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What is Core and What Future Holds for Blockchain Technologies and Cryptocurrencies: A Bibliometric Analysis

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ABSTRACT A new era awaits the development of cryptocurrency and blockchain technologies. This study highlights the influential and conceptual aspects of blockchain and cryptocurrency literature with bibliometric analysis. There are 1965 related documents from 2015 and 2020, represent various structures and technologies, cryptocurrencies, and blockchain applications. We have deployed "bibliometrix 3.0", the r-package, and VOS viewer to analyze key literature aspects. IEEE Access is the core journal for cryptocurrency and blockchain publications. The University of Cagliari, Notreported, and Peking University are key affiliations, and the USA, China, and India are core countries for literary research. H. Wang is the core author with the central theme of security of blockchain technologies. It is a set basis for conceptual aspects, core, and future research streams and themes. The study proposes three research streams: the structure of cryptocurrencies and implications of blockchain technologies, privacy, security management of data and information, and development of optimal information systems. The study further segregates themes into highly centralized and motor themes that are also core themes. Topics related to Consensus protocols, proof of work, distribution ledger technology, blockchain, and cryptocurrency procedures and structure comes under core themes. Highly developed and emerging themes are considered as a stepping stone for future directions. Underlying topics are related to fintech, Islamic finance, valuations, and dynamics of cryptocurrencies.

INDEX TERMS Blockchain, Bitcoin, Bibliometric Analysis, Cryptocurrency, Digital Currency, Litecoin, Ripple, Security

I. INTRODUCTION

The mode of a transaction has substantially evolved in the current decade due to the advancement in technology. The application of sophisticated technologies like blockchain protocols or distributed-ledgers in the financial technology sector has geared the attention of many financial experts, investment analysts, and technologists towards cryptocurrencies [1]. Blockchain technology has made business processes simple while maintaining a secure record of transactions. The financial sector seems to be the primary user of it due to its application in the cryptocurrency, bitcoin [2], but its usage is not limited to the financial sector. It can accelerate change in different fields of our routine life [3]. It promotes digital payment systems, facilitates shares issuance, trades on decentralized digital exchanges to promote smart contracts, and builds a direct relationship between parties without involving a mediator [4].

Therefore, it is crucial to understand how blockchain technology helps to deal with cryptocurrencies (bitcoin, litecoin, ripple, monero) in the past. What complications are involved in its functioning, what are the future challenges ahead, particularly regarding its acceptance as a medium of exchange? Business opportunities awaiting in the digital world as the question of whether cryptocurrencies are legal or illegal is still debatable in many counties. That is why the current study undertakes the previous literature related to

blockchain technology, cryptocurrencies, and bitcoin from finance, economics, and information technology and conducts the bibliometrics analysis.
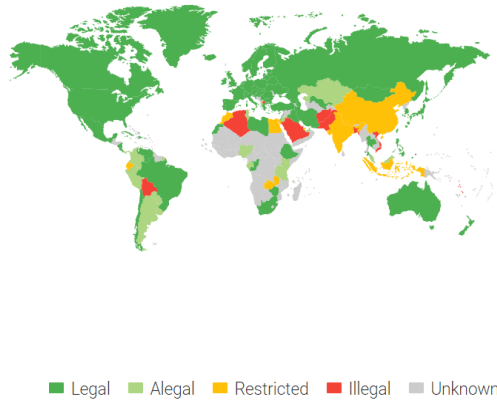

Figure 1. Legal map of Bitcoin and other cryptocurrencies. Source: [5]

This research aims to identify the top authors, affiliations, journals, reports, countries, and other related sources dealing
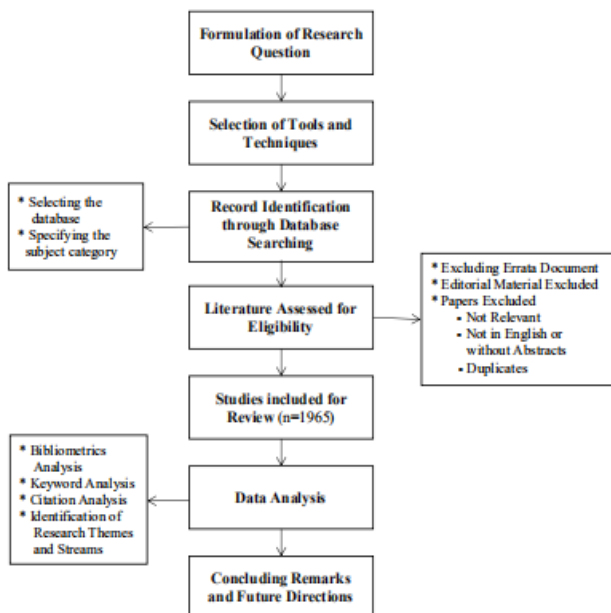

FIGURE 2. Study Workflow of Bibliometrics Analysis

with these concepts through extensive literature review. The information is collected from 2015-2020, which helps determine the major trends, themes, and research streams that further support the policymakers, researchers, analysts, and technologists.

II.   DATA COLLECTION FOR LITERATURE REVIEW

Bibliometrics is a technique to explore scholarly information from the various well-established databases in research articles, books, conference proceedings, and reports. About the concepts under study [6]. It is a process of extracting, arranging, and analyzing data used for strategic decision making [7]. Bibliometric information for the current study is collected in two steps. In the first step, we selected the databases (Scopus, Web of Sciences, Emerald, Elsevier, Google Scholar) for information collection purposes. These databases contain thousands of high-impact factor prestigious research publications from natural sciences, social sciences, arts, and humanities. These databases mostly comprise of ISI indexed journals that fall under the diversified subject categories. Therefore, in the second step, we narrow down the subject category and conduct the search query for more holistic data collection in social sciences. We have applied various filters to get the desired results.

The databases were searched by using the specific related keywords from the period of 2015-2020 at the date of September 12, 2020. The final search query is TITLE-ABS-KEY ("Blockchain" OR "Bitcoin" OR "Cryptocurrency" OR "Digital Currency" OR "Technology"). It is highly anticipated that the results may change with the inclusion of more publications related to the topic under study in future

III.   METHODOLOGY

This study aims to provide a framework for future researchers that can open a new avenue for further studies and delineates prior research for scholars to generate future knowledge. For this purpose, firstly, an extensive literature review is conducted systematically, and finalized information is discussed through the bibliometrics analysis, keyword analysis, and citation analysis. According to top authors, journals, institutions, keywords, citations, publishing countries, and publication years, all these approaches summarize the data. This sorted information can help to improve individuals' understanding of blockchain technology and cryptocurrencies in the modern technological world.

The 'Biblioshiny,' a web-specific R package ('Bibliometrix 3.0'), is used to describe the selected documents based on Bradford's law's analysis tools, global citations, h, g, and m-index. In the second step, key research themes and streams are identified through science mapping techniques of conceptual structure and using holistic keywords as the input data. We can provide an in-depth view of the data and suggest a future research agenda after completing these analysis steps. [8] used a similar pattern to analyze the influential and conceptual aspects of the corona pandemic in social science.

A)   BIBLIOMETRICS ANALYSIS

In the bibliometrics analysis, information related to top journals, authors, papers, universities, and countries is presented [9]. The current study also collected detailed information about blockchain technology cryptocurrency, and bitcoin, through a comprehensive literature review.

TABLE 1.
DESCRIPTIVE CHARACTERISTICS OF BLOCKCHAIN TECHNOLOGY AND CRYPTOCURRENCY

Particular	Results
Documents	1965
Sources (Journals, Books, etc.)	979
Keywords Plus (ID)	6516
Author's Keywords (DE)	3443
Period	2015 – 2020
Average citations per documents	10.36
Authors	4728
Author Appearances	6357
Authors of single-authored documents	220
Authors of multi-authored documents	4508
Single-authored documents	254
Documents per Author	0.416
Authors per Document	2.41
Co-Authors per Documents	3.24
Collaboration Index	2.63

A brief description of the concepts under study's characteristics is discussed in Table 1, which is vital to understand the selected literature's attributes before moving forward to the analysis section.

The current study has finalized 1965 documents, including articles (733), book chapters (02), conference papers and reviews (1172), and others (58). All these documents use 6516 keywords plus and 3443 author's keywords during the analysis period, i.e., 2015-2020. The average citation per document is 10.36. A total of 4728 authors were contributed to this emerging field; if we evaluate the authorship of the selected articles, then 220 were single-authored while 4508 were multi-authored documents. The document per author is almost 42%, while

the collaboration index is 2.63, which depicts high collaboration in blockchain technology and cryptocurrency publications. The total annual publication presented in Table 2 shows that these concepts remain a hot issue for discussion and publication in 2019. As a significant number of publications, i.e., 851 documents were published during this period. This figure also shows an increasing trend in the research of bitcoin from 2015 to 2020.

We use source impact to identify the core publications and authors related to the concepts under study. Table 2 ranks the publication sources, while table 3 arranges information based on the top ten authors in the field of social sciences according to h-index, g-index, m-index, total citations (TC), net production (NP), and publication starting year (PY-Start). Table 2 shows that the significant publication source is IEEE Access according to the indexes (h-index=16; g-index=33; m-index=4.00) in 2017.
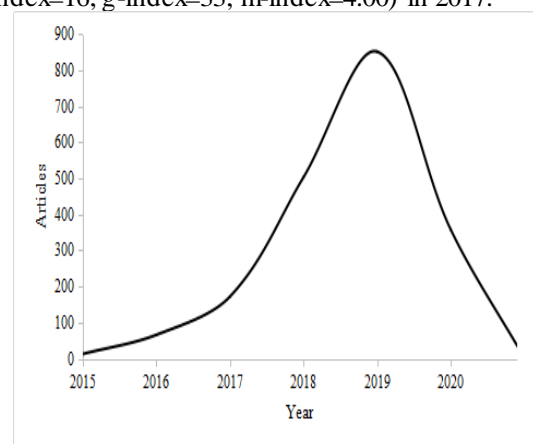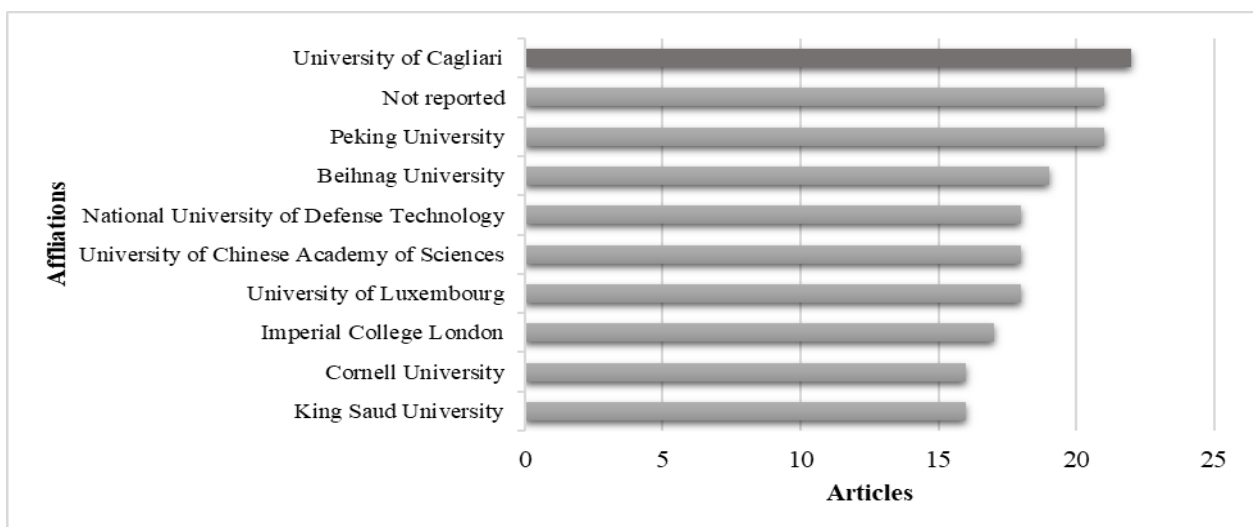

FIGURE 3. Annual Publications Output

Association for computing machinery (ACM) International Conference Proceeding Series is ranked as a top publication source in net production, 61 amongst all sources in 2015.

FIGURE 4. **Most Relevant Affiliations**

TABLE 2.
TOP TEN JOURNALS, ACCORDING TO PUBLICATION SOURCE IMPACT.

Source of Publication	h-index	g-index	m-index	TC	NP	PY-Start
IEEE Access	16	33	4.00	1134	61	2017
Proceedings of the ACM Conference on Computer and Communications Security	14	22	2.80	1552	22	2016
Future Generation Computer Systems	10	24	3.33	767	24	2018
ACM International Conference Proceeding Series	6	10	1.00	164	81	2015
IEEE Internet of Things Journal	6	9	3.00	120	9	2019
IEEE Communications Surveys and Tutorials	6	6	1.20	798	6	2016
Proceedings - IEEE 2018 International Congress on Cybernetics: 2018 IEEE Conferences on Internet of Things, Green Computing and Communications, Cyber, Physical and Social Computing, Smart Data, Blockchain, Computer And Information Technology, Ithings/ Greencom/ Cpscom/ Smart Data/ Blockchain/ Cit 2018	5	6	1.67	65	25	2018
Future Internet	5	9	1.00	238	9	2016
Proceedings - IEEE Symposium on Security and Privacy	5	7	1.25	162	7	2017
Metaphilosophy	5	5	1.25	51	5	2017

TABLE 3.
TOP 10 AUTHORS IMPACT IN BLOCKCHAIN, CRYPTOCURRENCY, BITCOIN LITERATURE

Author	h_index	g_index	m_index	TC	NP	PY_start
Wang H	5	16	1.250	1081	16	2017
Chen X	4	13	1.000	1033	13	2017
Li X	5	12	1.250	313	12	2017
Yuan Y	6	12	2.000	144	12	2018
Wang X	5	11	1.250	178	11	2017
Li J	7	10	1.750	113	14	2017
Liu Y	5	10	1.250	136	10	2017
Wang FY	5	10	1.667	136	10	2018
Wang Y	4	9	0.800	88	14	2016
Chen Y	4	9	1.333	123	9	2018

Note: h-index (measuring productivity and citation impact of publications); g-index (including highly cited papers in the dataset); and m-index (reflecting the ratio of h-index to several years the researchers has been actively publishing their research work).
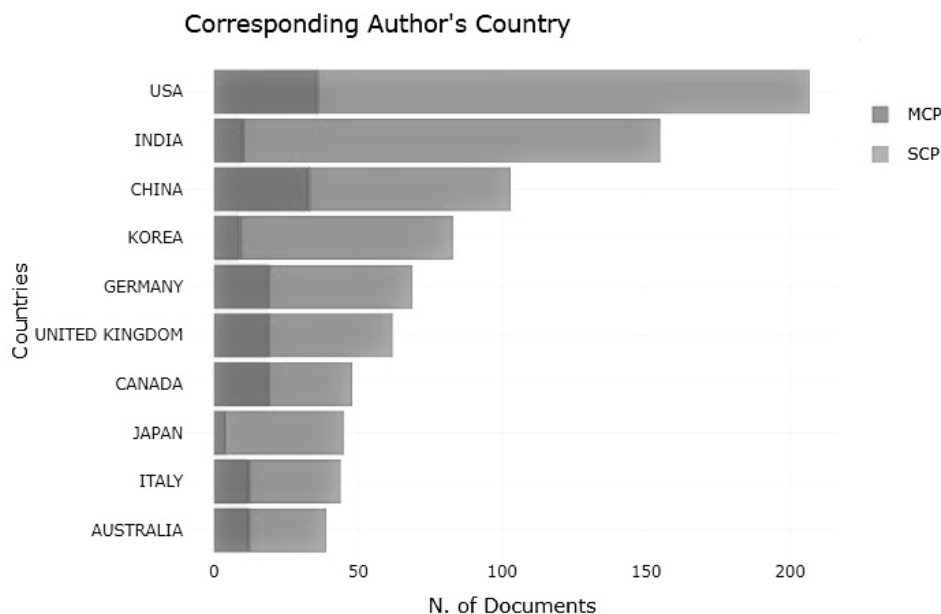
FIGURE 5. Corresponding Authors' Country

Furthermore, Proceedings of the ACM Conference on Computer and Communications Security remain at the leading source in 2018 based on total citations, i.e., 1552, while IEEE Access and IEEE Communications Surveys and Tutorials stay second and third position according to total citations, i.e., 1134 and 798 respectively. Table 3 provides information about the top ten authors' impact in the blockchain, cryptocurrency, and bitcoin literature.

Figure 5 represents the corresponding author countries, and the USA remains at the top of the list with multiple country publications (MCP) and single country publications (SCP). MCP refers to the collaboration between various countries, and SCP represents a collaboration by authors in a single country [10].

B) KEYWORD ANALYSIS

The keyword analysis presents the articles' main body's significant concepts, i.e., title, abstract, keywords, and author [11]. Table 4 showed the details about the keywords that are frequently used in the blockchain, cryptocracy, and bitcoin literature in social sciences from 2015 to 2020. This table summarized keywords in four parts: keyword plus, author keyword title, and abstract. In all aspects, the most common keyword is "Blockchain," which repeats maximum times in all categories. Social sciences are related to the activities involving people, society, and the economy, which is depicted in the keywords in the form of "Bitcoin," "Ethereum," "Electronic Money," "Cryptocurrency," "Transactions."

The current study is also associated with the technology and networks that facilitate the occurrence of the transaction. That is why the keywords like "Internet of Things," "Peer to Peer Networks," "Smart Contracts," "Technology" is also found in the selected documents. The main concern of the parties in the adoption of blockchain technology is the trust issues, which is also reflected by the keywords like "Data Privacy," "Network Security," "Security," "Privacy." In the blockchain literature, very few title keywords are used. The abstract keywords cover the broader scope, as reflected by the keywords "Technology," "Data," "System," "Paper," "Network." The title of the publications is very generic; that is why they fail to represent any theme or research stream for the analysis purpose.

C) CITATION ANALYSIS

Citation analysis provides information about the most cited sources of literature [12]. It presents a comprehensive view of the literature included in the study [13]. Table 5 provides the top counties' information in terms of total publication and citations relevant to the blockchain technology and its application in the financial sector, particularly cryptocurrencies.

The USA seems to be on the top of the list, both in terms of publications (617) and citations (4216), China is in the second place, Indian ranked third in publications (252) but did not list in the top ten countries in terms of citations. Singapore's total citations are better than in the United Kingdom. Germany is in the fourth position in terms of citation (1014) with 130 publications.

Singapore, Switzerland, and Finland are included in the top-cited positions at the rank of third (1205 citations), sixth (586 citations), and eight (509 citations) places respectively, even without included in the list of top publication countries. Similarly, there are the countries that appeared in the top ten publications countries list like India (282 Publications), Canada (104 Publications), France (101 Publications). Still, their names do not show in the list of top country's citations. Table 6 provides information about the top ten publications in social sciences, along with the

details about authors, their year of publication, and local and global citations.

TABLE 4.
KEYWORDS ANALYSIS

| Keyword Plus		Author Keyword	
Words	**Occurrences**	**Words**	**Occurrences**
Blockchain	1223	Blockchain	1264
Bitcoin	669	Bitcoin	660
Electronic Money	559	Cryptocurrency	394
Internet of Things	179	Ethereum	161
Peer to Peer Networks	161	Smart Contracts	94
Ethereum	147	Security	92
Network Security	134	Smart Contract	88
BlockChain	122	Privacy	71
Proof of Work	112	Consensus	64
Data Privacy	107	Proof of Work	64
Title		**Abstract**	
Words	**Occurrences**	**Words**	**Occurrences**
Blockchain	955	Blockchain	5162
Bitcoin	362	Bitcoin	2613
Technology	211	Technology	1980
Cryptocurrency	161	Paper	1412
Based	154	Data	1363
Analysis	123	System	1289
System	121	Transactions	1281
Network	100	Network	1199
Blockchains	94	Cryptocurrency	1158
Security	91	Security	953
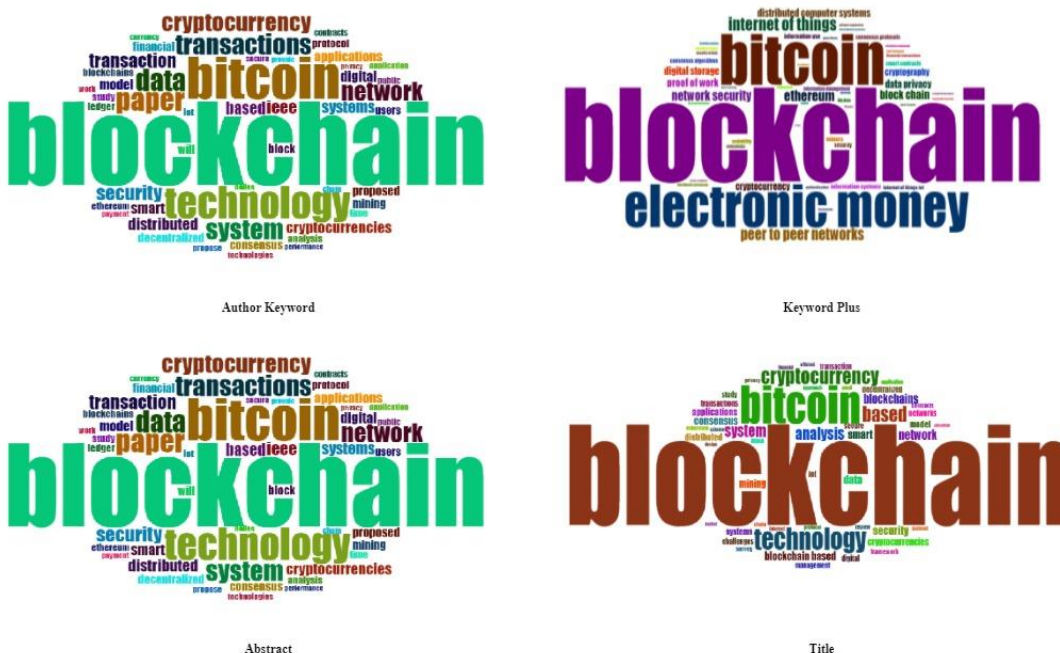
FIGURE 6. Word Cloud

TABLE 5.
TOP COUNTRIES IN TERMS OF PUBLICATIONS AND CITATIONS.

Total Publications		Total Citations		
Country/Region	Frequency	Country/Region	Total Citations	Average Article Citations
USA	617	USA	4216	20.367
China	550	China	1364	13.243
India	282	Singapore	1205	48.2
United Kingdom	186	Germany	1014	14.696
South Korea	135	Korea	669	8.06
Germany	130	Switzerland	586	34.471
Australia	118	United Kingdom	526	8.484
Italy	106	Finland	509	169.667
Canada	104	Australia	493	12.641
France	101	Italy	488	11.091

As publications in the field are increasing, people started acknowledging the top papers, researchers, and journals for their work. We have discussed the most locally cited articles, and its comparison with the global citation in table 6. [14] is a highly cited article at the local level with (local citations: 99; international citations: 409). They discussed the pros and cons of cryptocurrencies and presented a new "bitcoin-ng" (next generation), with a faster and more secure blockchain protocol. [15] stood second with (local citations: 95; global citations: 372). They introduced a framework to check the security of networks, performance implications of several consensuses, and network

parameters of proof of work blockchains. This framework provides an optimal adversarial strategy by considering real-life constraints and helps the user objectively compare the tradeoffs between the networks' security and performance provisions.

Tschorsch & Scheuermann in [16] is on the third number having local citations: 88; global citations: 473. They highlighted the significance of digital currency in the modern world. They discussed the structure, process, and application of bitcoin protocol and extended the study's scope by providing new ideas regarding bitcoins' applicability in other fields. Zheng et al. [17] has 87 local

and 662 global citations and ranked fourth in local and second in global citations. They explained the importance of blockchain technology for the functioning of bitcoins. Further, they discussed the trends, challenges, and opportunities associated with applying blockchain technology in the fields. Luu et al. [18] investigated the security of running the smart contract under Ethereum as an open distributed network like cryptocurrencies.

Zyskind et al. [19] are highly cited globally, having 811 citations, while its rank is sixth in a local citation (56 citations). They provided the solution to the user's privacy concerns by eliminating the role of third parties. They developed a personalized data management system in which users own and control all data through blockchain networks without involving a third party. Zheng et al. [23] describe blockchain's benefits as consistency, decentralization, anonymity, and audibility. They discussed the application of blockchain in the financial and other fields, advances the knowledge about recent developments in the area, and provide directions for further research. Yli-Huumo et al. [24] provided an overview of blockchain technology's history, justifies the need for its development and explains its importance in diversified fields.

Figure 7 presents the comparison of global total citations and average per year citations. Results show that every year the number of citations for the published material related to the blockchain networks and cryptocurrencies has increased. It depicts that now researchers have realized the importance of this topic in the current era and started exploring the new areas for its application, which is a good indication. In the current situation, when the whole world faces a thread of coronavirus spread through a public interaction [25]. People are even advised to avoid the usage of debit and credit cards. This situation highlights the importance of contactless payment methods like digital

currency, bitcoin through a secure, fast, and trustworthy network of blockchain technology. The figure shows that the most cited paper is "An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends," which has 811 total citations, whereas its per year citations were 135.167. The highest per year full citation is 165.5, received by Zheng et al. [17].

IV. CONCEPTUAL ASPECTS OF BLOCKCHAIN
This part of the study uses keywords to generate sustainable clusters, themes, and streams of a research study. We deploy the VOS view to analyze various clusters of the literature on blockchain and cryptocurrency. Furthermore, we conduct a thematic map to understand the emerging, dropping, motor, and developed themes in cryptocurrency and blockchain literature.

A) CO-OCCURRENCE ANALYSIS
We have used both Authors' keywords and keyword plus to analyze the various clusters of cryptocurrency and blockchain. Figure 8 shows the cluster of keywords linked together and form multiple groups led in different colours. The keywords used in the analysis represent various topics significantly because each keyword occurrence in the literature is set at a minimum threshold of 35 times. It means that none of the keywords present in figure 8 has a frequency of less than 35. This gives a robust and significant result because each keyword is significantly related to the cryptocurrency and blockchain literature. Different colours represent different clusters, and each cluster follows the mainstream of research. Research streams based on keywords in a specific cluster give a complete understanding of the directions of literature.

TABLE 6.
MOST LOCAL CITED DOCUMENTS

Document Title	Year	Local Citation	Global Citation
Bitcoin-NG: A Scalable Blockchain Protocol [14]	2016	99	409
On the Security and Performance of Proof of Work Blockchains [15]	2016	95	372
Bitcoin and Beyond: A Technical Survey on Decentralized Digital Currencies [16]	2016	88	473
An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends [17]	2017	87	662
Making smart contracts smarter [18]	2016	61	439
Decentralizing Privacy: Using Blockchain to Protect Personal Data [19]	2015	56	811
Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains [20]	2018	51	395
A Secure Sharding Protocol For Open Blockchains [21]	2016	48	235
Majority Is Not Enough: Bitcoin Mining Is Vulnerable [22]	2018	43	176
Blockchain challenges and opportunities: A survey [23]	2018	34	320
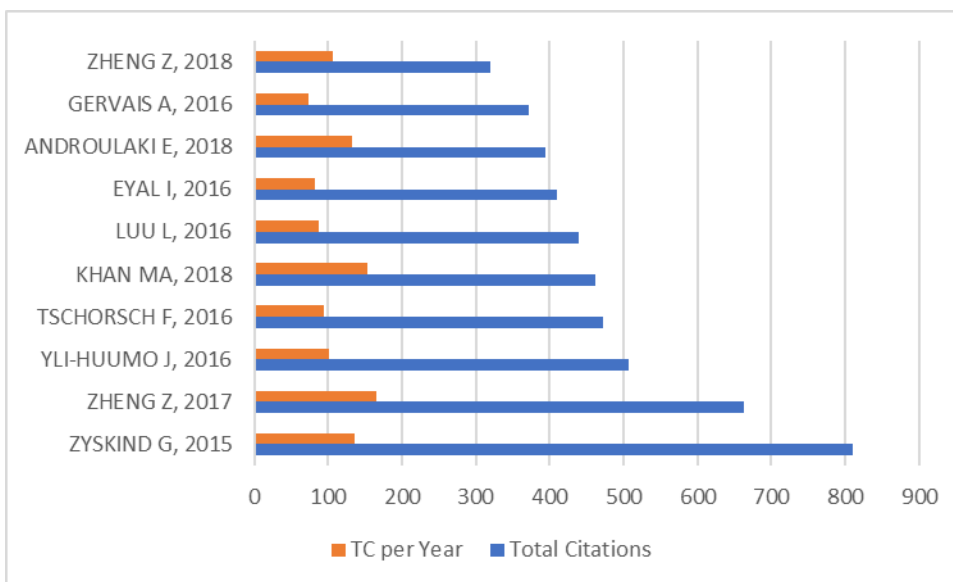
FIGURE 7. Comparison of Total vs.Per Year Citations (Global)
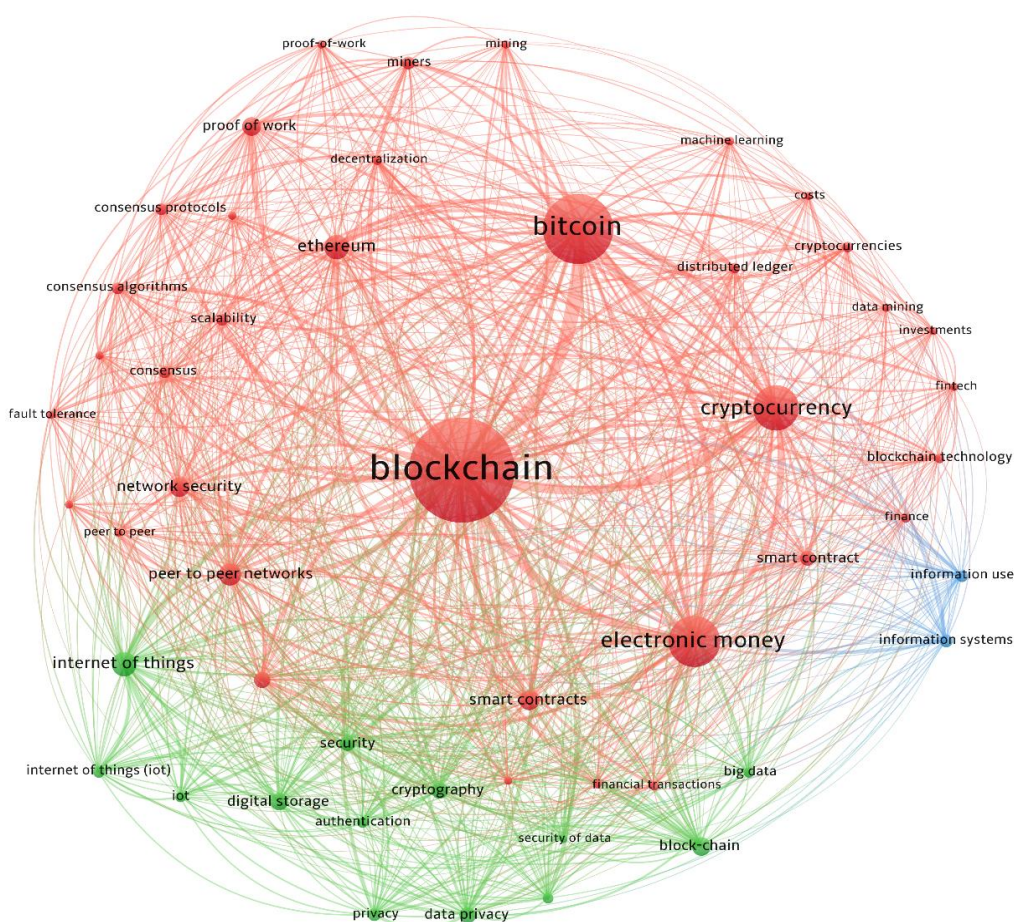
Figure 8. Co-occurrence Network

Cluster coloured in Red is the main cluster that represents the relationship of cryptocurrency and blockchain. The relationship offers the research stream of the structure of cryptocurrency and implications to blockchain technology. The streams cover blockchain and financial technology in various sectors discussed by [26], [27]. Furthermore, many studies focus on the information technology issues related to blockchain. Still, Du et al. [28] used affordance actualization theory to fill the gap of effective implementation of blockchain in organizations. [29] discussed the emergence of blockchain practices such as distributed ledger and global peer to peer transactions. [30] present countermeasures by preserving the decentralization of bitcoin peer to peer network architecture to reduce eclipse attacks. Furthermore, significance and development of blockchain technologies are studies by [31], [32], [33], [34].

The second research stream represents the studies related to the safety and security of data and information. Zyskind et al. [19] describe the personal decentralized data management system to better use and control user data. They developed the protocol that converts the blockchain into an automated access control manager, which did not require trust in a third party. Dorri et al. [35] tried to eliminate traditional blockchain applications that are expensive and required high bandwidth. They suggested that blockchain is essential for safety and security, but very few devices can afford it. They created a lightweight structure based on traditional blockchain applications architect with maximum maintenance of privacy and security benefits. Fernández-Caramés and Fraga-Lamas in [36] used blockchain technology to develop applications for the internet of things (IOT) that pave the way for seamless authentications, security, privacy against attacks. They develop an IoT based blockchain application, which was named BIOT. For significant security and privacy, Conti et al. [37] reviewed the existing vulnerabilities of bitcoin with related technologies such as blockchain and proof-of-work (POW) based consensus protocol. Furthermore, safety and privacy related to cryptocurrency and blockchain studied by [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53] and [54].

The third research dimension is limited and straightforward forward. It represents the sophisticated information system that cryptocurrency and blockchain represent and the use of that information effectively. At the inception of the skyrocketed behaviour of bitcoin prices, many investors were interested in cryptocurrency. Many companies issued unregulated crypto assets for financing. Many projects underperformed, and investors were unaware of the high risk of decentralized currency. Lausen in [55] studied the development of cryptocurrency over time and reported various taxonomies that enabled regulators to analyze that which features of cryptocurrency were subject to regulations. In addition to regulating the development of blockchain technology is highly adopted by the financial sector. There is a need to deploy these applications in smart cities, Nagel et al. in [56] introduced multi-layer taxonomies of smart cities business models for significant blockchain applications.

TABLE 7.
RESEARCH STREAMS

Keywords	Cluster	Research Stream
Blockchain, bitcoin, electronic money, cryptocurrency, Ethereum, peer to peer network, network security, smart contracts, proof of work, distributed computer system, miners, consensus algorithm, scalability, distributed ledger, decentralization, fintech, machine learning, investments	Red	Structure of Cryptocurrency and implications of Blockchain technology
Internet of things (IoT), blockchain, digital storage, data privacy, cryptography, security, big data, information management, authentication, the security of data	Green	Confidentiality and Security management of Data and information
Information system, Information use	Blue	Deployment of optimal information system

Abramova and Bohme in [57] conducted an exploratory study to explain bitcoin determinants used as the information system. The study informed about the benefit and perceived risk of bitcoin use. They also reported the technology acceptance theory and recognize various conceptual and methodological developments of bitcoin use. [58] conceptualized blockchain technology by discussing various blockchain applications. For better communication and information among stakeholders, they reported various blockchain technology functions and offered a dynamic discussion on contemporary and emerging blockchain applications. [59] proposed the trusted executed environment (TEE) for securing the information in the blockchain. Further, in optimal use and securing the information [60] stated that there were significant benefits of blockchain technology in the audit environment. They suggested that blockchain technology would help reduce frauds and would optimize audit processes. Blockchain can also provide benefits for the business environment; one of the benefits was discussed by [61] in the shape of smart contracts that established trust among contracting partners without the inclusion of a third party. [62] provided the comparative analysis of core cryptocurrencies (Ethereum, Bitcoin, and Ripple). Their comparative focus was on a scripting language, architecture, and properties related to security. Furthermore the architecture, information and data security and use is studied by [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], and [74].

B) THEMES EVOLVEMENT OVERTIME
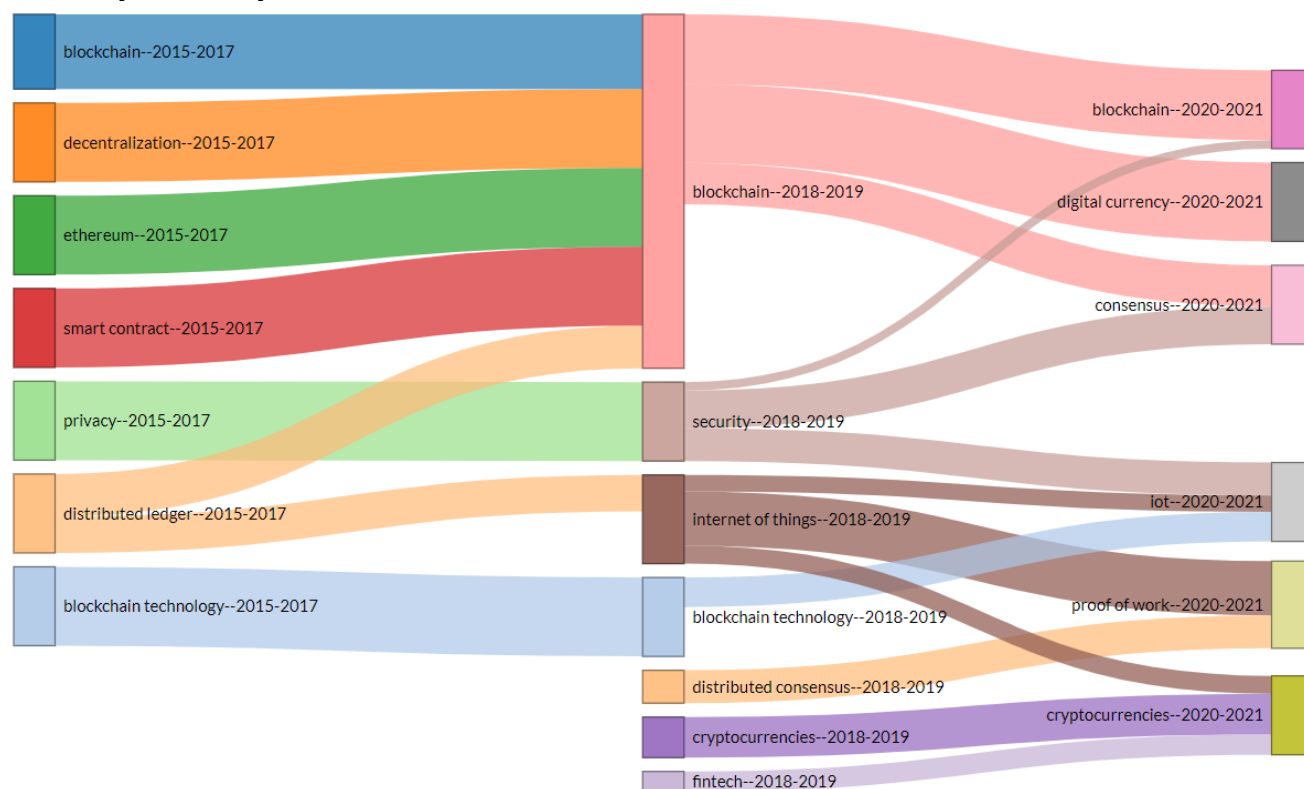Figure 9 represents the thematic evolution that indicates how themes related to blockchain and

cryptocurrency evolved overtime. It is observable that from the inception of the technology until 2020, the topics of blockchain and cryptocurrencies evolved significantly. At first, the literature keywords were related to the topic of introduction and structure of blockchain technology [75], decentralized currencies (Ali et al., 2016), and [76], smart contracts [77], [78] privacy and distribution ledger [79]. Then it has evolved to the development of structure and architecture of blockchain applications [80], the internet of things [81], and the latest financial technology named fintech [82], [83] and [84]. At final stages the evolved shape of blockchain and cryptocurrency literature has evolved into digital currency [85] and [86], internet of things (IoT) [87], [88], and [89], consensus [90] and proof of work [91], [92] and [93].

C) CLASSIFICATION OF RESEARCH THEMES

We have divided research themes into various categories for various types of stakeholders. After this classification, the perspective of researchers, developers, and information technology (IT) specialists will investigate relevant areas. Figure 10 represents the thematic map (TM), which is made by checking the topic according to centrality on the x-axis and density on the y-axis. TM further divides the blockchain and cryptocurrency literature into four broad quadrants. Quadrant, I represent the research themes that are emerging or dropping. This quadrant contains topics that are new and can provide the potential to be highly relevant in the future. Quadrant II represents high centrality and low density, and these topics have been frequent high publications, but less importance left in the area.

Figure 9. Thematic Evolution
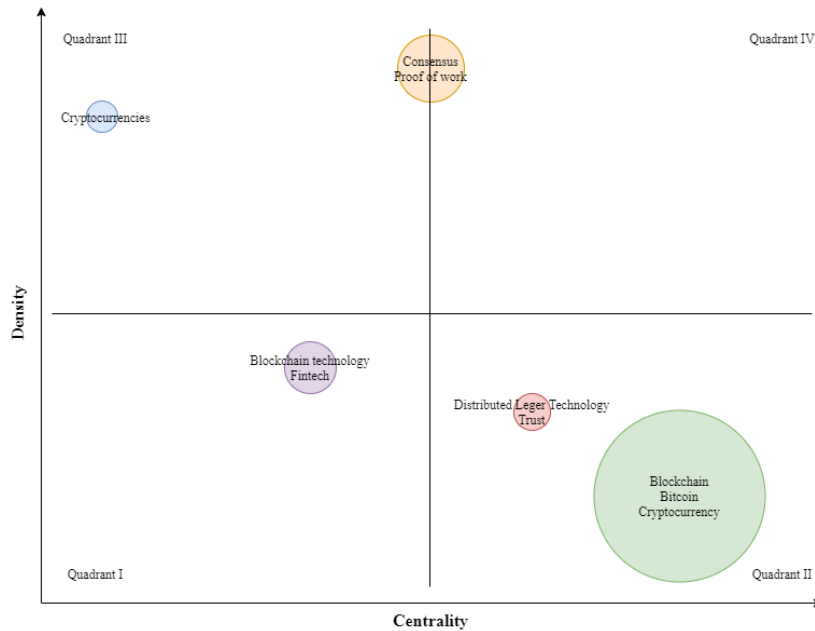
Figure 10. Thematic Map

Quadrant III represents high density, which means these topics are essential but low frequent publications due to low centrality. These themes can also be considered as future directions. Forth quadrant represents motor themes that are highly centralized and highly developed. We have subdivided the TM into two broad categories. One is related to future directions in which we are taking the latest publications related to quadrant I and quadrant III themes. Second, our core research themes are represented by quadrant II and quadrant IV of TM.

D) CORE RESEARCH THEMES

The core themes are represented by quadrant III and IV, topics related to consensus and proof of work are making the transition from quadrant II to quadrant IV to be considered in both future direction and core themes. Here we consider older studies as a core field and new studies as future direction studies. Quadrant IV themes are motor themes that have high centrality and density. The first core motor theme is identified in quadrant IV is "security of consensus protocol" and "proof of work consensus protocol." Kovalchuk et al. in [94] study come under motor themes that propose a new mathematical model to split attack on consensus protocol that is applied on cryptocurrencies. Furthermore, they tried to preserve the consensus protocol of cryptocurrencies [16] conducted a technical survey. Further studies related to consensus protocol applied on cryptocurrencies for security are done by [36], [95], [96], [97] and [98]. Gramoli in [99] worked on the proof of work (POW) consensus protocol to differentiate Ethereum and bitcoin proof of work consensus algorithms. Miraz & Ali in [100] considered POW as a significant determinant for the security of transactions of cryptocurrency. While research has underlined various pros related to POW, ensuring blockchain and cryptocurrency security, Borge et al. [101] went another way by stating that

re-centralization and energy waste are the reason for using POW technology.

As mentioned above, quadrant II represents the themes that possess high centrality. Themes of this quadrant are important and represent the most common topics with high publications. "Trust and distributed ledger technology" and "structure and objective of blockchain and cryptocurrencies" are highly centralized themes. Trust in distributed ledger technology from the last decade has been substantial. It changes the way of business. It preserves the data of business personal, track their payments and product. These features have gained much hype for distributed ledger technology. In contemporary commercial business, interest in building a distributed ledger application is growing [102]. Furthermore, significance of distributed ledger technology is reported by [103], [104], [105], [106], [107], [108] and [104].

The highly centralized blockchain and cryptocurrency literature area is the "structure and objective of blockchain and cryptocurrency." Every topic related is related to these topics that why it is highly centralized. For reference, see figure 8 of the co-occurrence analysis in which blockchain is in the center of the cluster, and every topic is related to blockchain. It is unlikely to different studies that are specifically relevant to these topics without the penetration of other topics. There is a significant contribution to developing the structure of blockchain and cryptocurrency from a technological perspective and economic perspective [109]. Due to the popularity of bitcoin and other cryptocurrencies, it is becoming a financial asset. There is a listed and over the counter market and emerging derivative market of digital currencies [110]. Furthermore, the past transactions stored in a distributed ledger known as blockchain has also contributed to its development and growth [97]. The major disadvantage of digital currency is attacked, such as quantum computing attacks that disrupt

the blockchain's whole structure. Studies such as [111], [112], [113], [114], [45], [115], and [116] tried to solve related issues with blockchain technologies.

V. FUTURE RESEARCH THEMES AND TOPICS

We have used two methods to find future research agendas in the literature of blockchain and cryptocurrency. First, we use the technical formation of future research studies based on quadrant I and quadrant II of the thematic map. Second, we have used core influential and conceptual aspects of literature to form a general idea of the future direction for blockchain and cryptocurrency.

Quadrant I represent themes that are either emerging or dropping in a specific research area. According to the thematic map (see figure 10), we propose that the structure of blockchain with fintech technology is the emerging theme that needs further elaboration in the body of knowledge. After reviewing 141 research articles on bitcoin, blockchain, and fintech Fosso Wamba et al. (Wamba et al., 2020) suggested that organizations needed to develop research and development on these technologies to understand it better. They needed to optimize their business strategies with penetration of fintech, which would help them generate critical decision-making insights.

The emergence of Islamic finance practices posts a significant need for the significance of blockchain and fintech application in Islamic business and commerce. Rabbani et al. [118] extensively reviewed 133 research studies related to fintech, blockchain, and Islamic finance. They divided the literature into three holistic categories, i.e. Islamic fintech challenges and opportunities, Sharia compliance of blockchain and cryptocurrency, and law and regulations. This post a significant gap in the application of blockchain, cryptocurrencies, and fintech in Islamic finance and banking, which needs to be addressed in future research studies.

Quadrant III proposed research themes that are highly developed with little centrality. The findings of these research papers can provide gaps for future research. As cryptocurrency has grown as a financial asset, many questions may arise for estimating the true intrinsic value. This opens a new debate for a stream of research studies proposing the best valuation model for cryptocurrencies. Nadler & Guo in [119] offered an asset pricing model based on market risk and blockchain-related risk factors. Saad et al. [120] tried to identify the supply and demand dynamics of cryptocurrencies and construct a machine learning model to predict its prices. For future research, there is a need for advancement in valuation models for better pricing and valuation of various cryptocurrencies.

Härdle et al. [121] clear some structural misunderstanding about the operations of cryptocurrency and blockchain. Further study is required in developed and developing nations to remove misconceptions about the transactions related to cryptocurrencies. Proof of work (POW) and proof of stake (POS) are the most common ways to ensure security but Borge et al. in [101] highlighted

disadvantages such as POW consumes high electricity and re-centralization, and there is a monopoly of significant shareholders in POS which can post challenges. They introduced proof of personhood (POP), the security protocol that connects physical entities with virtual entities to ensure accountability and preserve anonymity. They further raised Popcoin cryptocurrency with a consensus mechanism that eliminates the disadvantages proposed by POP and POS. The structure and characteristics of the latest created cryptocurrencies are needed to be discussed in future research.

A) LIMITATIONS OF STUDY

The search query of this study has been used on September 12, 2020. With passing time, the search result may change as there is a stream of studies in this field daily.

VI. CONCLUSION

The study has elaborated significant influential and conceptual aspects related to blockchain and cryptocurrency literature. The study has found that IEEE access is the core journal that started publishing blockchain and cryptocurrency literature in 2017. It has the highest h-, g- and m-index in this field. Researchers, policy markets, and investors must explore this journal for further directions, regulations, and investments. Furthermore, Wang H.'s contribution to IEEE access is significant, and he is also a core author. University of Cagliari, Notreported, and Peking University are the leading influential affiliations in blockchain literature. USA lead as the top country of corresponding the cryptocurrency and blockchain-related literature. USA lead in corresponding within and outside the country. India and China come in second and third positions. The USA, China, and India lead the total publications, but in high rankings in terms of citations, Singapore replaces India.

Zyskind et al. [19] write the core globally cited article that proposed the data management system where users can control and own the data using a blockchain network without penetration of the third party. This study elaborates that with passing the time, the literature related to cryptocurrency and blockchain gaining a significant reputation. This increasing importance brings this study to the second part to key focused areas and themes of blockchain and cryptocurrency literature. With the help of a co-occurrence network, we can identify three main research streams of available publications. These streams help direct the future result in a specific area. The first stream is related to the structure of cryptocurrency and implications for blockchain technology. The second stream is significantly covered in literature and linked with the first stream that is the privacy and security management of data and information. The development of information systems and their optimal use is the third stream of cryptocurrency and blockchain literature. In a short time, the literature has evolved significantly the themes have changed from blockchain technologies, decentralized currencies, smart contracts, and distribution ledgers to the

Internet of Things (IoT), fintech, and then it evolved to the digital currency, consensus, and proof of work. We divided highly anticipated themes of literature into four quadrants with the help of a thematic map. The quadrant is arranged according to high density and centrality, motor themes, and emerging or dropping themes. The study considers high centrality and motor themes as core themes. These themes are based on the security of consensus protocol and proof of work consensus protocol. Related studies are highly centered in literature and they have a high density which makes them motor themes. Furthermore, distribution ledger, structure, and objective of blockchain and cryptocurrencies are highly centered themes that are linked with all other minor themes in literature. Lastly, we propose emerging and highly important themes that set the future direction of research. Fintech, implementation of Islamic finance practices, valuation methods of cryptocurrencies, and structural development of cryptocurrencies are the themes that set the future directions of blockchain and cryptocurrency literature.

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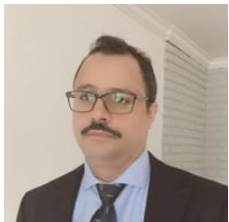
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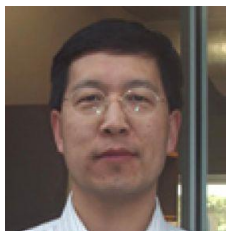
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