of Cleaner Production, Computers and Industrial Engineering and Business Strategy and the Environment, which concentrate 23% of the publications, the rest of the publications are scattered among different magazines. In turn, the author with the most published articles is Sarkis, J. with fifteen publications; Taking into account that 88% of the researchers in this field are transient, likewise, the institutions that carry out the most research in the subject of study are Uttaranchal University, Yasar University, Malaviya National Institute of Technology, Centro Di Ricerca Ingegneria e Trasformazioni Agroalimentari and The University of Hong Kong that contribute 13% of the total publications.

With the analysis carried out, it has been shown that through the blockchain, pioneering companies in implementation have optimized and improved their processes for the creation of their products and their supply chain. It is evident that the transparency, traceability, efficiency and security of this technology has gained the trust of more companies and people, which can be seen in the statistics of the increase in popularity and search for the use of this tool (Kumar et al., 2023). The blockchain also reduces costs and intermediaries through smart contracts, which are self-executed by meeting conditions previously established by the parties that are in the supply chain. The tool guarantees the security of the process, leaving the possibility that the defined nodes establish the security of maintaining that stamp and traceability over time.

In this sense, the findings obtained from the investigative exercise carried out can be contrasted in the first instance with other studies associated with the application of 4.0 technologies in the various sectors of the economy and society, which emphasize the revitalization of processes and achieving sustainability of supply chains (Tavana et al., 2022; Alsadi et al., 2023). In the same way, the growing interest on the part of academics to delve into the subject is revealed due to the localized need for knowledge in the context (Morella et al., 2021).

In a more specific way, the studies associated with the blockchain as an emerging technology show a similar behavior by revealing an important growth of the matter, but with important deficiencies within the context of the benefits and opportunities of this (Rico-Pena et al., 2023). In turn, the importance of carrying out analyzes and tests on the functionalities of this technology and its weaknesses is recognized, so that it improves its operation to achieve the sustainability of supply chains (Fang et al., 2022).

It is therefore essential for the productive sector to quickly identify the functionalities offered by the blockchain for the transformation of supply chain processes towards sustainability. This framework invites managers and researchers to reassess sustainability as an opportunity for improvement and take the new technologies of 4.0 as catalysts towards a balance between the elements of the economic end and the contribution to a sustainable humanity.

Blockchain technologies still show an important path in their validation, improvement and application within society, which expectantly awaits the new functionalities and benefits that it can bring to the international context.

6. Suggestions for Future Research and Limitations

Once the results have been obtained and the conclusions of the investigative process established, it is important to

recognize that within it is located the limitation of the novelty of this type of technology and its functionalities at a scientific level. In the same way, this novelty also makes it difficult to identify certain trends within the area of blockchain knowledge applied to supply chains.

It is therefore recommended for future studies to analyze in a timely manner the aforementioned applications, challenges, benefits and weaknesses of blockchain technology within the framework of the reengineering of supply chains from sustainability. In turn, it is necessary to inquire about each of the 4.0 technologies separately and their integration as a whole. Finally, it recommends carrying out future studies that go beyond the observation process or documentaries that generate a contribution on cases of application and development of these technologies to promote sustainability practices and policies within the industry.

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