TRENDS IN SUPPLY CHAIN AND LOGISTICS RESEARCH IN THE CONTEXT OF THE INTERNET OF THINGS: A BIBLIOMETRIC ANALYSIS

NESNELERİN İNTERNETİ VE TEDARİK ZİNCİRİ YÖNETİMİ KONUSUNA ODAKLANAN YAYINLAR

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ABSTRACT

The Internet of Things is among the important topics of recent years in the academic world and is known as Industry 4.0. This new technology relates to supply chain management, supply chain and logistics. Businesses want to be competitive in their supply chain processes by using internet of things technologies. Businesses want to do more efficient work at lower costs. It is necessary to use internet of things technologies for features such as speed, which is an important factor in supply chain processes. Due to the importance of the subject, this study focuses on the Internet of Things. Bibliometric analysis method was used in the review. The bibliometric analysis method is important in terms of showing the general academic status of a field. Analyzes made with this method are important for the academic world and policy makers. In the bibliometric analysis conducted in this study; It is seen that internet of things and supply chain focused publications started to increase after 2004 and this increase continues. Analysis shows that the topic continues to be popular. Contributions are made to the internet of things and supply chain literature with the data obtained as a result of bibliometric analysis. This contribution is important as it shows the future of the sector. In the study; Only the WoS database was searched. For this reason, all publications on the subject could not be included in the study. Many databases around the world, other than WoS, keep track of scientific publications. This situation; constitutes the limitation of the study. In this article; it is important to give ideas to researchers and decision makers who are interested in the mentioned issues. Since the Internet of Things is a new trend, no bibliometric analysis with the same features as this study has been found in the accessible literature. Therefore, it is of great value for researchers who will conduct a literature review in this field of study or for those who are interested in the subject.

Keywords: Internet of things, supply chain management, supply chain, logistics, science mapping

ÖZET

Nesnelerin İnterneti (Internet of Things), son yıllarda akademik dünyada önemli konular arasında yer almakta olup Endüstri 4.0 olarak da bilinmektedir. Bu yeni teknoloji, tedarik zinciri yönetimi ile tedarik zinciri ve lojistik süreçleriyle ilişkilidir. İşletmeler, nesnelerin interneti teknolojilerini kullanarak tedarik zinciri süreçlerinde rekabetçi olmayı hedeflemektedir. Daha düşük maliyetlerle daha verimli çalışmalar yürütmek istemektedirler. Tedarik zinciri süreçlerinde önemli bir faktör olan hız gibi özelliklerin sağlanabilmesi için

nesnelerin interneti teknolojilerinin kullanılması gerekmektedir. Konunun önemi nedeniyle bu çalışma Nesnelerin İnterneti üzerine odaklanmaktadır. Çalışmada inceleme yöntemi olarak bibliyometrik analiz yöntemi kullanılmıştır. Bibliyometrik analiz yöntemi, bir alanın genel akademik durumunu ortaya koyması açısından önemlidir. Bu yöntemle yapılan analizler, akademik dünya ve politika yapıcılar için önemli bilgiler sunmaktadır. Bu çalışmada gerçekleştirilen bibliyometrik analiz sonucunda; nesnelerin interneti ve tedarik zinciri odaklı yayınların 2004 yılından sonra artmaya başladığı ve bu artışın devam ettiği görülmektedir. Analiz sonuçları, konunun popülerliğini sürdürdüğünü göstermektedir. Bibliyometrik analiz sonucunda elde edilen verilerle nesnelerin interneti ve tedarik zinciri literatürüne katkı sağlanmaktadır. Bu katkı, sektörün geleceğini göstermesi açısından önemlidir. Çalışmada yalnızca WoS (Web of Science) veri tabanı taranmıştır. Bu nedenle konuya ilişkin tüm yayınlar çalışmaya dâhil edilememiştir. WoS dışında dünya genelinde birçok veri tabanı bilimsel yayınları indekslemektedir. Bu durum çalışmanın sınırlılığını oluşturmaktadır. Bu makalede, belirtilen konularla ilgilenen araştırmacılara ve karar vericilere fikir verilmesi amaçlanmaktadır. Nesnelerin İnterneti yeni bir eğilim olduğundan, erişilebilir literatürde bu çalışmayla aynı özelliklere sahip bir bibliyometrik analize rastlanmamıştır. Bu nedenle çalışma, bu alanda literatür taraması yapacak araştırmacılar ve konuya ilgi duyan kişiler için büyük değer taşımaktadır.

Anahtar kelimeler: Nesnelerin interneti, tedarik zinciri yönetimi, tedarik zinciri, lojistik, bilimsel haritalama

1. INTRODUCTION

Digital technologies play a crucial role, particularly in defining the connections between companies and the relevant ecosystem when organizing logistics on an international scale. By utilizing digital technologies, companies can obtain high-value information and use this information to improve overall decision-making processes across all layers of global supply chains [1]. In recent years, the positive impact of logistics on increasing digitalization in businesses and enhancing inter-firm collaboration has been observed [2].

Modern Supply Chain Management (SCM) should be able to self-optimize and leverage contemporary technologies to grow. Examples of current technologies for SCM include the Internet of Things (IoT), machine learning, and blockchain. In this model, blockchain will eliminate trust issues, machine learning will ensure the flawless processing of significant data for businesses, and IoT will enable monitoring processes within the supply chain [3]. In short, employing technologies such as cloud computing, artificial intelligence, big data analytics, blockchain, and IoT in SCM applications will lead to more efficient process management [4]. Technology is essential for an environmentally conscious, socially aware, and sustainable SCM [5]. Companies now prefer to conduct their operations using fast and reliable technological solutions [6].

IoT technologies offer various advantages. Nowadays, supply chain members are connected through IoT technologies because many risks cannot be controlled by humans alone. IoT technologies should be used for a flexible and less risky supply chain. IoT reduces costs, completion time, and security risks while increasing efficiency and quality. A well-designed IoT structure is essential for accurately forecasting demands within the supply chain [7].

SCM and IoT have been popular research topics in recent years. For example, Khan et al. [8] have investigated IoT and sustainable SCM. Systematic literature reviews can be utilized in SCM research, as demonstrated in the study by Kunrath et al. [9]. The motivation for this study is based on the work done by Rejeb et al. [10]. This 2020 study focuses on the

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use of IoT in supply chain management and logistics. Besides the mentioned study, there are similar studies on the topic, but this study differs in aspects such as data sets, keywords, methods used in analysis, and programs used in the analysis. In some studies, the data set is older [11]. Another example focuses solely on supply chain management [12]. In a third example, a logistics-centered approach is taken [13][14]. In a fourth example, studies are directed towards the water and food supply chain [15][16]. Due to its different aspects from the mentioned examples, this study has a unique structure and supports the literature in this field.

In this study, the bibliometric analysis method was used. Bibliometric analysis is an important method for providing an overview of the research topic. The aim of this analysis is to present a comprehensive view of publications focused on the Internet of Things and supply chain and logistics. The study is valuable in terms of providing the characteristics of the literature on the mentioned topics. This study will contribute to the literature on the Internet of Things and supply chain management. The study is valuable in addressing the gap in the literature on this field.

2.Literature Review

2.1. Publications Focusing on IoT and SCM

Table 1 contains publications examining IoT and SCM issues together. Publications highlight the importance of digitalization in the field of SCM. In some publications, the subject of SCM is discussed together with Industry 4.0 components and IoT is considered as an Industry 4.0 component. In addition, IoT; It is also evaluated together with technologies such as cloud computing, blockchain and machine learning.

Table 1. Publications researching IoT and SCM

SN	Author	Description-Short Publication Title
1	[17]	SCM using an industrial IOT
2	[18]	Application of the IoT in logistics
3	[19]	Digitalization of SCM with industry 4.0
4	[20]	Industry 5.0 in SCM
5	[21]	Designing SCM using cloud computing and the IoT
6	[22]	Intelligent system utilizing blockchain, IoT and machine learning for SCM
7	[23]	Exploring the relationship between digitalization, SCM and firm performance
8	[24]	Supply chain integrated with blockchain and IoT to track the logistics of products
9	[25]	IoT based perspective view of traceability supply chain using optimized classifier algorithm
10	[26]	RFID authentication protocol for supply chain in the domain of 5G mobile computing
11	[27]	Evaluation of the service capability of logistics enterprises based on IoT supply chain system
12	[28]	A systematic literature review for sustainable supply chain 4.0.
13	[29]	Blockchain and IoT for SCM
14	[30]	The impact of industry 4.0 technologies on a resilient supply chain
15	[31]	IoT Implementation in Automotive Sector

3. Research methodology

2.1. Publications Focusing on IoT and SCM

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15	[31]	IoT Implementation in Automotive Sector

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2.2. Publications Focusing on IoT and Logistics

Table 3 contains publications examining IoT and logistics issues together. Some researchers associate smart logistics with information and communication technologies, and these technologies include many technologies such as IoT, AI, Blockchain, Cloud computing and 5G [32]. More than one technology can be examined together, such as IoT technologies and ensuring security with blockchain in the use of these technologies in the logistics sector [33].

Table 3. Publications researching IoT and Logistics

SN	Author	Description – Short Publication Title
1	[34]	IoT-Based Information System in Logistics 4.0
2	[35]	Regenerating the logistics industry through the Physical Internet Paradigm
3	[36]	IoT and blockchain based logistics application
4	[37]	E-Commerce Logistics and Optimization of Internet of Things Network
5	[38]	IoT-Based Emergency Logistics
6	[39]	Logistics parks and IoT
7	[40]	Big Data, Cloud Computing and IoT: Logistics Security
8	[41]	Green Logistic System
9	[42]	IoT and sustainability performance of logistics industries
10	[43]	IoT-Based Supply Chain Management in Logistics: Risk Prediction System
11	[44]	IoT, logistics and blockchain technology
12	[45]	Dynamic packing approach for IoT and logistics
13	[46]	Smart logistics
14	[47]	IoT and space logistics system
15	[48]	IoT and Logistics scheduling optimization

3. Research methodology

The primary aim of this study is; To reveal the current status of academic publications covering IoT and supply chain issues.Toward this end, this study utilizes bibliometric analysis as an effective and usable method to examine the current scientific knowledge base on which IoT in SCM and logistics relies.

3.1. Bibliometric analysis

There are studies on the subject of IoT using the bibliometric analysis method. First; Security aspects of IoT-enabled smart grids [49]. Latter; Interaction between IoT and agriculture [50]. Third; IoT and situation assessment in healthcare [51].

In bibliometric analysis; publication year, countries, institutions, journals, authors, citations and keyword analysis, etc. can be used. It is possible to include tables and graphs for these in the research [52] [53] [54] [55] [56]. In this method, the data used can be limited to a certain time period [57] [58] [59].

3.2.Search strategy

On 26.04.2024, the WoS database was scanned using keywords. Browse query: ("internet of things" or "IoT" (Topic) and "supply chain " or logistics (Topic)). The scanning was done for the "title, abstract and author keywords fields" fields. The publication search covers the period between 2000-01-01 and 2023-12-31. In the scan for the specified time period, 4,216 publications were reached. 17 of these publications were not used due to lack of data. The obtained bibliometric data was analyzed using the R programming language bibliometrix library.

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3.3. Data Analysis

The science mapping technique is becoming increasingly important for more scientists and disciplines. In the scientific world, where the number of publications increases rapidly, conducting studies on these issues becomes more critical every day. Determining the characteristics of scientific fields is important information not only for scientists but also for policy makers. On such an important issue; The bibliometrix package can be used in bibliometric analysis in the R programming language. The Bibliometrix library allows the user to analyze flexibly [60]. There are many studies on the use of the mentioned package in the academic field [61] [62] [63] [64] [65].

3.4. Purpose of study

In this study; An overview of studies on internet of things and supply chain management, supply chain and logistics is shown. This study attempts to determine the characteristics and direction of academic interest in the mentioned topics. Research; The internet of things and supply chain management are important in terms of showing the characteristics of academic interest in supply chain and logistics issues. With this study, a contribution to the literature on the subject will be made and ideas will be given to researchers who want to work on the subject. In addition to researchers, both public and private sector representatives will shape their perspectives on the sector according to the results obtained here.

3.5. Data quality

The WoS database can be used in academic studies due to its features such as allowing systematic querying. There are academic studies conducted using the WoS database and this database is accepted in the scientific world [66] [67] [68].

3.6. Future Work

This work; The research can be expanded by searching on different databases. In addition, the subject can be approached from different perspectives by using different programs in analysis.

3.7. Limitations

In the study; Only the WoS database was searched.For this reason, all publications on the subject could not be included in the study. Many databases around the world, other than WoS, keep track of scientific publications. This situation; constitutes the limitation of the study.

3.8. Problem Formulation

In the study; Only the WoS database was searched.For this reason, all publications on the subject could not be included in the study. Many databases around the world, other than WoS, keep track of scientific publications. This situation; constitutes the limitation of the study. To shape the structure of this research; Based on the publications (Inspiring Publication, IP) that inspired the question, the following research questions were used:

• IP: [69].Research Question 1 (RQ1): Which years do the publications on the subject cover and what is the rate of international collaboration in the publications?

• IP: [70].Research Question 2 (RQ2): Which publications stand out in terms of country-author-institution?

• IP: [71].Research Question 3 (RQ3): Which publishers have the most publications on the subject and which journals receive the most citations from these local publications?

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• IP: [72].Research Question 4 (RQ4): Which authors have the most publications on the subject and which authors have the most citations from these local publications?

• IP: [73].Research Question 5 (RQ5): Is there multinationality in the responsible authors of publications?

• IP: [74].Research Question 6 (RQ6): Which country has the most citations?

• IP: [75].Research Question 7 (RQ7): Which article is the most cited?

4. Results and discussion

In this section, the data obtained from the literature review and bibliometric analysis are presented and the results will be discussed.

4.1. Descriptive Statistics

In bibliometric analysis, general statistics of publications can be examined [76]. In this context; The obtained publications cover the period 2004-2024. According to WoS records, the publications obtained have an H-index value of 136. When the statistics of the publications for the last 3 years are examined; 716 publications in 2021 have 17,118 citations, 813 publications in 2020 have 24,106 citations, and 647 publications in 2023 have 24,794 citations. This situation; It shows that interest in the subject continues and that it is an active area of academic study.

Figure 1. Descriptive statistics

Figure 1 contains the answers for RQ1. In terms of RQ1; The publications obtained on the subject cover the years 2004-2024. During this period, 1945 publishers produced 4199 publications and the annual increase rate of publications was 18.75%.11,568 authors, 367 of whom were single authors, contributed to the publications, and the international work rate of these authors was 30.46%. The studies have a 3.69% author rate per publication. A total of 9,117 keywords were used in the studies and a total of 142,651 publications were used.

4.2. Three-Field Analizi

In Figure 2, publications are examined in terms of country-author-institution and an answer to the question RQ2 is sought. According to this analysis, China ranks first as a

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country. The prominent author here is "Huan" and the prominent institution is "University of Hong Kong". Additionally, in this analysis, China stands out in the field with the contributions of more than 10 authors.
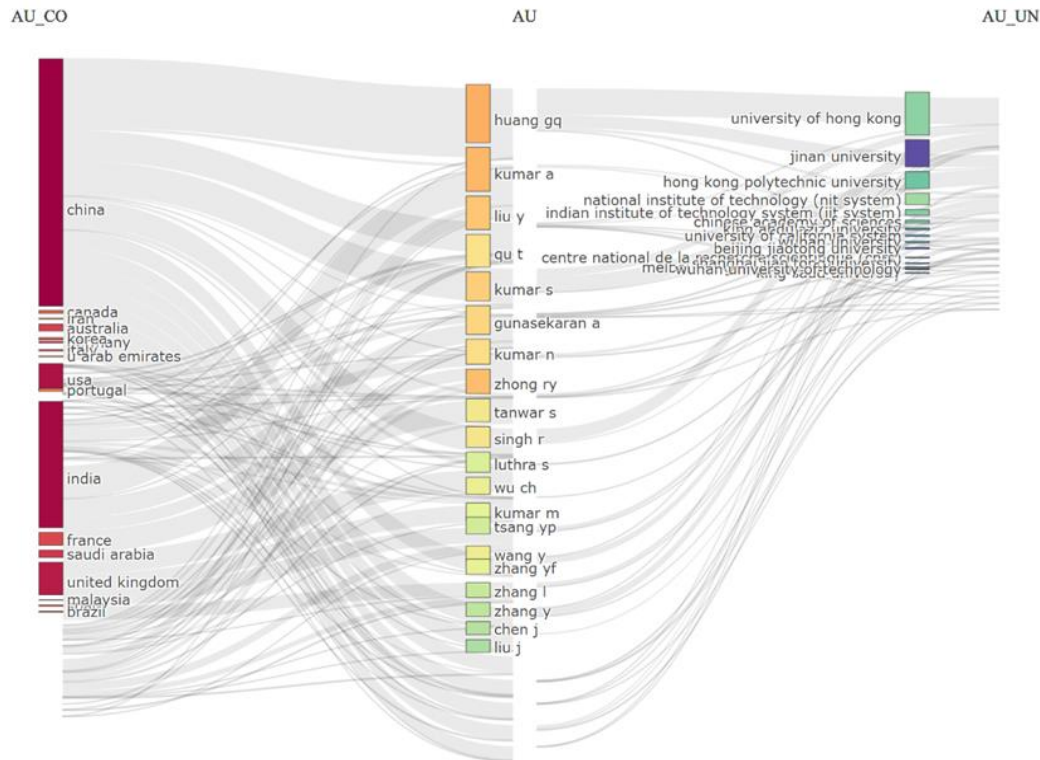

Figure 2. Examination of publications in terms of country-author-institution

4.3. Publisher Analytics

Table 4. Publishers with the most publications and publications with the most citations

Most Relevant Sources		Most Local Cited Sources	
Sources	Articles	Sources	Articles
Sensors	131	IEEE Access	4042
IEEE Access	128	Int J Prod Res	3607
Sustainability	124	J Clean Prod	3567
IEEE Internet of Things Journal	60	Int J Prod Econ	3122
Applied Sciences-Basel	56	Sustainability-Basel	2343
Computers & Industrial Engineering	42	Sensors-Basel	2133
Electronics	39	IEEE Internet Things	1998
International Journal of Production Research	37	IEEE T Ind Inform	1707
Journal of Cleaner Production	35	Future Gener Comp Sy	1623
International Journal of Production Economics	29	Comput Ind Eng	1616

Table 4 contains the answers to question RQ3. In this context; The journals that published the most on the research topic were "Sensors", "IEEE Access" and "IEEE Internet of Things Journal", respectively. The most cited journals in terms of publications obtained locally as a result of the search were "IEEE Access", "Int J Prod Res" and "J Clean Prod", respectively.

4.4. Author Analysis

Table 5. Author analyzes

Most Relevant Authors			Most Local Cited Authors	
Authors	Articles	Articles Fractionalized	Author	Localcitations
Huang GQ	40	8,60	Huang GQ	287
Kumar A	22	4,65	Gunasekaran A	286
Zhong RY	22	5,50	Zhong RY	237
Liu Y	21	4,30	Bahroun Z	198
Kumar S	18	4,14	Ben-Daya M	198
Gunasekaran A	17	4,52	Hassini E	198
Kumar N	15	3,67	Xu LD	197
Qu T	15	2,68	Choy KL	194
Singh R	15	3,56	Kamble SS	166
Tanwar S	13	2,34	Beulens AJM	150

Table 5 contains author analyses. Accordingly, the author with both the most publications and the most publications was "Huan GQ". The author's total publication has reached 287 citations (locally).

4.5. Multinationality Analysis in Corresponding Authors

Table 6. Multinationality in Responsible Authors of Publications

Country	Articles	SCP	MCP	Freq	MCP_Ratio
China	1164	918	246	0,277	0,211
India	425	318	107	0,101	0,252
USA	276	190	86	0,066	0,312
United Kingdom	172	82	90	0,041	0,523
Germany	157	121	36	0,037	0,229
Italy	148	107	41	0,035	0,277
Korea	130	92	38	0,031	0,292
Australia	106	60	46	0,025	0,434
France	90	51	39	0,021	0,433
Saudi Arabia	89	46	43	0,021	0,483

Research question RQ5 concerns the multinationality of the corresponding authors of publications by country. According to Table 5, the 10 countries with the most publications have authors from a different nationality.

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4.6. Most Cited Countries

Table 7. List of Most Cited Countries

Country	TC	Average Article Citations
China	17485	15,00
USA	13342	48,30
India	6948	16,30
United Kingdom	6597	38,40
Italy	3992	27,00
Germany	3622	23,10
Australia	3110	29,30
Korea	2941	22,60
France	2413	26,80
Brazil	2170	31,00

Table 7 contains the answer to RQ6. This table lists the countries with the most citations. China has the most citations, with 17,485. In contrast, China has an average article citation value of only 15.00. It is seen that countries with fewer citations have a higher average citation value than China.

4.7. Most Cited Publications Globally

In this section, the list of publications is given in terms of all the citations they received, not just the publications obtained as a result of the search. The most cited article; Zhong et al. It is a study titled "Intelligent Manufacturing in the Context of Industry 4.0: A Review" conducted by in 2017. There are 1,282 publications received by this publication.

Table 8. Most Cited Publications Globally

Paper	Citations	DOI	Total Citations	TC per Year	Normalized TC
Zhong RY, 2017, Engineering-Prc	[77]	10.1016/J.ENG.2017.05.015	1282	160,25	25,44
Lee I, 2015, Bus Horizons	[78]	10.1016/j.bushor.2015.03.008	1270	127,00	32,09
Frank AG, 2019, Int J Prod Econ	[79]	10.1016/j.ijpe.2019.01.004	1169	194,83	35,01
Wolfert S, 2017, Agr Syst	[80]	10.1016/j.agsy.2017.01.023	1155	144,38	22,92
Li SC, 2015, Inform Syst Front	[81]	10.1007/s10796-014-9492-7	926	92,60	23,40
Oztemel E, 2020, J Intell Manuf	[82]	10.1007/s10845-018-1433-8	881	176,20	22,76
Hofmann E, 2017, Comput Ind	[83]	10.1016/j.compind.2017.04.002	871	108,88	17,28
Kshetri N, 2018, Int J Inform Manage	[84]	10.1016/j.ijinfomgt.2017.12.005	840	120,00	22,55
Casino F, 2019, Telemat Inform	[85]	10.1016/j.tele.2018.11.006	835	139,17	25,00
Jabbour ABLD, 2018, Ann Oper Res	[86]	10.1007/s10479-018-2772-8	604	86,29	16,22

Conclusions

Internet of things and supply chain management are topics that attract the attention of the academic world and it is possible to conduct literature studies on the subject [87]. Studies on this subject include bibliometric studies conducted by scanning the WoS database [88]. In

this study, the Internet of Things issue was examined with supply chain management, supply chain and logistics issues. The bibliometric analysis method was used in the review and the data for analysis was obtained from the WoS database. Within the scope of this research, answers were sought to the following research questions:

RQ1: It is seen that publications on the subject were made between 2004 and 2024, and the international collaboration of the authors in these publications was 30.46%.

RQ2: The prominent country was "China", the author was "Huan" and the affiliated institution was "University of Hong Kong".

RQ3: It is seen that the most publications on the subject are called sensors, and according to the publications obtained as a result of the search, the most cited journal locally is "IEEE Access".

RQ4: The author who has the most publications on the subject and has received the most publications is "Huan GQ".

RQ5: According to countries, some of the responsible authors of publications are multinational.

RQ6: The highest number of citations, with 17,485, was received by researchers of Chinese origin.

RQ7: Zhong et al. The article titled "Intelligent Manufacturing in the Context of Industry 4.0: A Review" published by 2017 is the most cited publication with 1,282 citations.

This study focuses on the Internet of Things; It provides the intellectual accumulation of studies focused on supply chain, supply chain management and logistics. The results show that the research area of IoT has expanded in recent years and has found a wide-ranging application area focused on supply chain/logistics. It is seen that the interest in the subject, which mostly attracts researchers from China and the USA, started in 2004. With research; Contributions are made to the literature in this field. This work; It is important to give ideas to researchers and decision makers who are interested in the mentioned issues.

Data availability

Query link: https://www.webofscience.com/wos/woscc/summary/5e70d91c-f02e-4631-9bc4-b5109db46604-ec0eec30/relevance/1

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