

# Collaborative Landscape and Knowledge Dynamics in IoT and Blockchain Research: A Bibliometric Analysis

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**Abstract**—This research article presents a bibliometric analysis of the intersection between Internet of Things (IoT) and Blockchain, utilizing data sourced from the Web of Science database. The analysis employs the VOSviewer tool to investigate cocitation, co-occurrence, and bibliometric correlations among the publications. The findings indicate a surge in publications, with the highest number recorded in 2022, reflecting the growing interest and significance of this research area. Moreover, the analysis reveals China as the leading country in terms of research output, underscoring its active involvement in IoT and Blockchain research. Additionally, the study identifies IEEE Access as the leading publisher, indicating its prominence in disseminating relevant research. Notably, the analysis of keywords reveals "blockchain" as the most frequently occurring term, highlighting its central role in the field. These findings contribute to a better understanding of the research landscape in IoT and Blockchain, providing insights into collaboration patterns, influential countries, leading publishers, and the prominence of blockchain as a research topic.

**Keywords**-IoT, Blockchain, bibliometric analysis, Web of Science, VOSviewer, cocitation, co-occurrence, etc.

## I. INTRODUCTION

The Internet of Things (IoT) and blockchain are two technologies that have received a lot of attention in recent years due to their rapid development and increasing applicability. The Internet of Things (IoT) is a system of devices that can exchange information and work together to gather and process massive volumes of data. Blockchain, on the other hand, is a distributed and secure ledger technology that makes it possible to record transactions in a way that is both public and immutable. The

Internet of Things and blockchain technology have the potential to disrupt many different markets, from healthcare and supply chain management to finance and energy.

By bringing together the advantages of distributed ledger technology and the Internet of Things, new problems could be solved and opportunities presented. IoT applications and business models can benefit from blockchain technology since it helps solve problems like data integrity, privacy, and security.

Researchers, practitioners, and policymakers alike can all benefit from having a firm grasp on where the area of IoT and blockchain research now stands. The current state of knowledge in this area can be better understood by conducting a thorough literature review. Such understanding can help academics understand the present research landscape, spot knowledge gaps, and zero in on promising new fields. A bibliometric study can help practitioners make better decisions by identifying and highlighting the most important authors, publications, and research subjects. This study can be used by policymakers to zero in on specific problems and design targeted solutions.

## II. LITERATURE REVIEW

The application of blockchain technology and its consensus algorithms is also the subject of one of the types of research [5]. The results of this bibliometric study are as follows: The United States, China, and Germany are the most active countries in blockchain publication, in that order; researchers are beginning to adopt blockchain in the healthcare area; the United States is the most active country in blockchain publication; and Switzerland and Singapore are two small size countries that published few publications, but receives many citations. With the exception of Canada, India, and Brazil, research publications increased as a result of international collaborations. Data privacy, digital storage, data security, big data, and distributed databases are just few of the areas where researchers are beginning to use blockchain as a solution. The importance of the algorithm and its widespread acceptance were also addressed in this study.

In another article [6], the bibliometric analysis tools CiteSpace and VOSviewer were used to gain an in-depth understanding of blockchain technology and its present research focus. For this study, researchers relied heavily on data from the Web of Science core collection database. A total of 3826 papers published between 2013 and 2020 were used to compile the data. In this respect, the patterns and types of publications may shed light on the directions and foci of recent blockchain research. This bibliometric study included the world's most renowned researchers, as well as the leading publications, libraries, countries, and research institutes. Smart contracts, bitcoin, security, Ethereum, and cryptography dominated the theoretical understanding and popular research into blockchain. To identify developing tendencies and new frontiers in blockchain, a cluster analysis was performed from a keyword perspective. The findings highlighted the need for more investigation into areas such smart home technology, machine learning, energy, blockchain technology, and management.

In one of the studies [7], researchers used Scopus to undertake a bibliometric analysis of all scholarly articles on the topic of IoT and Blockchain integration. Annual publishing and citation patterns, most-cited papers, most-used keywords, and

most-used publication venues are just some of the things we looked at when analysing the compiled papers.

## III. BIBLIOMETRIC ANALYSIS

A bibliometric analysis is warranted because it allows for a systematic and quantitative evaluation of the field of study as a whole [1][2]. Publication output, authorship patterns, citation networks, and keywords can all be analyzed in a bibliometric study to unearth previously unknown linkages, gaps, and patterns in the literature. It provides a holistic view of how study of the Internet of Things and blockchain has developed over time. The analysis can also reveal the knowledge structure and collaborative networks in the subject by highlighting the most important authors, research institutions, and journals.

This study intends to add to the existing body of knowledge and give a thorough overview of the present state of research by conducting a bibliometric analysis of IoT and blockchain studies. Using this approach, we will be able to reveal significant themes in the study, single out leading researchers and institutions, and highlight cross-disciplinary links. These results will not only improve our familiarity with the subject matter, but they will also guide future studies and foster new prospects for teamwork. The ultimate goal of this study is to facilitate the creation of novel solutions that leverage both the Internet of Things and blockchain technology.

Scientific literature, especially academic publications, can be evaluated and analyzed quantitatively through the use of bibliometric analysis. Bibliographic data like as citation counts, publication patterns, and authorship are analyzed using statistical and analytical methods.

The major goal of bibliometric analysis is to gain insights into the organization, output, influence, and trends of a study field or of research in general [3][4]. It aids academics, institutions, and policymakers in gauging the significance of specific works, authors, journals, or fields of study.

Bibliometric analysis often makes use of the following elements and metrics:

- Citation analysis: It entails studying the references referenced in a publication and analyzing the citation trends. It's useful for gauging how much weight a given article/ book or author carries in a given discipline.
- Bibliographic coupling and cocitation analysis: These methods examine the relationships between texts based on their shared citations. Cocitation analysis looks at how often two publications appear together in the citation lists of other works, whereas bibliographic coupling emphasizes the similarity of reference lists. These techniques can show interconnected research efforts, single out seminal publications, and monitor how certain fields of study evolve over time.

- Productivity and collaboration analysis: These analyses look at publication trends, such as the number of publications by authors, institutions, or nations. In order to determine which researchers or institutions produce the most results, they examine collaborative patterns like co-authorship networks and calculate the effect of collaboration on research production.
- Journal impact analysis: This assesses the impact and influence of academic publications within a certain topic. Journal impact factor is a common metric used in this context; it represents the average number of citations an article published in a journal receives over time.
- Mapping and research trends: Bibliometric analysis can be used to detect new research directions, monitor how a field develops over time, and graphically display the relationships between various fields of study. Several methods exist for this, including keyword analysis, co-word analysis, and topic modelling.

Research, funding choices, rankings of institutions, and evaluations of policies are just some of the numerous areas one might find bibliometric analysis at work. To provide a full picture of the significance and quality of research, qualitative

assessments should be combined with the quantitative indications provided by bibliometric analysis.

To conduct the bibliometric analysis, a comprehensive dataset of relevant scientific publications on IoT and blockchain is collected. The data is primarily sourced from the Web of Science database, which is a widely recognized and reliable source for scholarly literature. The search is conducted using specific keywords related to IoT and blockchain individually, as well as titles that include both IoT and blockchain to capture publications specifically focused on the intersection of these technologies.

The selection criteria for the publications include relevance to IoT and blockchain, availability of complete bibliographic information, and a sufficient level of scientific rigor.

#### IV. METHODOLOGY

Let us break down the process in a simpler way as per the diagram shown in figure 1:

- Stage 1: We start by selecting a database, and in this case, we choose the Web of Science database. This database contains a lot of useful information that we'll analyze.

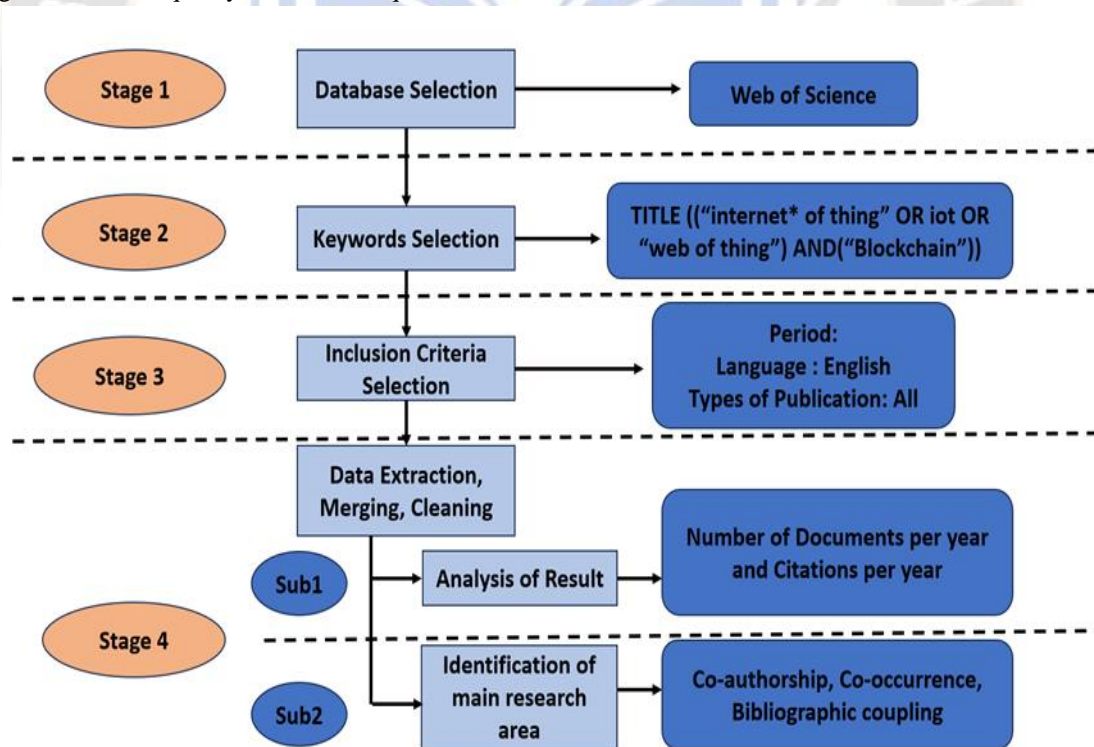


Figure 1: Steps of Bibliometric analysis for IoT and Blockchain research.

- Stage 2: Next, we extract the data from the database based on specific criteria. In this stage, we focus on extracting the titles of the documents. We use keywords

like "Internet of Things," "IoT," "Web of Things," and "Blockchain" to find the relevant data.

- Stage 3: Now we move on to selecting the data that meets our criteria. We narrow down the timeframe from

2016 to 2023 and include all types of publications written in English. After this selection process, we have a total of 2083 documents from different fields.

To manage this large amount of data, we divide it into three parts or slots. Each slot contains a maximum of 1000 columns. We extract the data in both .csv and .txt file formats for easier analysis. Then the files were merged.

- Stage 4: This stage is divided into two sub-stages. In substage 1, we analyze the data based on the number of publications per year. We also take into account the number of citations received by each publication. This helps us understand the growth and impact of the research. In substage 2, we utilize a tool called VOSviewer for bibliometric analysis. [21][22] VOSviewer assists us in exploring intricate connections and patterns within the data.

By following these stages, we aim to gain valuable insights from the data collected and enhance our understanding of the topics related to the Internet of Things, Blockchain, and more.

### V. DATA ANALYSIS

Once we have merged the extracted documents and obtained the data, we can begin the analysis. Publication years among the 2083 extraction started in 2016 and are still going strong as of this year. Figure 2 displays a graph depicting the annual publication count dispersion.

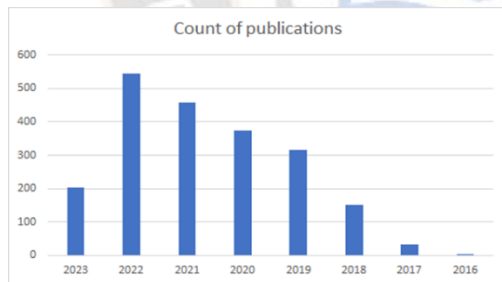


Figure 2: Graph depicting the annual publication count dispersion.

We also found that publications published in 2019 received the most citations, while papers published in 2023 received the fewest. One can view a graph depicting the breakdown of citations by publication year in figure 3. We have also broken down the various types of publications included in this total. The information is depicted in the figure 4 below.

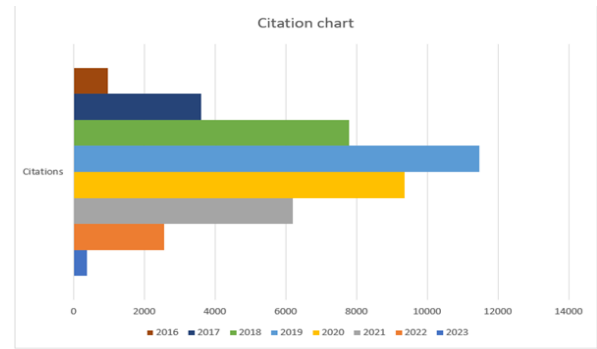


Figure 3: Breakdown of citations by publication year

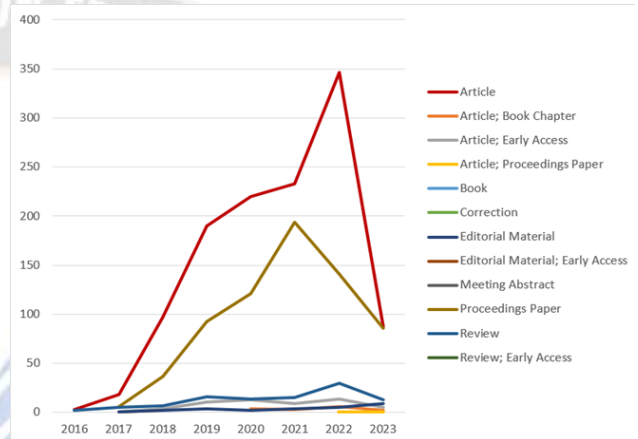


Figure 4: Distribution of count of type of publication over years.

### VI. COAUTHORSHIP ANALYSIS:

Coauthorship analysis is an important component of bibliometric analysis, which involves studying the patterns and characteristics of coauthorship relationships among researchers. It provides insights into collaborations and networks within a scientific or academic community, allowing researchers to understand the dynamics of knowledge production and dissemination.

Here are some key aspects of coauthorship analysis in bibliometric analysis:

- Coauthorship networks: Coauthorship analysis helps in constructing coauthorship networks, where researchers are represented as nodes, and their coauthorship relationships are represented as links or edges. These networks visualize the collaborations and connections between researchers, and various network analysis techniques can be applied to understand the structure and properties of the network.
- Collaboration patterns: Coauthorship analysis reveals patterns of collaboration among researchers. It helps identify prolific authors, research groups, or institutions that frequently collaborate and produce influential work. By examining collaboration patterns, researchers can gain insights into interdisciplinary collaborations, the

formation of research clusters, and the dissemination of knowledge across different domains.

- Author productivity and impact: Coauthorship analysis can be used to measure the productivity and impact of individual authors or research groups. Metrics such as the number of publications, coauthorship centrality, or the number of citations received can provide quantitative measures of productivity and influence. These metrics can help evaluate the research output of authors or groups and identify influential contributors.
- Collaboration dynamics: Coauthorship analysis allows researchers to study the dynamics of collaborations over time. By analyzing coauthorship patterns in successive time periods, researchers can identify emerging collaborations, changes in collaboration networks, and the evolution of research communities. This information can be valuable for understanding research trends and the development of scientific fields.
- Collaboration types and characteristics: Coauthorship analysis enables the identification of different types of collaborations, such as international collaborations, inter-institutional collaborations, or collaborations between researchers from different disciplines.

Researchers can explore the characteristics of these collaborations, such as geographic distribution, institutional affiliations, or subject areas, to gain a comprehensive understanding of the collaborative landscape.

- Coauthorship indicators: Coauthorship analysis can generate various indicators that help evaluate research collaborations. Examples include measures like average number of authors per paper, average degree of collaboration, or collaboration diversity indices. These indicators provide quantitative information about the extent and nature of collaborations within a research community.

We've identified ten of the most influential authors in this area. Documents were ranked from 1 to 10 based on their link weights, total link strengths, and overall weights. Choo, Kimkwang Raymond is at the top of the list, as seen in the table 1 below. Therefore, working together with these authors can improve the research. Figure 5 displays the same thing.

The table 2 below displays the results of a ranking of the cooperation of various countries. China is in first place, followed by India and then the United States. The data in the figure 6 demonstrates how countries lower on the list can benefit from working with these nations.

Table 1: Top 10 authors from coauthorship analysis

Si No.	ID	Country	Cluster	Calculated weight			
				Links	Total link strength	Documents	Citations
1	60	Peoples R China	8	49	572	693	15051
2	32	India	2	50	333	349	5578
3	88	USA	8	47	359	294	7564
4	69	Saudi Arabia	1	40	301	193	2749
5	76	South Korea	6	32	182	164	4273
6	3	Australia	3	39	194	152	4479
7	13	Canada	8	32	194	135	3028
8	22	England	2	47	233	134	3804
9	58	Pakistan	3	35	175	103	2712
10	38	Italy	1	31	67	83	1616

Table 2: Top 10 authors from coauthorship analysis

Si.No.	ID	Author	Cluster	Calculated Weight		
				Links	Total link strength	Documents
1	1083	Choo, Kim-kwang Raymond	3	14	21	23
2	1779	Guizani, Mohsen	3	13	24	18
3	1201	Das, Ashok Kumar	1	7	23	16
4	4768	Srivastava, Gautam	10	10	22	16
5	5770	Yu, F. Richard	6	9	27	15
6	2734	Kumar, Neeraj	1	13	19	14
7	4545	Sharma, Pradip Kumar	2	7	17	10
8	4682	Singh, Saurabh	2	7	12	8
9	1597	Gadekallu, Thippa Reddy	2	9	11	7
10	1646	Garg, Sahil	5	8	13	5

Coauthorship analysis is a valuable tool in bibliometric analysis as it uncovers collaboration networks, identifies influential researchers and research groups, and offers insights into the dynamics of knowledge creation. It complements other bibliometric methods and contributes to a deeper understanding of research landscapes, interdisciplinary collaborations, and the impact of research outputs.

## VII. CO-OCCURRENCE

Co-occurrence analysis is a method used to examine the relationships and associations between terms or entities within a dataset. It involves analyzing the frequency with which different terms appear together in the same context, such as documents, texts, or records. Co-occurrence analysis for all terms is critical in bibliometric analysis for the following reasons:

- **Knowledge Integration:** By examining the associations between all keywords in a dataset, co-occurrence analysis enables for the integration of varied knowledge. It aids in the identification of linkages and associations that may not be apparent through individual keyword research. Researchers can acquire a thorough knowledge of the interplay between distinct concepts and their relevance in the literature by considering the co-occurrence of all keywords.
- **Conceptual Mapping:** By analyzing the co-occurrence of all keywords, conceptual maps or networks that illustrate the relationships between distinct ideas or topics can be created. These maps give researchers an overview of a field's intellectual structure, allowing them to discover clusters, subfields, or areas of interest. Conceptual maps aid in the identification of the most influential or central concepts, as well as their linkages and interdependencies.

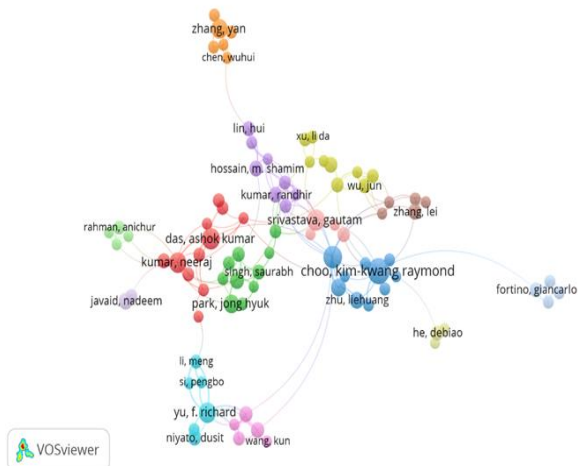


Figure 5: Coauthorship analysis (authors)

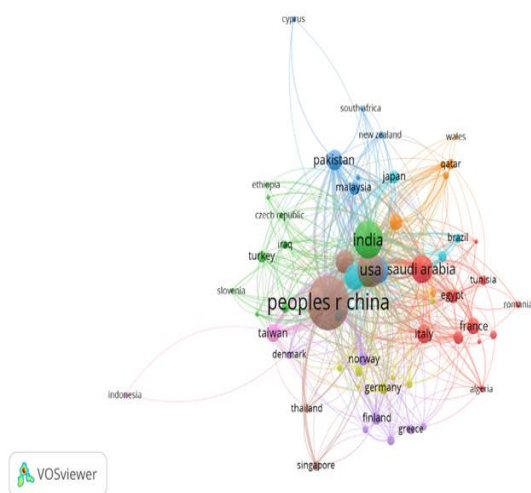


Figure 6: Coauthorship analysis (country)



- **Research Evaluation and Decision Making:** Cocitation analysis is used in research evaluation to assess the impact and influence of scholarly works. It helps in identifying highly cited authors, influential journals, and impactful research areas. It supports decision-making processes for research funding, collaborations, and identifying potential research partners.
- **Literature Review and Information Retrieval:** Cocitation analysis aids in conducting comprehensive literature reviews by identifying relevant articles that are highly cocited with other key works. It helps researchers navigate through a large body of literature and retrieve articles that are central to a particular research topic or concept.

In our data for cocitation among sources we observed that IEEE Access is listed on top with maximum calculated link weight. For our analysis we took 200 as the minimum number of citations and 41 were found to meet this criterion out of 18784 sources. Top 10 sources and their details can be found in table 3.

Figure 8 shows the graphical representation of the links of 41 sources who meet this criterion. The link weight is 40 for all in this case because these sources are connected to every other node in the graph.

Cocitation analysis for most cited documents we found figure 9 and table 4 as a consequence of the analysis. Cocitation analysis is a valuable bibliometric method that provides insights into the intellectual structure of a field, identifies influential works, and facilitates research evaluation and decision making. It helps researchers understand the knowledge landscape, discover connections between articles, and stay informed about the latest trends and developments in their research domain.

### IX. BIBLIOGRAPHIC COUPLING

Significance of bibliometric analysis with countries as the unit of analysis Bibliometric analysis with countries as the unit of analysis provides valuable insights into the research landscape, collaboration patterns, and impact of different countries. Figure 10 below shows the result of our analysis. It supports decision-making processes in research funding, policy formulation, and international collaborations. Top 10 research countries on IoT and Blockchain can be seen in table 5. This analysis helps identify research leaders, emerging players, and areas for cooperation, ultimately contributing to the advancement of knowledge on a global scale.

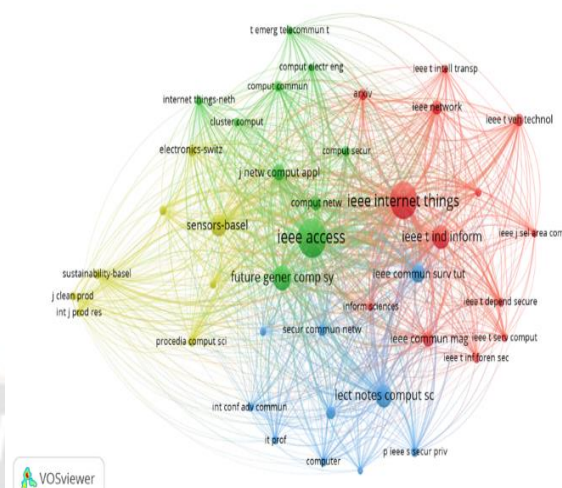


Figure 8: Sources of publication and their link

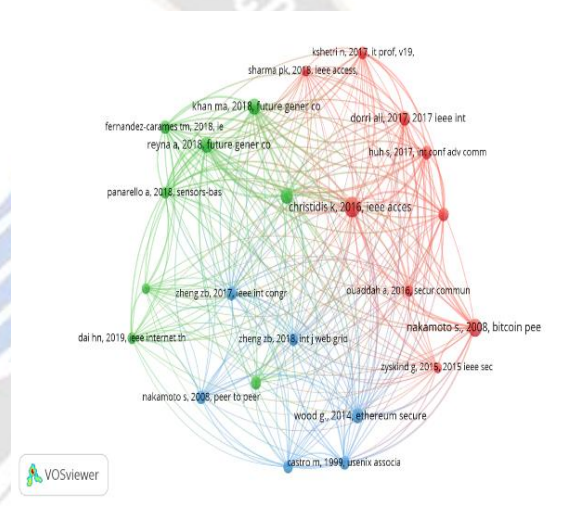


Figure 9: Cocitation analysis of cited reference

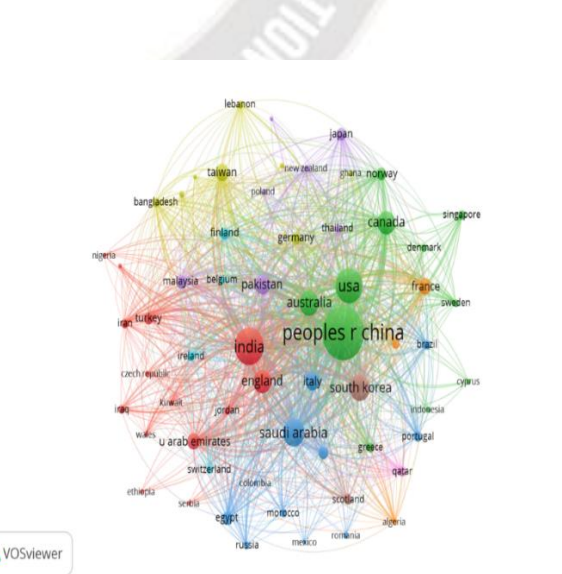


Figure 10: Bibliometric analysis with countries as unit of analysis



Table 3: Top 10 sources of publication

Si. No	ID	Source	Cluster	Calculated Weight		
				Links	Total link strength	Citations
1	8203	Ieee Access	2	40	94781	4433
2	8461	Ieee Internet Things	1	40	86348	3969
3	7341	Future Generation Computer Systems	2	40	43383	1829
4	8632	IEEE Transactions on Industrial Informatics	1	40	35961	1675
5	11655	Lecture Notes in Computer Science LNCS	3	40	29973	1579
6	16689	Sensors (Basel, Switzerland)	4	40	29733	1380
7	8251	IEEE Communications Surveys & Tutorials	3	40	29150	1031
8	11218	Journal of Network and Computer Applications	2	40	22841	795
9	8246	IEEE Communications Magazine	1	40	17185	744
10	8504	Ieee Network	1	40	15966	597

Table 4: Most cited papers meeting the crite

	Title	Reference	Cluster	Calculated Weight		
				Links	Total link strength	Citations
1	Blockchains and smart contracts for the internet of things	[11]	1	22	1032	336
2	IoT security: Review, blockchain solutions, and open challenges	[12]	2	22	839	226
3	On blockchain and its integration with IoT. Challenges and opportunities	[13]	2	22	768	216
4	Blockchain meets IoT: An architecture for scalable access management in IoT	[14]	2	22	723	227
5	Blockchain for IoT security and privacy: The case study of a smart home	[15]	1	22	659	166
6	Bitcoin: A Peer-to-Peer Electronic Cash System	[16]	1	20	621	261
7	Managing IoT devices using blockchain platform	[17]	1	22	615	152
8	A Review on the Use of Blockchain for the Internet of Things	[18]	2	22	586	151
9	Towards an optimized blockchain for IoT	[19]	1	22	560	143
10	An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends	[20]	3	22	506	153

- Research Landscape and Comparative Analysis: Bibliometric analysis with countries as the unit of analysis allows for a comprehensive understanding of

the research landscape on a global scale. It enables researchers to compare the scientific output, collaboration patterns, and impact of different

countries. This analysis provides insights into the strengths and weaknesses of countries in terms of their research contributions.

- **Identifying Research Leaders and Emerging Players:** By examining the publication output and citation impact of countries, bibliometric analysis helps identify research leaders who have made significant contributions to their fields. It also highlights emerging players and countries that are rapidly advancing in research areas. This information is valuable for recognizing research excellence and promoting collaboration opportunities.
- **Collaboration and Networking Opportunities:** Analyzing collaboration patterns between countries reveals opportunities for international research collaboration and networking. Identifying countries that frequently collaborate helps researchers and policymakers facilitate knowledge exchange, foster

partnerships, and promote interdisciplinary research initiatives.

- **Research Funding and Policy Decisions:** Bibliometric analysis with countries as the unit of analysis supports evidence-based decision-making in research funding and policy formulation. By understanding the research strengths and impact of different countries, policymakers can allocate resources effectively, promote strategic research initiatives, and identify areas for investment or collaboration.
- **Science Diplomacy and International Relations:** Bibliometric analysis contributes to science diplomacy and international relations by providing objective data on research collaborations and scientific impact. It helps foster cooperation between countries, build diplomatic relationships, and strengthen scientific ties. This analysis can be used as a basis for promoting international research cooperation and resolving global challenges through scientific collaboration.

Table 5: Bibliometric Analysis- Top 10 research countries on IoT and Blockchain

Si No	ID	Country	Cluster	Calculated weight			
				Links	Total link strength	Documents	Citations
1	60	Peoples R China	2	60	579299	693	15051
2	32	India	1	60	357488	349	5578
3	88	USA	2	60	319940	294	7564
4	69	Saudi Arabia	3	60	207876	193	2749
5	76	South Korea	8	60	163653	164	4273
6	3	Australia	2	60	239451	152	4479
7	13	Canada	2	60	128255	135	3028
8	22	England	1	60	166672	134	3804
9	58	Pakistan	5	60	145409	103	2712
10	38	Italy	3	60	95795	83	1616

- **Research Evaluation and Rankings:** The analysis of countries in bibliometric studies contributes to research evaluation and rankings. By considering the scientific output, citation impact, and collaboration patterns of countries, researchers can assess the performance and influence of research systems. This information is used in global university rankings, research assessments, and evaluations of national research policies.
- **Policy Monitoring and Benchmarking:** Bibliometric analysis with countries as the unit of analysis facilitates monitoring of research policies and benchmarking

against other countries. It helps policymakers track progress, evaluate the effectiveness of research policies, and make informed decisions to improve research performance.

#### X. CONCLUSION

Finally, bibliometric examination of IoT and Blockchain technologies provide light on their research landscape, trends, and impact. Bibliometric analysis helps academics track IoT and Blockchain research growth by examining scholarly publications, citations, and collaboration patterns. Bibliometric

analysis shows that IoT and Blockchain research has grown recently. An increasing number of publications indicates the growing interest and importance of these technologies in numerous sectors. It also identifies notable contributors, research institutions, and countries advancing these subjects. IoT and Blockchain research is similarly interdisciplinary, involving computer science, engineering, economics, and finance. This interdisciplinary approach acknowledges these technologies' broad applications and ramifications.

Bibliometric analysis also identifies IoT and Blockchain research trends, including subtopics, developing areas, and current research. This data helps academics and policymakers focus on promising areas of research and innovation. Citation analysis shows IoT and Blockchain research's influence. Researchers can find foundational works and thought leaders by reviewing highly cited publications and prominent authors. This helps grasp IoT and Blockchain research's core concepts, techniques, and theoretical frameworks. IoT and Blockchain bibliometric analysis aids scholars, policymakers, and industry experts. It supports strategic planning, evidence-based decision-making, and collaboration opportunities. Bibliographic analysis illuminates the research landscape and impact, advancing understanding in these continuously changing disciplines.

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