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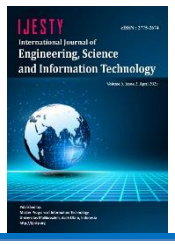

Decentralized Finance: Bibliometric Analysis and Research Trends

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Abstract

This research explores the developments and challenges in decentralized finance (DeFi) since 2015 and the increasing use of blockchain technology. DeFi provides access to financial services without traditional intermediaries, improving the economic system's efficiency through automated and transparent smart contracts. The bibliometric analysis shows a significant growth in DeFi-related publications, with 1,909 articles identified between 2015 and 2025. The research also highlights the importance of collaboration between authors and stakeholders to build a more secure and sustainable financial ecosystem. Analysis results using VOSviewer identified 173 keywords in 18 clusters, focusing on "digital twin" and "artificial intelligence." This research recommends further exploration into DeFi adoption, blockchain technology innovation, and the application of smart contracts to support the development of an inclusive, efficient, and innovative DeFi ecosystem in the future. In addition, this research aims to bridge existing research gaps and provide deeper insights into the potential of DeFi in the global financial system.

Keywords: *Decentralized Finance, Development, Analysis, Research Trends, VOSviewer.*

1. Introduction

Decentralized finance has developed into one of the most influential innovations in the global financial ecosystem in recent years. Using blockchain technology, DeFi presents solutions that enable the execution of financial transactions and services without traditional intermediaries such as banks or other financial institutions[1]. Along with the growing interest in DeFi, various projects, protocols, and applications related to this sector have emerged, attracting the attention of multiple parties, ranging from technology developers to investors and regulators[2] [3].

On the other hand, the surge in research publications on DeFi points to the need for a deeper understanding of existing metrics and trends. Bibliometric analysis plays a vital role in assessing the direction and patterns of DeFi research development. This method involves collecting data related to scientific publications, measuring citations, and exploring relationships between publications [4].

With the growing interest in DeFi, it is essential to systematically analyze the available literature to understand the impact and contributions of existing research. This understanding benefits researchers in identifying unexplored gaps and provides policymakers and practitioners with valuable insights into relevant developments in the DeFi space.

Through the bibliometric analysis and research trends in this Journal, it is hoped that valuable information can be obtained about the direction of emerging DeFi research, the industry's challenges, and its future potential. By utilizing bibliometric data and methodologies, this Journal aims to present a more comprehensive mapping of the DeFi topic, covering subtopics such as DeFi protocols, security, asset tokenization, and the economic impact of blockchain technology adoption in the financial sector.

2. Literature Review

DeFi is an attempt to create an alternative financial system that allows anyone, anywhere, to access various financial services, such as loans, insurance, and investments, using digital assets. This shows how DeFi describes decentralized finance as a collection of financial applications designed and operated using Blockchain and distributed ledger technology [5] [6]. The existence of DeFi can improve the

efficiency of the economic system by eliminating the need for traditional trust and replacing it with smart contracts that are automated and transparent. Several essential elements are needed for DeFi to operate optimally. Among them are smart contracts, DeFi software protocols, decentralized applications (dApps), decentralized finance platforms, decentralized exchanges (DEXs), and decentralized financial lending platforms. However, the unique characteristics of smart contracts, especially their immutable nature, demand a thorough audit to ensure a high level of security and minimize the risk of vulnerabilities in the code [7].

Therefore, this research contributes to developing the DeFi theory and provides practical guidance to developers and stakeholders to build a more robust and secure financial ecosystem [8]. By identifying key factors and current trends, this research aims to design effective strategies, increase technology adoption, and reduce risks associated with DeFi implementation. In addition, the findings from this research are expected to facilitate collaboration between innovators in the technology sector and traditional financial institutions, creating synergies that support inclusive and sustainable economic growth [9] [10].

Table 1. Search Keywords

Factor	Information	Resources
Blockchain	Blockchain has great potential to revolutionize the financial system by allowing direct transfer of ownership without the need for intermediaries.	[11], [12], [13]
Decentralized finance	utilizing blockchain technology to build a transparent and innovative financial system. The existence of this system is also influenced by various factors, such as economic, technological, cultural, social, and political.	[3], [14], [15]
Decentralized platform	Decentralized blockchain platforms have the potential to increase transparency in education and facilitate public participation. However, they still face challenges related to regulation and technology adoption.	[16], [17]
Decentralization	Removing intermediaries to enable direct transactions through Blockchain while increasing transparency, efficiency, and accessibility within the financial sector.	[18], [19]
Intermediation	The world of finance involves various aspects such as asset gathering, market creation, risk management, and precise information delivery.	[5], [20]
Algorithm	Support pricing, liquidity, and risk management in a decentralized and transparent ecosystem without involving third parties.	[21], [22]
Human	DeFi reduces the involvement of mediators by utilizing Blockchain and algorithms, with almost no human intervention. This concept aligns with Society 5.0, which emphasizes human integration as the primary user.	[5], [23]
transaction cost	Transaction fees are fees charged for executing transactions on the blockchain network.	[24], [25]
Information asymmetry	Information asymmetry occurs if one party has more complete or valuable information than another.	[26], [27]
Cryptocurrency	Serves as a digital currency integrated into various DeFi applications and protocols. In this ecosystem, cryptocurrencies such as Bitcoin, Ethereum, and stablecoins are used to execute transactions.	[28], [29]
Bitcoin	Plays a vital role in Decentralized Finance as a popular crypto asset. However, Bitcoin does not support smart contracts like Ethereum. However, it is useful primarily as a store of value and means of payment.	[30], [31]
Ethereum	A blockchain platform that supports decentralized finance (DeFi) applications using smart contracts for automated transactions without intermediaries.	[32], [33]
Dezentralized autonomus organization	A blockchain-based system that has self-governance and rules that run automatically. This system has the potential to revolutionize the world of business and society.	[34], [35], [36]
digital twin	Digital copies of physical assets are used to model and optimize financial processes.	[37], [38]
nonfungible token	A unique digital asset representing ownership of a tradable digital good or work..	[38], [39]
distributed ledger technology	Systems that do not use a distributed ledger like Blockchain to record transactions.	[40], [41]
Protocol	The rules and mechanisms that govern interactions in a decentralized financial system generally take the form of smart contracts implemented on the Blockchain.	[42], [43]

Factor	Information	Resources
Token	DeFi is used to conduct transactions, staking, and management, allowing access to decentralized financial services without intermediaries.	[44], [45]
total value locked	In the DeFi ecosystem, the measurement of the amount of funds locked in the protocol is an important indicator that reflects the overall size and liquidity of the ecosystem.	[46], [47]
smart contract	Allows automated and secure transactions without intermediaries, where rules and agreements can be executed directly within the Blockchain.	[48], [49], [50]
literature review	This study explores endpoint vulnerabilities and mitigation measures while highlighting the potential of Decentralized Finance (DeFi) to complement traditional financial systems.	[51], [52]
research agenda	This literature brings attention to financial services, regulatory issues, and the transformation of research towards a technology- and customer-focused model. This has important implications for practitioners while opening up new research opportunities for researchers.	[53], [54]

3. Research Methods

This article adopts a qualitative research method with a historical approach. This approach aims to identify developments, trends, and research mapping related to decentralized finance. The research was conducted in two stages. The first stage involves systematic data collection, focusing on articles published in reputable international journals.
The second stage involves analyzing the collected articles through bibliometric methods. Bibliometric analysis analyzes and organizes data in the form of words or phrases taken from the titles and abstracts of published articles. This approach supports developing, identifying trends, and mapping recent research on decentralized finance. Thus, the results of this analysis can also provide recommendations on research themes or variables for future researchers.

3.1. Data Collection Method

Data collection was done by collecting research articles from several leading journal publishers, namely: 1) Elsevier, 2) Emerald, 3) Ieeexplore, 4) Sagepub, 5) Researchgate, 6) Springer, 7) Wiley, and 8) Taylor & Francis. The articles were retrieved from databases accessible through these eight journal publisher groups.
Utilize Publish or Perish (PoP) software to search for articles. This tool is handy in finding articles relevant to your research topic. Here are the steps to follow to collect data:

1. The search is limited to the years 2015-2025.
2. The keywords used as search criteria are [“Decentralized finance”].
3. The combination of keywords used as search criteria consists of five groups. The first group includes terms such as “blockchain,” “decentralized finance,” “decentralized platform,” and “decentralization,.” The second group consists of keywords such as “intermediation,” “algorithm,” “human,”. “transaction cost,” ‘information asymmetry,’ ‘cryptocurrency,’ ‘bitcoin,’ and ‘Ethereum,’ The third group consists of keywords such as, ‘decentralized autonomous organization,’ ‘digital twin,’ ‘nonfungible token,’ The fourth group consists of keywords such as ‘distributed ledger technology,’ ‘protocol,’ ‘token,’ ‘total valued locked,’ ‘smart contract,’ Meanwhile, the fifth group consists of keywords such as ‘literature review,’ and ‘research agenda’.
4. Next, the research collected by this software is filtered based on journals written in English. The sources of the articles are from reputable journals.
5. The search was limited to journal articles focusing on the scientific fields of management, business, economics, social science, information, and entrepreneurship. In addition, the data collected in this study did not include conference proceedings, meeting proceedings, or books.
6. The articles to be analyzed will be checked for research completeness, especially regarding the presence of “title,” “abstract,” and “keywords”.
7. As an essential step in selecting articles to be processed, some elements to consider include DOI, journal where the article was published, publisher name, article URL, number of citations, GS rank, citations per Year, citations per Author, and the number of authors.

3.2. Data Analysis Methods

This Journal uses the bibliometric analysis method using the VOSviewer application, which produces bibliographic maps related to decentralized finance. The bibliometric analysis produced bibliographic data maps and text data extracted from the titles and abstracts of selected articles.
The results of this analysis are used to map and develop the field of reference studies. The scientific mapping will examine the trends and patterns of research developments related to the study of decentralized finance.
VOSviewer analyzes scientific articles that have been published, while VOSviewer serves to visualize knowledge development through visual networks and displays cluster labeling. Thus, VOSviewer provides valuable information regarding research updates and shows how much research related to this field has been conducted.

The output of VOSviewer presents maps and networks generated from the co-citation data and keyword maps based on the co-occurrence data. In addition, the information presented also comes with very in-depth details regarding keyword relevance.
The map and keyword network visualizations display different colors for each data cluster. The VOSviewer application shows an overlay network that illustrates the development of articles over time. This overlay network shows the period (years) in which the relationship between each keyword is presented as a network. From this overlay network visualization, we can understand the extent of research progress related to decentralized finance. In addition, density visualization provides an overview of the high or low frequency of concepts or constructs that are the focus of research.

4. Results and Discussions

4.1. Number of Years Published

The early 2015s witnessed the evolution of decentralized finance (DeFi), with the increasing use of blockchain technology creating a new ecosystem for digital finance. The rise of DeFi platforms, which provide easy access to investments, loans, and trading without traditional intermediaries, has led to increased user participation. These changes in the technological environment dramatically alter the landscape of financial asset management. This situation has prompted many researchers to conduct research related to DeFi, either in the title of their papers or as keywords in their academic study. The search results include 1909 articles from 2015 to 2025, as shown in Table 2.

Table 1. Number of Years of Publication 2015-2025

Years	Years of Publication	Years	Years of Publication
2015	1	2021	222
2016	12	2022	347
2017	30	2023	508
2018	66	2024	433
2019	121	2025	12
2020	156	**Total**	1909

The value continues to increase from 2015 to 2024. All businesses, both large and small companies, are required to optimize the use of digital technology. Many new problems arise due to dramatic changes in the business environment. In this situation, decentralized finance becomes a necessity. Therefore, experts and researchers worldwide are trying to conduct research to explain, predict, and manage activities to adapt to the new digital environment.

4.2. Author's Analysis

The analysis conducted by the Author relies on Google Scholar (GS) ranking. Fundamentally, GS has a function similar to that of Thomson ISI Web of Knowledge, which generates Journal Impact Factors (JIF) that are used to assess the impact of an article. However, GS offers an advantage in ranking by providing access to free articles. This access allows researchers to use the article as a reference without being hindered by the financial limitations of the institution.

Table 2. Active Publications per Year from 2015-2025

Author Name	Title	GS Rank
M Marescotti, M Blicha, AEJ Hyvärinen, S Asadi (2018)	Computing exact worst-case gas consumption for smart contracts	980
I Bashir (2020)	Blockchain	979
A Alketbi, Q Nasir, M Abu Talib (2020)	Novel blockchain reference model for government services: Dubai government case study	978
JC Brau, J Gardner, HA DeCampos (2023)	Blockchain in supply chain management: a feature-function framework for future research	977
XA Inbaraj, TR Chaitanya (2020)	Need to know about the combined technologies of Blockchain and machine learning	975
H Halaburda, M Sarvary, G Haeringer (2022)	Smart Contracts and Blockchain	974
J Wu (2023)	Factors Affecting Uniswap Liquidity	974
I Krasteva, T Glushkova (2021)	Blockchain-based approach to supply chain modeling in an innovative farming system	973
D Kaid, MM Eljazzar (2018)	Applying Blockchain to automate installment payments between supply chain parties	972
V Kumar, D Ramachandran, B Kumar (2021)	Influence of new-age technologies on marketing: A research agenda	971
PJ Duckworth (2022)	The Shared Frontiers of Economic	969

Author Name	Title	GS Rank
	and Civil Society: Toward Optimal Political Context for Distributed Ledger Technology in Finance	
J Wu, F Xiong, C Li (2019)	Application of Internet of Things and blockchain technologies to improve accounting information quality	968
H Benedetti, S McKeon, C Pfiffer (2021)	Blockchain trading and exchange	967
M Di Angelo, G Salzer (2023)	Consolidation of ground truth sets for weakness detection in smart contracts	967
SY Al-Imamy, S Zygiaris (2022)	Innovative students' academic advising for optimum courses' selection and scheduling assistant: A Blockchain-based use case	966
Q Tang (2021)	Towards using blockchain technology to prevent diploma fraud	964
A Satybaldy, M Nowostawski, J Ellingsen (2020)	Self-sovereign identity systems: Evaluation framework	963
S Salih, D Mhlanga (2023)	Blockchain for Food Supply Chain: Trust, Traceability, and Transparency Enhancement, How Can Africa Benefit?	963
A Pfeiffer, T Wernbacher, N Koenig, N Denk (2022)	Blockchains, Kryptowährungen, Utility-Token, NFTs und das Metaverse: Eine Einführung für den Bereich der Cyberkriminologie	962
H Falwadiya, S Dhingra (2022)	Blockchain technology adoption in government organizations: a systematic literature review	962

GS rank can be measured based on the Author's contribution to producing articles each Year. Table 3 discusses the authors' contribution to producing articles each Year, considering the GS rank. Table 3 shows how authors contribute to producing articles each Year.

4.3. Citation Analysis

Citation analysis reveals the number of articles referred to or cited by other researchers. The number of researchers focusing on decentralized finance continues to increase, especially between 2015 and 2025.

Changes in the macro environment bring challenges to business management. Managers, both in large and small companies, are required to be able to adapt to the existing dynamics. Efforts to improve this adaptability encourage researchers to commit to developing scientific knowledge that can provide solutions to digital-based business management problems. One of the journals with the highest number of publications on decentralized finance is ieeexplore.ieee.org, as shown in Table 4.

Table 3. Top Authors and Articles Cited in Decentralized Finance Publications.

Author Name	Publisher	Quoted frequency
S Saberi, M Kouhizadeh, J Sarkis	Taylor &Francis	3686
A Kosba, A Miller, E Shi, Z Wen	ieeexplore.ieee.org	3277
M Andoni, V Robu, D Flynn, S Abram, D Geach	Elsevier	2660
A Reyna, C Martín, J Chen, E Soler, M Díaz	Elsevier	2268
YK Dwivedi, L Hughes, AM Baabdullah	Elsevier	2103
P Gomber, RJ Kauffman, C Parker	Taylor &Francis	2059
SM Park, YG Kim	ieeexplore.ieee.org	1736
SA Abeyratne, RP Monfared	researchgate.net	1481
Y Guo, C Liang	Springer	1342
Y Wang, JH Han, P Beynon-Davies	emerald.com	1315
AV Thakor	Elsevier	1314
HN Dai, Z Zheng, Y Zhang	ieeexplore.ieee.org	1297
Y Wang, Z Su, N Zhang, R Xing, D Liu	ieeexplore.ieee.org	1292
W Wang, DT Hoang, P Hu, Z Xiong, D Niyato	ieeexplore.ieee.org	1268
S Corbet, B Lucey, A Urquhart, L Yarovaya	Elsevier	1267
K Salah, MHU Rehman, N Nizamuddin	ieeexplore.ieee.org	1123
M Risius, K Spohrer	Springer	1089
H Wang, H Ning, Y Lin, W Wang	ieeexplore.ieee.org	1054
M Conoscenti, A Vetro	ieeexplore.ieee.org	1007

4.4. Bibliometric Analysis

Bibliometric analysis plays a vital role in mapping and evaluating the development of research on decentralized finance. As such, the results of this analysis can identify relevant and cutting-edge themes or variables and shed light on the potential impact that can be generated if the research is further developed.

4.5. Joint authorship analysis

In the Co-authorship analysis, authors associated with other authors were identified. This analysis shows that collaboration between authors takes place in research related to decentralized finance, as shown in Figure 1. Liu, Y, for example, has collaborated with other authors in more than three articles produced by more than three research teams. Similarly, Luo, X, and Chen, J have successfully published more than two articles through different author teams.

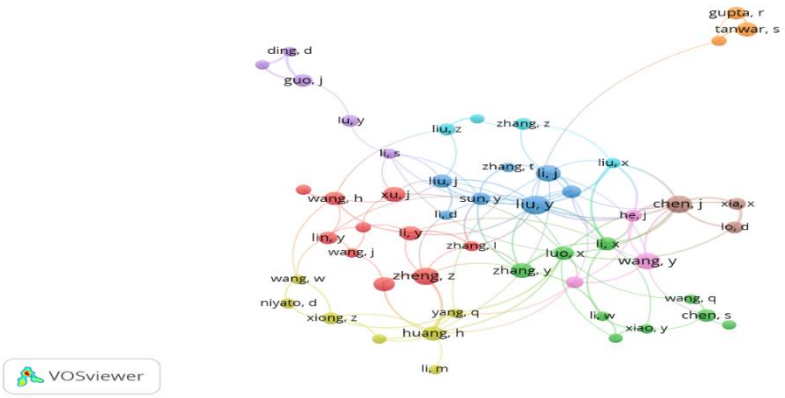

Fig 1. Author network

The collaboration between the authors reflects a strong commitment to continue exploring the research related to decentralized finance. In Table 5, the titles of the research conducted by them are listed.

Table 4. Author Collaboration

Author	Title
C Guan, D Ding, J Guo (2022)	Web3. 0: A review and research agenda
C Guan, D Ding, J Guo, Y Teng (2023)	An ecosystem approach to Web3. 0: A systematic review and research agenda
J Guo, J Leng, JL Zhao, X Zhou, Y Yuan, Y Lu (2024)	Industrial metaverse towards Industry 5.0: Connotation, architecture, enablers, and challenges
R Belen-Saglam, E Altuncu, Y Lu, S Li (2023)	A systematic literature review of the tension between the GDPR and public blockchain systems
W Zhang, L Wei, SC Cheung, Y Liu, S Li (2023)	Combatting front-running in smart contracts: Attack mining, benchmark construction, and vulnerability detector evaluation
H Wang, C Guo, S Cheng (2019)	LoC—A new financial loan management system based on smart contracts
C Liu, J Gao, Y Li, H Wang, Z Chen (2020)	Studying gas exceptions in blockchain-based cloud applications
Z Liu, Y Xiang, J Shi, P Gao, H Wang (2021)	Make web3. 0 connected
J Zhao, J Liu, H Wang, L Lin, S Xiang (2022)	Decentralized Counterparty Matches and Automatic Settlement of Interest Rate Swap Through Blockchain's Smart Contracts
H Tian, K Xue, X Luo, S Li, J Xu, J Liu (2021)	Enabling cross-chain transactions: A decentralized cryptocurrency exchange protocol
X Peng, Z Zhao, X Wang, H Li, J Xu, X Zhang (2023)	A review on blockchain smart contracts in the agri-food industry: Current state, application challenges, and future trends
H Wang, H Ning, Y Lin, W Wang (2023)	A survey on the metaverse: The state-of-the-art, technologies, applications, and challenges
DS Sarwatt, Y Lin, J Ding, Y Sun (2024)	Metaverse for Intelligent Transportation Systems (ITS): A Comprehensive Review of Technologies, Applications, Implications, Challenges, and Future Directions
Y Lin, Z Gao, H Du, J Wang (2025)	Semantic Communication in the Metaverse
Y Li, W Yang, P He, C Chen, X Wang (2019)	Design and management of a distributed hybrid energy system through smart contracts and Blockchain
P Tolmach, Y Li, SW Lin, Y Liu (2021)	Formal analysis of composable DeFi protocols
C Chen, L Zhang, Y Li, T Liao, S Zhao	When the digital economy meets Web3. 0: Applications and

Author	Title
(2022)	challenges
X Meng, Y Li, K Liu, Y Liu, B Yang, X Song, G Liao (2023)	Spatial Data Intelligence and City Metaverse: A Review
C Chen, L Zhang, Y Li, T Liao, S Zhao, Z Zheng (2023)	When Digital Economy Meets Web3: Applications and Challenges
HN Dai, Z Zheng, Y Zhang (2019)	Blockchain for the Internet of Things: A survey
L Liu, S Zhou, H Huang, Z Zheng (2021)	From technology to society: An overview of blockchain-based DAO
P Zheng, Z Jiang, J Wu, Z Zheng (2023)	Blockchain-based decentralized application: A survey
J Wu, K Lin, D Lin, Z Zheng, H Huang (2023)	Financial crimes in web3-empowered metaverse: Taxonomy, countermeasures, and opportunities
D Li, D Han, TH Weng, Z Zheng, H Li, KC Li (2024)	On Stablecoin: Ecosystem, architecture, mechanism, and applicability as a payment method
Y Zhang, Z Chen, Y Sun, Y Liu, L Zhang (2023)	Blockchain network analysis: A comparative study of decentralized banks
X Wang, J Wang, C Wu, S Xu, W Ma (2022)	Engineering Brain: Metaverse for Future Engineering
C Zhao, X Wang, Y Lv, Y Tian, Y Lin (2023)	Parallel transportation in TransVerse: From foundation models to DeCAST
J Wang, T Wang, Y Shi, D Xu, Y Chen, J Wu (2022)	Metaverse, SED model, and new theory of value
W Wang, DT Hoang, P Hu, Z Xiong, D Niyato (2019)	A survey on consensus mechanisms and mining strategy management in blockchain networks

4.6. Bibliometric Network Visualization Analysis.

The VOSviewer analysis, which focuses on co-occurrence analysis, identified 6,946 keywords related to decentralized finance. This analysis limited the occurrence of keywords in the title and abstract to a maximum of three to obtain more specific keywords. With this restriction, 173 keywords were obtained, which were divided into 18 clusters, as shown in Table 6.

Table 5. Keyword Grouping

Cluster	Keywords
Cluster 1	Assurance, banking system, blockchain economy, blockchain interoperability, blockchain research, capital, central bank, cryptocurrency exchange, decentralized database, decentralized app, decentralized environment, decentralized finance application, decentralized financial system, decentralized method, decentralized storage, decentralized structure, decentralized system, defi protocol, defi smart contract, digital token valuation, disruptive technology, distributed ledger technology, entrepreneurial finance, entrepreneurship, Ethereum network, financial asset, financial protocol, financial services industry, fintech ecosystem, fintech platform, fintech sector, a fintech start-up, initial coin offering, Islamic crypto asset, low transaction cost, open finance, token sale, total value, transparency challenge, venture.
Cluster 2	Accessible banking pillar, autonomous organization, bitcoin regulation, centralized finance, climate finance, credit unions cryptocurrency, crypto wallet, decentralized nature, decentralization characteristic, decentralized Blockchain, decentralized consensus, decentralized financedefi, defi platform, defi service, digital finance, digital platform, digital token, disruption, enhanced AML regulation, finance industry, finance sector, financial crime, financial ecosystem, financial institution, financial intermediation, financial technology, fintech application, a fintech firm, fintech revolution, high transaction cost, information asymmetry, money laundering, third party, third party intermediary, virtual currency.
Cluster 3	Banking industry, bitcoin blockchain, block chain, blockchain technology application, blockchain use, central intermediary, cryptocurrency market, decentralised application, decentralised autonomous organisation, decentralised finance platform ecosystem, decentralized insurance, digital currencies, digital currency transaction, digital ledger, digital representation, digitalization, finance platform, financial disintermediation, financial inclusion, financial industry, financial regulation, fintech company, fintech innovation, fintech solution, future challenge, green finance, intermediation cost, islamic finance, lower transaction cost, myth, traditional financial system.
Cluster 4	Blockchain architecture, decentralized autonomous organizations, decentralized exchange, decentralized metaverse, digital twin technology, Ethereum ecosystem, governance token, heterogeneous Blockchain, nonfungible tokens, token standard.
Cluster 5	Bitcoin transaction, blockchain ecosystem, clever contract execution mechanism, decentralized blockchain network, defi application, defi project, digital, industrial

	Blockchain, metaverse technology, operational efficiency.
Cluster 6	AI-enhanced blockchain technology, artificial intelligence, augmented reality, collaboration, digital twin approach, digital twinning, environmental sustainability, fungible tokens.
Cluster 7	Decentralized autonomous organization, digital business, digital twin avatar, metaverse, special purpose financing, utility token.
Cluster 8	Autonomous organization, business model innovation, decentralized digital currency, digital technology, towards Blockchain.
Cluster 9	Behavioral finance approach, decentralized finance asset pricing, digital asset, ecosystem approach, fungible token.
Cluster 10	Code cloning, Ethereum blockchain platform, Ethereum Virtual Machine, trustless architecture.
Cluster 11	Decentralized identity system, digital twin edge network, edge computing, Ethereum account.
Cluster 12	Cryptocurrency transaction, digital twin, edge technology, nonfungible token.
Cluster 13	Digital twins, NFT, nonfungible token
Cluster 14	Decentralized finance business model, traditional finance
Cluster 15	Direction, finance application
Cluster 16	Industrial metaverse
Cluster 17	Decentralized autonomous
Cluster 18	Artificial intelligence technology

Based on the network visualization in this figure, several small nodes represent the main keywords from the analysis. The figure highlights that the topic of “digital twin” is the focus of attention, with various connections established to other keywords such as “nonfungible token”, “financial technology”, “augmented reality”, and “business model innovation”. However, there are some gaps in the connections between specific nodes. For example, the topic “digital twin” shows stronger connections with keywords related to technology and innovation. In contrast, topics such as the “behavioral finance approach” or “decentralized blockchain” still appear less connected to key nodes. This indicates the need for further research to bridge the gap. Additional research exploring the causal relationships between these nodes could provide deeper insights, supporting an effective and integrated decentralized finance process in various fields.

Fig 2. Bibliometric Network Visualization in financial decentralization

4.7. Overlay Visualization Analysis

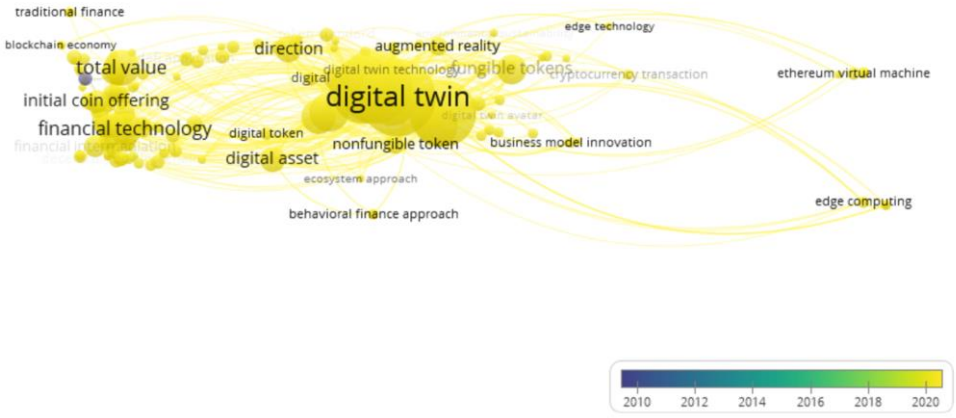

Fig 3. Overlay visualization in decentralized finance

Figure 3 shows the novelty of the variables regarding DeFi. The node color of each variable shows a light color (yellow), which indicates the most recent variables often used for research with the central theme of DeFi. Visualization overlay analysis that illustrates the relationship between terms based on frequency and temporal relevance.
Key terms, such as “digital twin” and “artificial intelligence”, show significant weight and are the focus of this analysis, especially with more active development in the 2019-2020 period, marked in yellow. The relationship between terms is illustrated through connecting lines, reflecting their co-occurrence in the same context.

4.8. Destiny Overlay Analysis

Fig 4. Visualization of density in decentralized finance

Figure 4 presents a density visualization analysis that illustrates the density of key terms based on their frequency of occurrence in the analyzed data. The term “digital twin” emerges as the most dominant, marked in bright yellow, indicating that this topic takes center stage in the dataset. In addition, other terms such as “financial technology,” “total value,” and “nonfungible token” also show significant density in green, signifying their high relevance. On the other hand, terms such as “Ethereum virtual machine” and “edge computing” have a lower density, visible in blue, indicating their minor contribution to the central theme. This visualization is handy for identifying key topics and understanding their relationship with broader themes in the dataset.

5. Conclusion

Bibliometric analysis shows that scientific mapping in developing decentralized finance (DeFi) research still has many research gaps. This opens up opportunities for researchers to dig deeper into various aspects of DeFi that have not been widely explored. Some suggested themes for further research include the adoption of DeFi in financial inclusion, blockchain technology innovation, its impact on the traditional financial system, and the application of smart contracts in various sectors. In-depth research in these areas is essential to support the future development of a more inclusive, efficient, and innovative DeFi ecosystem.

Fig 5. Recommended variables for further research

Figure 5 shows the variables that are recommended for further research. Forty-five variables can be used by future researchers.

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