Digital Assets Research: Current Status and Future Trends

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Abstract

Digital assets, through the integration of emerging technologies such as blockchain, hold the promise to link with potential values. This article aims to examine the development trends and current research of digital assets. It presents a theoretical framework that facilitates researchers and practitioners in digital assets. A descriptive analysis of relevant articles was conducted, e.g., the analysis of annual publications and citations, categories distribution analysis, country and institutional analysis, and journal co-citation analysis. Through the cluster analysis, the research topics were identified and explored in depth. The findings indicate that, since 2018, there has been an increase in the annual publications and citations, accompanied by a broad distribution across various categories. The current research focuses on Bitcoin Price Volatility & Forecast, Investor Sentiment, Other Cryptocurrency & NFT, Bitcoin Environment & Energy, Safe-Haven Properties of Bitcoin. We intend to seek implicit connections between topics that will perform in the future. This research provides theoretical support for comprehending the features of digital assets and their role in investment portfolios in the market.

Keywords: digital assets, blockchain, cryptocurrency, bitcoin

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I. INTRODUCTION

With the rapid development of the economy, digital assets have emerged as a value chain and are becoming the focus of global attention. Digital assets include digital currencies (such as Bitcoin and Ethereum), digital equity assets (such as non-fungible tokens NFT, digital copyright works), virtual assets (such as virtual game props, social media platform accounts and related data), and digital information assets (such as text, media files, data and information assets). Its core is a string of code or digital certificates that represent ownership and value and achieve point-to-point transfer and circulation through distributed ledger technologies such as blockchain. The asset is decentralized, secure and transparent, and can achieve instant and low-cost transfers.

As technology continues to advance and market demand evolves, the digital assets market is experiencing tremendous growth. The fundamental technological basis offers support of immutability and transparency for digital assets transactions. Digital assets consist of a wide range of categories, e.g., digital currencies, digital securities, and digital copyrights, and are also integrated with cutting-edge technologies, such as blockchain, encryption, and smart contracts. These assets leverage advanced technologies to facilitate secure and efficient transactions. Various platforms, including digital assets trading platforms, NFT markets, and decentralized exchanges, provide a convenient environment for trading digital assets. The platforms facilitate the rapid and transparent buying and selling of digital assets in the open market for value transfer and appreciation.

Digital assets, particularly cryptocurrencies, are increasingly recognized as a new frontier for investment. With the advancement of technology and the continual expansion of application scenarios, digital assets offer investors fresh avenues for capital deployment. Furthermore, the continuous evolution

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of digital technology has led to a proliferation of digital assets varieties and application contexts.

The research in digital assets mainly revolves around big data and blockchain technology. As an important part of digital assets, the research on data assets has deepened, such as the ownership confirmation, measurement and pricing, and accounting treatment. These studies provide guidance for the theoretical development, practical application and management of digital assets. Despite the substantial progress made in the research on digital assets, numerous issues remain unresolved. This study aims to provide an in-depth review of the existing research on digital assets and to explore potential future research directions. Cluster analysis was conducted to interpret the hot topics that represent the status of digital assets. Furthermore, citing and cited references are examined to illustrate the connections between topics and offer future guidelines.

This article is structured as follows (Figure 1). Section Ⅱ delineates the research methodology employed in this study. Section Ⅲ furnishes an overview and descriptive analysis. Section Ⅳ delves into the primary clusters identified in the extant literature, examining the 138 highly cited references associated with these clusters. These highly cited references constitute the cornerstone of digital assets research. In Section Ⅴ, we identify 77 core articles within the domain of digital assets. These 77 highly cited core articles are categorized to ascertain the principal topics of digital assets research. Furthermore, this section explores the significant topics emanating from digital asset articles published between 2022 and 2024. Lastly, Section Ⅵ concludes the paper.

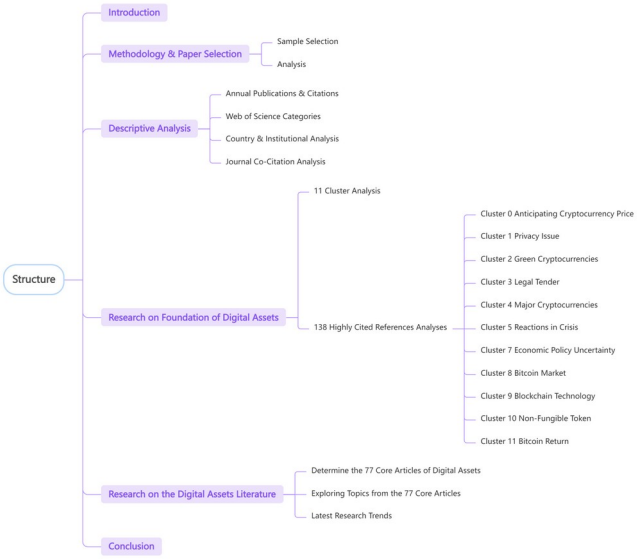

Figure 1. The Structure of the Paper

II. Methodology & Paper Selection

Sample Selection

We searched for the articles from the WoS core collection database. "Digital assets" was chosen as the author keyword to search for published papers. The keywords related to "digital assets" were collected as well. Combined with the definition of digital assets themselves, 35 relevant keywords were identified: "digital asset", "digital asset chain", "digital asset inheritance", "digital asset investment", "digital asset management", "digital asset price", "digital asset regulation", "digital asset reuse", "digital asset trading", "digital asset valuation", "digital asset value", "digital assets", "digital assets management", "digital currency", "digital finance", "digital financial asset", "digital gaming assets", "digital intellectual property", "digital rights management", "Bitcoin", "blockchain-based digital asset", "central bank digital currency", "crypto asset", "cryptocurrency", "cryptocurrencies", "digital art assets", "information asset", "initial coin offering", "non-fungible token", "non-fungible tokens", "operations with cryptocurrency", "security token offering", "social media digital assets", "supervisable digital currency model", "virtual real estate". Based on the keywords, we searched for articles in the title, author keywords, and Keywords Plus (the deadline for the search was December 31, 2024, and the search date was January 20, 2025).

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Analysis

According to the literature review search process, a total of 6,392 documents were obtained with publication years ranging from 2012 to 2024.

Based on the analysis, by screening WoS categories, we limited the types of documents to research papers and review articles, excluding records in categories with less relevance to the focus of this research, and obtained 5,762 main documents. Based on the 5,762 articles collected, a descriptive analysis was conducted, such as the annual publications and citations analysis; the categories distribution analysis; the country & institutional analysis, and the journal Co-citation analysis.

Since the main publication period started in 2018, we limited the research to 2018-2024 and obtained 5,570 samples.

The 50 highest cited references of the samples every year were selected to establish a Co-citation network for cluster explore. 21 clusters were obtained, and we selected the largest 11 clusters for subsequent analysis of an in-depth analysis of the 138 high cited references. The high cited references is the foundation of research. we took the intersection of the 138 highly cited references and the 5,570 articles of digital assets that were released between 2018 and 2024 to obtain 77 core articles. We explored the hot topics in the field of digital assets from the 77 core articles. However, the 77 core articles is only updated to 2022, and the articles after 2022 were not high cited references because of its short publication. We analyzed the 3,597 articles of the digital assets from 2022 to 2024, aiming at the state-of-the-art topics. As shown in Figure 2.

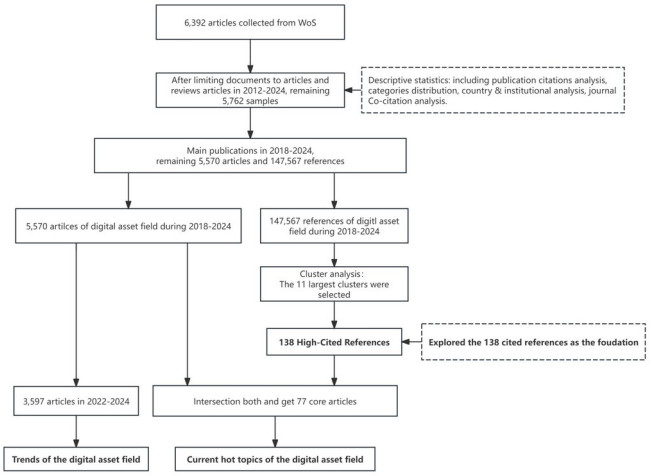

Figure 2. Article Selecting Procedures

III. Descriptive Analysis

Annual Publications & Citations

From 2012 to 2024, we selected 5,762 digital asset-related articles in WoS (5580 articles + 182 reviews). The publications and citations have increased annually (Figure 3). The annual publications of articles increased from 18 in 2012 to 1,303 in 2024, while the citations increased from 6 in 2012 to 43,137 in 2024. Specifically, the publications and citations in 2012-2017 increased slowly, but since 2018, scholars' interest has improved qualitatively, and the annual publications and citations have maintained a high growth trend. We focus on the articles from 2018 to 2024. The categories are Computer Science Information Systems, Engineering Electrical Electronic, Telecommunications, Business Finance, and Economics. This growth trend continues to grow, and more related research may appear.

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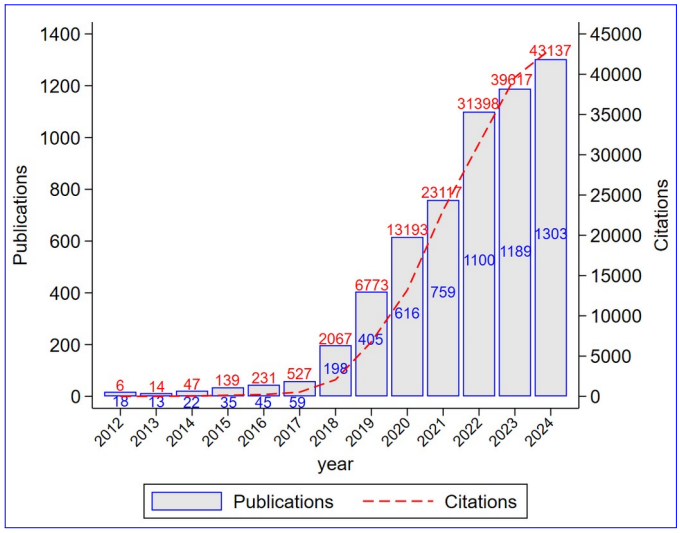

Figure 3. Analysis of Annual Publications & Citations (2012 - 2024)

Web of Science Categories

We classified the 5,762 articles published between 2012 and 2024. The categories with the most articles are Business Finance (1,586 articles), Economics (1,185 articles), Computer Science Information Systems (932 articles), Electrical and Electronic Engineering (683 articles), Telecommunications (559 articles), Business (337 articles), Management (279 articles), and Computer Science Theory and Methods (244 articles). To better observe the categories distribution of digital assets, we refer to Business Finance, Economics, Business, and Management as Economics & Business (Figure 4).

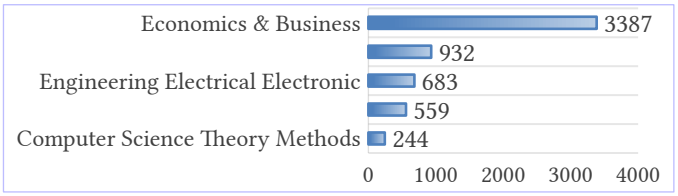

Figure 4. Publications of Digital Asset by Categories (2012-2024)

The five categories have shown a growth trend since 2018 (Figure 5). However, there are differences in the development speed of these categories. Among these categories, Economics & Business has the highest number of publications, and the number of documents has increased rapidly since 2018; Computer Science Information Systems, Engineering Electrical Electronic, and Telecommunications have similar publications and growth trends, all of which began to grow in 2018, slowed down in 2020, then peaked in 2022, slightly declined in 2023, and rebounded significantly in 2024. The growth of publications has the same trend as the number of publications. In contrast, Computer Science Theory Methods have the lowest number of publications, and the fluctuation is relatively gentle.

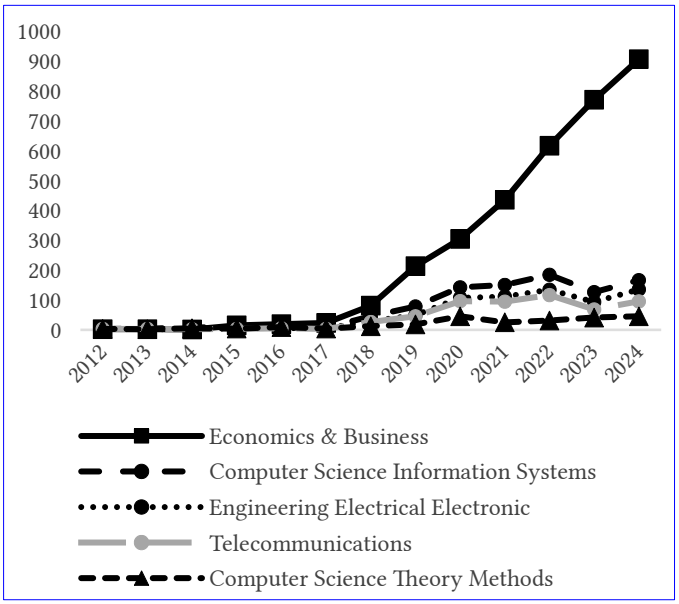

Figure 5. Annual Publications of the 5 Categories

Country & Institutional Analysis

In this part, analysis of the publications that institutions engaged from 2012 to 2024 was conducted. The top five countries are China, USA, the United Kingdom, Australia and South Korea. China, USA, the United Kingdom and South Korea started research on digital assets as early as 2012. China has invested significantly in digital assets research, with 73 institutions and 1,803 papers published. It accounts for almost a third of the world's publications. USA, the United Kingdom and South Korea have also launched research on digital assets. 23 institutions in USA published 950 articles, 19 institutions in the United Kingdom published 670 articles, and 7 institutions in South Korea published 332 articles, respectively. Australia started its research on digital assets later (in the year of 2013), with 13 institutions and 318 published papers. Subsequently, France, Canada, Germany, Spain and the United Arab Emirates have carried out research related to digital assets (Table 1).

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Table 1
Institutions & Publications Analysis

Country	Institutions	Publications
China	73	1803
USA	23	950
United Kingdom	19	670
Australia	13	318
South Korea	7	332
France	6	298
Canada	5	251
Germany	5	240
UAE	5	139
Spain	4	237

Notes: Limited to the top 10 countries by the number of institutions

Journal Co-Citation Analysis

Journal Co-citation analysis is to determine the main publication by counting the Co-citation frequencies between journals. In view of the few research in digital assets between 2012 and 2017, we conducted an in-depth analysis of the articles published between 2018 and 2024. Papers published in 18 journals, including *Finance Research Letters, Economics Letters, International Review of Financial Analysis, The Journal of Finance, Research in International Business and Finance, The Review of Financial Studies, Journal of International Financial Markets Institutions & Money, Physica A: Statistical Mechanics and its Applications, Lecture Notes in Computer Science, Economic Model, Journal of Financial Economics, Applied Economics, Energy Economics, Econometrica, The Journal of Banking and Finance, and The Journal of Econometrics*, were cited more than 1,000 times (Table 2).

Table 2
Journal Co-Citation

Cited Journals	Publications
Finance Research Letters	2698
Economics Letters	2098
International Review of Financial Analysis	1912
Journal of Finance	1527
Research in International Business and Finance	1453
Review of Financial Studies	1374
Journal of International Financial Markets, Institutions & Money	1346
Physica A: Statistical Mechanics and its Applications	1280
Lecture Notes in Computer Science	1240
Economic Modelling	1237
Journal of Financial Economics	1199
Applied Economics	1136
Energy Economics	1134
Econometrica	1060
Journal of Banking & Finance	1056
Journal of Econometrics	1013

Notes: Limited to the journals with citation frequencies above 1000

IV. Research on Foundation of Digital Assets

11 Cluster Analysis

The high cited references of the samples are the basis for conducting digital asset research. The cluster analysis is conducted on these articles to explore the important clusters of digital assets. Based on 147,567 cited references, this article selected the top 50 high cited references each year to construct a Co-citation network and clustered them according to the article title of the cited references. 21 clusters were finally identified, of which the largest 11 clusters covered a total of 138 highly cited references (Table 3).

Table 3
Summary of the Largest 11 Clusters

Cluster	Size	Silhouette	Period	Mean (year)	Keywords
Cluster 1 Anticipating Cryptocurrency Price	17	0.972	2013-2020	2016	anticipating cryptocurrency price, price volatility, cryptocurrency coin, market capitalization, analyzing difference

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Table 3
Summary of the Largest 11 Clusters

Cluster	Size	Silhouette	Period	Mean (year)	Keywords
Cluster 2 cryptocurrency privacy issues	17	0.969	2013-2018	2014	privacy issue, Bitcoin-like digital cash system, unlinkable coin, transaction privacy enhancement, mixing scheme
Cluster 3 Green Cryptocurrencies	14	0.906	2018-2022	2020	green cryptocurrencies, dirty cryptocurrencies, clean energy, asymmetric spillover
Cluster 4 Legal Tender	14	0.967	2018-2022	2019	legal tender, el Salvador, blockchain characteristics, blockchain factor, volatile safe-haven asset
Cluster 5 Major Cryptocurrencies	14	1	2018-2022	2018	Major cryptocurrencies, cryptocurrency market, volatility connectedness, spillover effect, dynamic volatility connectedness
Cluster 6 Reactions in Crisis	13	0.979	2017-2021	2019	covid-19 pandemic, covid-19 crisis, major cryptocurrencies, safe haven, safe haven properties
Cluster 7 Economic Policy Uncertainty	11	0.948	2017-2022	2018	economic policy uncertainty, uncertainty indice, resource commodity future, of-sample forecasting, pandemic condition
Cluster 8 Bitcoin Market	10	1	2016-2019	2017	covid-19 pandemic, Bitcoin market, price appreciation, roughness duality, exploring asymmetric multifractal cross-correlation
Cluster 9 Blockchain Technology	10	1	2015-2017	2015	blockchain technology, covid-19 pandemic, future direction, cryptocurrency market, comprehensive survey
Cluster 10 Non-Fungible Token	9	1	2018-2022	2021	non-fungible token, frequency connectedness, extreme connectedness, cryptocurrency nft, defi asset
Cluster 11 Market Efficiency & Hedge Dynamics	9	0.951	2016-2018	2017	covid-19 pandemic, Bitcoin return, covid-19 crisis, major cryptocurrencies, volatility persistence
Total	138		2013-2022		

The 138 highly cited references contained in these 11 clusters were published between 2013 and 2022. Among them, Cluster 3 green cryptocurrencies have the smallest silhouette value, but it is also greater than 0.7 (the clustering effect is very ideal when the silhouette value of the cluster is greater than 0.7). Hence, these 11 clusters are good, and the homogeneity of the articles within the cluster is very high. Cluster 1 anticipating cryptocurrency price is the largest cluster, containing 17 references from 2013 to 2020, and the median year of the cited references is 2016. Cluster 2 cryptocurrency privacy

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issues is the second largest cluster, and the clustering effect is slightly worse than Cluster 1. Cluster 2 contains 17 references from 2013 to 2018, and the median year of the cited references is 2014. Cluster 3 green cryptocurrencies is the 3rd cluster, with 14 references from 2018-2022, and the median year of citations is 2020. Cluster 4 legal tender is the 4th cluster, with 14 references from 2018-2022, and the median year of citations is 2019. Cluster 5 major cryptocurrencies is the 5th cluster, with 14 references from 2018-2022, and the median year of citations is 2018. Cluster 6 reactions in crisis are the 6th cluster, with 13 references from 2017-2021, and the median year of citations is 2019. Cluster 7 economic policy uncertainty is the 7th cluster, with 11 references from 2017-2022, and the median year of citations is 2018. Cluster 8 Bitcoin market is the 8th cluster, containing 10 references from 2016-2019, and the median year of citations is 2017. Cluster 9 blockchain technology is the 9th cluster, containing 10 references from 2015-2017, and the median year of citations is 2015. Cluster 10 non-fungible token is the 10th cluster, containing 9 references from 2018-2022, and the median year of citations is 2021. Cluster 11 Market Efficiency & Hedge Dynamics is the 11th cluster, containing 9 references from 2016-2018, and the median year of citations is 2017.

The degree of integration between clusters is high. These 138 highly cited references are the basis of research for 5,570 citing articles in the digital assets area from 2018 to 2024. The overlap of the keywords in the 11 clusters indicates that the highly cited references in each cluster provided the basis for the citing articles among clusters.

These 11 clusters study 11 mutually integrated topics of digital assets related. The research stages of each topic are different. Some topics have not produced new articles for many years, and the research is almost in a state of hibernation or provides a research basis for other topics only. On the other hand, some topics continue to have new highly cited references, and the research topics are more attractive. From the research period and the median year of the cited references, the articles in Cluster 1 anticipating cryptocurrency price, Cluster 2 cryptocurrency privacy issues, cluster 8 Bitcoin market, cluster 9 blockchain technology, and Cluster 11 market efficiency & hedge dynamics were all published earlier than 2021, which is relatively old, since these clusters have no highly cited references in recent years. These clusters do not have hotpots, but they may be the research basis for other topics. Cluster 3 green cryptocurrencies, Cluster 4 legal tender, Cluster 5 major cryptocurrencies, Cluster 6 reactions in crisis, cluster 7 economic policy uncertainty, cluster 10 non-fungible token, the articles of these 6 clusters published relatively new. Next, we analyze cited references and citing articles around these 11 clusters.

138 Highly Cited References Analyses

138 highly cited references published between 2013 and 2022 distribute among the 11 clusters (Table 4). While the highly cited references of Cluster 2 cryptocurrency privacy issues, Cluster 1 anticipating cryptocurrency price, cluster 8 Bitcoin market, cluster 9 blockchain technology, and Cluster 11 Market Efficiency & Hedge Dynamics are all published relatively early, Cluster 3 green cryptocurrencies, Cluster 4 legal tender, Cluster 5 major cryptocurrencies, Cluster 6 reactions in crisis, cluster 7 economic policy uncertainty, and cluster 10 non-fungible token have newer highly cited references published. Considering that the contents of the 11 clusters have a high degree of overlap, the articles in some clusters were published relatively early and no highly cited references appeared in recent years, the early articles of these clusters are still constantly cited by the subsequent research of the other clusters.

Table 4
Distribution of 138 Papers among 11 Clusters (2013-2022)

Cluster	Year										Total
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Cluster 1 Anticipating Cryptocurrency Price	1	2	6	2	2	1	2	1			17
Cluster 2 Cryptocurrency Privacy Issues	6	5	2	2	1	1					17

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Table 4
Distribution of 138 Papers among 11 Clusters (2013-2022)

Cluster	Year										Total
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
Cluster 3 Green Cryptocurrencies						1	2	5	3	3	14
Cluster 4 Legal Tender						1	6	3	3	1	14
Cluster 5 Major Cryptocurrencies						6	6		1	1	14
Cluster 6 Reactions in Crisis					1	5	1	5	1		13
Cluster 7 Economic Policy Uncertainty					3	2	5			1	11
Cluster 8 Bitcoin Market				1	2	6	1				10
Cluster 9 Blockchain Technology			4	4	2						10
Cluster 10 Non-Fungible Token						1			2	6	9
Cluster 11 Market Efficiency & Hedge Dynamics				2	5	2					9
Total	5	7	11	10	16	26	23	14	10	12	138

Cluster 1 Anticipating Cryptocurrency Price

During 2013-2020, the 17 highly cited references in Cluster 1 focused on anticipating cryptocurrency price. The research on the factors influencing cryptocurrency prices, including price formation mechanism, investor sentiment, speculative and price bubbles, macroeconomic factors. By examining these elements, we aim to provide an understanding of the mechanisms driving cryptocurrency price dynamics and the implications for market participants and policymakers.

Table 5
Topics of Cluster 1

Topics	Explanations
Price Formation Mechanism	This articles mainly discusses the formation mechanism and driving factors of Bitcoin price, including market supply and demand, investor attraction, macroeconomic factors and speculative bubbles [Brandvold & Brooks, 2015; Baek & Elbeck, 2015; Cheah & Fry, 2015; Dwyer, 2015; Fry, 2016; Ciaian, et al., 2016; Urquhart, 2018].
Investor Sentiment	Investor sentiment, significantly impacts Bitcoin's trading volume and realized volatility. A reciprocal causal relationship exists between Bitcoin attention and returns [Urquhart, 2018; Shen, 2019; Kraaijeveld, 2020; Dastgir, 2019; Kondor, 2014].
Speculation & Price Bubbles	The Bitcoin market is highly speculative, with price fluctuations primarily driven by internal factors. Bitcoin's volatility is closely linked to speculative trading activities [Baek & Elbeck, 2015; Cheah & Fry, 2015; Blau, 2017; ElBahrawy, et al., 2017; Garcia, 2014; Kristoufek, 2015].
Macroeconomic Factors	While macroeconomic factors do not significantly drive Bitcoin prices in the long term, the dynamic relationship between Bitcoin and traditional financial assets is notable [Ciaian, et al., 2016; Kristoufek, 2013; Selgin, 2015].

The research highlights the multifaceted nature of Bitcoin's price formation mechanism, influenced by a combination of market forces, investor sentiment, speculative activities, and macroeconomic factors. As the cryptocurrency market continues to evolve, further research is needed to explore the long-term implications of these findings and to develop robust frameworks for market analysis and policy formulation.

Cluster 2 Cryptocurrency Privacy Issues

During 2013-2018, the 17 highly cited references in Cluster 2 focused on cryptocurrency privacy issues. Bitcoin, as a pioneering cryptocurrency, has revolutionized digital transactions by offering a decentralized and transparent system. However, its unique characteristics also raise significant concerns regarding user privacy. The articles examined the privacy risks associated with Bitcoin, the

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advancements in privacy protection technologies, and the challenges in implementing these solutions.

Table 6
Topics of Cluster 2

Topics	Explanations
Privacy Risks	The articles focus on Bitcoin's pseudo-anonymity, characterized by concealed ownership and publicly accessible fund flows, which raises concerns regarding potential criminal or fraudulent activities [Androulaki, et al., 2013; Meiklejohn, et al., 2013; Biryukov & Tikhomirov, 2015; Biryukov, et al., 2014; Koshy, et al., 2014; Ron & Shamir, 2013; Spagnuolo, et al., 2014; Conti, et al., 2018; Eyal & Sirer, 2014; Ziegeldorf, et al., 2017].
Privacy Protection Technologies	This articles shows the significant advancements in privacy protection technologies to protect the privacy of Bitcoin users [Ziegeldorf, et al., 2017; Kosba, et al., 2016; Miers, et al., 2013; Ben-Sasson, et al., 2014].
Privacy Protection Solutions	The papers focus on developing a framework for evaluating privacy enhancement proposals, conducting an in-depth analysis of the feasibility and robustness of existing privacy protection schemes [Conti, et al., 2018; Bonneau, 2015].

The research highlights the privacy risks associated with Bitcoin and the need for advanced privacy protection technologies. While significant progress has been made in developing solutions such as the Hawk system, Zerocoin, and Zerocash, practical implementation challenges remain. The analysis of Bitcoin transaction graphs and the potential for re-identification through various attack vectors emphasize the ongoing need for robust privacy safeguards.

Cluster 3 Green Cryptocurrencies

During 2018-2022, the 14 most cited references in Cluster 3 focused on green cryptocurrencies, exploring the performance of cryptocurrencies as safe-haven assets, their relationship with clean energy, their energy consumption and environmental impact, and their interaction with traditional financial assets. These studies provide an understanding of the sustainability of cryptocurrencies and their role in the financial system.

Table 7
Topics of Cluster 3

Topics	Explanations
Environmental Impact & Energy Consumption	This topic examines the energy consumption and carbon emissions associated with Bitcoin, highlighting the pressing environmental concerns and potential mitigation strategies [Mora & Dyer, 2018; Stoll, 2019; Corbet & McGee; 2021; Naeem & Bouri; 2021].
Market Dynamics & Safe Havens	This topic synthesizes research on Bitcoin's volatility, market connectedness, safe-haven role, hedging capabilities, and the potential of green financial assets as hedges and diversification tools [Ji & Bouri, 2019; Antonakakis & Gabauer, 2020; Ren & Bouri, 2022; Conlon, et al., 2020; Shahzad, et al., 2020; Bouri, et al., 2020; Okorie & Bouri, 2020; Mariana & Corbet, 2021; Pham & Bouri, 2022; Elsayed & Bouri, 2022].

In summary, research has advanced in understanding cryptocurrencies as safe-haven assets, their ties to clean energy, energy use, environmental effects, and correlation with traditional financial assets. These studies highlight cryptocurrency performance in various market scenarios and their environmental impact.

Cluster 4 Legal Tender

During 2018-2022, the 14 highly cited references in Cluster 4 focused on the potential role of cryptocurrencies as legal tender. The research explored in depth the position of cryptocurrencies in financial markets, their potential as safe-haven assets, their interactions with traditional assets, and their market characteristics and risks.

Table 8
Topics of Cluster 4

Topics	Explanations
Comparison with Traditional Assets	This topic mainly focuses on the differences between Bitcoin and traditional assets. Bitcoin can diversify investment risks but has poor hedging effects [Klein & Baur, 2018; Charfeddine & Ben Rejeb, 2020; Guesmi & Bouri, 2019].
Safe-Haven Properties	This topic examines the safe-haven role of cryptocurrencies, with Bitcoin, gold, and commodities considered weaker safe-havens in extreme markets. Bitcoin offers intraday hedging for some currencies and risk diversification for others [Shahzad, et al., 2019; Urquhart, 2019].

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Table 8
Topics of Cluster 4

Topics	Explanations
Market Characteristics & Risks	Cryptocurrencies are susceptible to tail risks and have little correlation with global assets. Cryptocurrency returns are mainly affected by market-specific factors and network effects, investor attention and momentum effects [Borri & Pellegrino, 2019; Griffin & Shams, 2020; Liu & Tsyvinski, 2021; Liu & Tsyvinski, 2022].
Exchange Arbitrage & Network Effects	The topic focused on the significant arbitrage opportunities between cryptocurrency exchanges. The equilibrium price is determined by user trading demand rather than discounted cash flow [Easley & O'Hara, 2019; Makarov & Schoar, 2020; Cong & He, 2021].
Economic & Social Impact	The topic focused on limiting illegal activities of cryptocurrency users. There is high volatility and correlation between cryptocurrencies, fintech assets, and traditional stocks. Traditional assets such as gold and oil are more effective as hedging tools compared to cryptocurrencies [Foley & Hamrick, 2019; Le & Phan, 2021].

Overall, the research has made progress in the comparison of cryptocurrencies with traditional financial assets, their potential as safe-haven assets, their interactions with financial markets, and market characteristics and risks. These studies reveal differences between cryptocurrencies and traditional assets such as gold in terms of volatility, correlation, and role in portfolios, and examine illegal activities, market manipulation, and price prediction factors in the cryptocurrency market.

Cluster 5 Major Cryptocurrencies

During 2018-2022, the 14 highly cited references in Cluster 5 focused on major cryptocurrencies such as Bitcoin, Ethereum, and Litecoin. This study consolidates key findings into four main topics: Market Interdependencies & Dynamics, Crypto Market Structure & Speculation Behavioral of Crypto Markets Blockchain Technology on Crypto Markets.

Table 9
Topics of Cluster 5

Topics	Explanations
Market Interdependencies & Dynamics	This topic explores the interdependencies and dynamic relationships between Bitcoin and other cryptocurrencies, highlighting their interconnectedness and volatility spillovers [Corbet, et al., 2018; Phillip & Gkillas, 2018; Ciaian & Rajcaniova, 2018; Corbet, et al., 2018; Yi & Bouri, 2018; Ji & Bouri, 2019; Koutmos, 2018; Katsiampa, 2019].
Crypto Market Structure & Speculation	This topic explores market structure and speculation in cryptocurrencies such as Bitcoin. It uses machine learning to predict cryptocurrency prices and develop profitable strategies, while also highlighting challenges such as regulatory scrutiny and illicit use [Sebastiao & Bouri, 2021; Corbet, et al., 2019].
Behavioral of Crypto Markets	This special feature explores the behavioral characteristics of cryptocurrency markets. Herding behavior is particularly evident in cryptocurrency markets, especially during periods of heightened uncertainty [Bouri & Roubaud, 2019; Bouri & Roubaud, 2019].
Blockchain Technology on Crypto Markets	This topic explores the impact of blockchain technology on the cryptocurrency market, mainly including: economic benefits, blockchain technology, initial coin offerings, fintech revolution and sharing economy [Xu & Bouri, 2019; Fang & Shen, 2022].

In summary, the crypto market is a highly complex and dynamic field, and its development is influenced by multiple factors such as technological progress, market behavior and regulatory environment. By deeply understanding these factors, we can better seize market opportunities while addressing potential risks and challenges.

Cluster 6 Reactions in Crisis

During 2017-2021, the 13 most cited references in Cluster 6 focused on the complex performance of cryptocurrencies in crisis. The articles consolidated key findings into three topics: Asset Relations & Safe-Haven, Speculative Use & Diversification, and Investor Sentiment in the Crisis.

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Table 10
Topics of Cluster 6

Topics	Explanations
Asset Relations & Safe-Haven	This study investigates Bitcoin's role as a hedge/safe haven, its correlation with other assets, and behavior in crises. It also explores evolving Bitcoin-financial asset relationships and the development of monitoring procedures to assess safe-haven properties [Bouri, et al., 2017; Corbet, et al., 2020; Conlon & McGee, 2020; Smales, 2019; Ji & Bouri, 2018; Ji & Bouri, 2020].
Speculative Use & Diversification	This topic examines Bitcoin's statistical properties, its use as a speculative investment, and its relationship with traditional asset classes [Gandal, et al., 2018; Baur, et al., 2018; Baur, 2018; Zhang & Bouri, 2020].
Investor Sentiment in the Crisis	This topic investigates the impact of suspicious trading activity and investor sentiment on Bitcoin's market dynamics in crisis [Gandal, et al., 2018; Goodell & Goutte, 2021; Corbet, et al., 2020; Corbet, et al., 2018].

This article significantly advances understanding of cryptocurrencies as safe-havens, market volatility, asset correlations, trading strategies, and investment potential. Studies reveal crisis behavior, relationships with traditional assets, and market dynamics. It emphasizes the complexity of the cryptocurrency market, influenced by Bitcoin-altcoin interdependencies, unique market structures, trading strategies, behavioral and economic factors, and technological contexts.

Cluster 7 Economic Policy Uncertainty

In 2017-2019 and 2022, the 11 highly cited references in Cluster 7 focused on the impact of economic policy uncertainty (EPU) on crypto markets, with a particular focus on Bitcoin. The articles consolidates key findings into two main topics: Safe-Haven & Hedging Properties, and Market Dynamics & Predictive Power. These insights provide a comprehensive understanding of Bitcoin's behavior as an asset and its implications for investors and policymakers.

Table 11
Topics of Cluster 7

Topics	Explanations
Safe-Haven & Hedging Properties	This topic examines Bitcoin's role as a hedge or safe haven against various types of market uncertainties and movements in other asset classes [Bouri & Roubaud, 2017; Selmi & Bouri, 2018; Demir & Demir, 2018; Aysan & Bouri, 2019; Wang & Bouri, 2019].
Market Dynamics & Predictive Power	This topic explores the predictive power of various factors on Bitcoin's returns and volatility, as well as its dynamic relationships with other assets [Balcilar & Demir, 2017; Bouri & Roubaud, 2017; Bouri & Roubaud, 2019; Lucey, 2022; Aalborg & Bouri, 2019; Fang & Bouri, 2019].

Overall, The research highlighted the multifaceted role of Bitcoin in financial markets. While Bitcoin exhibits significant hedging and safe-haven properties under certain conditions, its returns and volatility are influenced by a variety of factors, including trading volume, economic policy uncertainty, and global geopolitical risks.

Cluster 8 Bitcoin Market

During 2016-2019, the 10 highly cited references in Cluster 8 focused on studying the efficiency of the Bitcoin market. The study provides the key research findings in two critical areas: Market Efficiency and Long-term Memory & Correlations. Understanding these aspects is crucial for investors, regulators, and researchers interested in the evolving dynamics of crypto markets.

Table 12
Topics of Cluster 8

Topics	Explanations
Crypto Market Efficiency	This topic includes studies focusing on the overall efficiency of the Bitcoin market, examining whether it adheres to the efficient market hypothesis [Urquhart, 2016; Tiwari & Muttaqi, 2018; Jiang & Zhou, 2018; Sensoy & Baur, 2019].
Long Memory & Market Efficiency	This topic explores Bitcoin’s long memory in prices and returns, with markets alternating between efficiency and anti-persistence. It highlights increased uncertainty during high-price periods and notes Bitcoin is less efficient than traditional markets [Bariviera, 2017; Bariviera, 2017; Alvarez-Ramirez & Rodriguez, 2018; Lahmiri & Bekiros, 2018; Kristoufek, 2018; Al-Yahyaee & Bouri, 2018].

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Overall, while the Bitcoin market has shown improvements in information efficiency over time, its long memory and multifractal characteristics contribute to more complex dynamics in prices and returns. Compared to traditional asset markets, Bitcoin remains less efficient overall but demonstrates short-term efficiency gains in certain periods.

Cluster 9 Blockchain Technology

During 2015-2017, the 10 most cited references in Cluster9 focused on the application of blockchain technology in the field of cryptocurrency and its wide-ranging impact. These studies deeply analyze the key research studies in the fields of Bitcoin market dynamics, Bitcoin and blockchain technology, and the integration of blockchain with the Internet of Things (IoT). These studies cover a range of topics, from market behavior and investment characteristics to technical design and practical applications, highlighting the multifaceted nature of blockchain and cryptocurrency research.

Table 13
Topics of Cluster 9

Topics	Explanations
Bitcoin Bubble & Dynamics	This study focused on the Bitcoin market bubble, exploring its decentralized advantages, payment and investment characteristics, price formation, and speculative bubble. It also analyzed transaction network structure and price drivers [Cheah & Fry, 2015; Kondor, 2014; Kristoufek, 2015; Selgin, 2015; Cheung & Ng, 2015; Brière, et al., 2015; Polasik & Kozinski, 2016; Li & Li, 2017].
Blockchain Technology	This topic covers Bitcoin's protocol and blockchain basics, including CoinParty for anonymity, mining incentives, and blockchain research [Eyal & Sirer, 2014; Ziegeldorf, et al., 2017; Böhme, et al., 2015; Tschorsch, et al., 2016; Zheng, et al., 2017; Christidis & Devetsikiotis, 2016; Yli-Huumo, et al., 2016].

Overall, the research in cluster 9 comprehensively covers the application of blockchain technology in cryptocurrency and its broad impacts. These findings underscore the importance of continued research to better understand the dynamics of crypto markets and to inform investment strategies and regulatory frameworks.

Cluster 10 Non-Fungible Token

In 2018, 2021, and 2022, the 9 highly cited references in Cluster 10 focused on the study of non-fungible token (NFT). NFTs, which stand for Non-Fungible Tokens, represent tradable rights of digital assets, recorded on blockchain through smart contracts. Recent research endeavors on NFTs have primarily focused on their pricing mechanisms, market behavior, and intricate relationships with both traditional and digital asset classes.

Table 14
Topics of Cluster 10

Topics	Explanations
NFT Growth & Financial Tie	This topic studies a new framework for financial connectedness and NFT market growth. The framework measures connectedness among financial variables due to heterogeneous frequency responses to shocks [Baruník & Křehlík, 2018; Nadini & De Domenico, 2021; Wang, et al., 2021].
Token Diversification	This study explores token diversification. Blockchain market volatility highlights the need for diversification via tokens and cryptocurrencies. NFTs offer diversification potential and act as a low-correlation asset, with weak static but dynamic links to traditional assets under stress [Karim & Bouri, 2022; Yousaf & Bouri, 2022].
NFT Pricing & Asset Relationships	This topic examines NFT pricing and market behavior. NFTs show inefficiency and value growth. NFTs are mostly independent of traditional assets and Ethereum. NFTs transmit risk normally but absorb it during stress [Wang, et al., 2021; Ando & Bai, 2022; Dowling & Faff, 2022; Aharon & Bouri, 2022; Dowling & Faff, 2022].

In summary, as one of the important applications of blockchain technology, NFT has emerged from the crypto market and become a digital asset with a unique market structure and pricing model. The research highlighted the emerging role of NFTs and DeFi tokens in the financial markets. While these new assets offer significant diversification potential and risk-bearing capacity, their market dynamics and pricing behavior are complex and influenced by a variety of factors.

Cluster 11 Market Efficiency & Hedge Dynamics

During 2016-2018, the 9 highly cited references in Cluster 11 focused on the study of Bitcoin returns.

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The study of Bitcoin's market dynamics has been a focal point of research due to its significant impact on the cryptocurrency ecosystem. The articles examined the existing literature on Bitcoin's volatility, hedging capabilities, price behavior, and regulatory impact.

Table 15
Topics of Cluster 11

Topics	Explanations
Bitcoin Volatility & Market Efficiency	This topic explores Bitcoin's volatility and market efficiency. It highlights similarities to gold and the dollar. Market efficiency improves with liquidity, and high-liquidity cryptocurrencies show lower return predictability [Dyhrberg, 2016; Katsiampa, 2017; Urquhart, 2017; Nadarajah & Chu, 2017; Wei & Wang, 2018].
Hedge & Market Dynamics	This study explores Bitcoin's role as a hedge and its market dynamics. Cryptocurrency efficiency decreases with increased liquidity [Dyhrberg, 2016; Kim & Bouri, 2017; Pieters, 2017; Brauneis & Mestel, 2018].

The research summarized here highlights the complex and multifaceted nature of Bitcoin's market dynamics. While Bitcoin exhibits significant volatility and clustering behavior, it also shows potential as a short-term hedging tool with lower transaction costs compared to traditional markets. The impact of liquidity and regulatory measures on market efficiency underscores the importance of continued research and regulatory oversight.

V. Research on the Digital Assets Literature 5570

To explore the foundations of digital asset research, Section Ⅳ analyzes 138 highly cited references. These highly cited references are the foundation of digital assets research. However, the research scope of these articles goes far beyond the field of digital assets. If we examine the topics by the 138 highly cited references, there may be two problems: First, the topics explored are not directly related to digital assets; Second, the articles published in recent years (highly cited references were published earlier) would be missed.

Determine the 77 Core Articles of Digital Assets

Selecting the intersection of the 138 highly cited references and the 5,570 articles of digital assets that were released between 2018 and 2024 to obtain 77 core articles. Based on the clustering and topics in Part Ⅳ of this paper, Table 16 categorizes the 77 highly cited core articles of digital assets, with colors used to indicate their publication years. From Table 16, it can be seen that clusters 3, 4, 5, 7, and 10 published the most articles between 2020 and 2022, highlighting the latest topics in digital assets.

Table 16
Distribution of 77 Core Articles1

Topics	Distribution of 77 Core Articles				
Cluster 1 Anticipating Cryptocurrency Price 4 Articles					
Price Formation Mechanism	2018				
Investor Sentiment	2018	2019*2	2020		
Cluster 2 Cryptocurrency Privacy Issues 1 Article					
Privacy Risks	2018				
Privacy Protection Solutions	2018				
Cluster 3 Green Cryptocurrencies 12 Articles					
Environmental Impact & Energy Consumption		2019		2021*2	
Market Dynamics & Safe Havens		2019	2020*5		2022*3
Cluster 4 Legal Tender 13 Articles					
Comparison with Traditional Assets	2018	2019	2020		
Safe-Haven Properties		2019			
Market Characteristics & Risks		2019	2020	2021	2022
Exchange Arbitrage & Network Effects		2019	2020		
Economic & Social Impact		2019		2021	
Cluster 5 Major Cryptocurrencies 13 Articles					
Market Interdependencies & Dynamics	2018*6	2019*2			
Crypto Market Structure & Speculation		2019		2021	
Behavioral of Crypto Markets		2019*2			
Blockchain Technology on Crypto Markets					2022
Cluster 6 Reactions in Crisis 11 Articles					
Asset Relations & Safe-Haven	2018	2019	2020*3		
Speculative Use & Diversification	2018*3				

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Table 16
Distribution of 77 Core Articles1

Topics	Distribution of 77 Core Articles				
Investor Sentiment in the Crisis	2018*2		2020	2021	
Cluster 7 Economic Policy Uncertainty 8 Articles					
Safe-Haven & Hedging Properties	2018*2	2019*2			
Market Dynamics & Predictive Power		2019*3			2022
Cluster 8 Bitcoin Market 7 Articles					
Crypto Market Efficiency	2018*2	2019			
Long Memory & Market Efficiency	2018*4				
Cluster 10 Non-Fungible Token 6 Articles					
NFT Growth & Financial Tie				2021	
Token Diversification					2022*2
NFT Pricing & Asset Relationships				2021	2022*3
Cluster 11 Market Efficiency & Hedge Dynamics 2 Articles					
Bitcoin Volatility & Market Efficiency	2018				
Hedge & Market Dynamics	2018				

However, we found that some of the core articles in Figure 6, which are distributed across different clusters, share similar topics. This is because the 77 articles were categorized based on cited references related to digital assets. Therefore, by reclassifying these 77 core articles, we can more succinctly identify the research topics of digital assets.

Exploring Topics from the 77 Core Articles

We classified the topics of 77 articles on digital assets and annotated the publication years of the literature included in each topic, as shown in Table 17.

Table 17
Distribution of 77 Core Articles2

Topics	Distribution of 77 Core Articles				
Bitcoin Price Volatility & Forecast	2018*5	2019*5	2020*7	2021*4	2022*3

Table 17
Distribution of 77 Core Articles2

Topics	Distribution of 77 Core Articles				
Investor Sentiment	2018*5	2019*8	2020	2021*2	2022
Other Cryptocurrency & NFT		2019*2		2021	2022*7
Bitcoin Environment & Energy		2019		2021*2	2022*3
Safe-Haven Properties of Bitcoin	2018*3	2019*5	2020*5		2022
Bitcoin Market Efficiency	2018*8	2019*6			
Security & Privacy of Blockchain Technology	2018*4	2019*3			

As can be seen from Table 17, the 77 papers are mainly distributed in seven topics, which are: Bitcoin Price Volatility & Forecast, Investor Sentiment, Other Cryptocurrency & NFT, Bitcoin Environment & Energy, Safe-Haven Properties of Bitcoin, Bitcoin Market Efficiency, Security & Privacy of Blockchain Technology

We assumed that the topics of recent publications were more important, and that the topics of more publications in the same time period were more important. Based on this rule, we identified five topics: Bitcoin Price Volatility & Forecast, Investor Sentiment, Other Cryptocurrency & NFT, Bitcoin Environment & Energy, Safe-Haven Properties of Bitcoin. The five topics have been cited highly in recent years, indicating that the five topics are hot spots. The two topics (Bitcoin Market Efficiency, Security & Privacy of Blockchain Technology) have been no highly cited references since 2019, indicating that there have been no important research results on the two topics in recent years. We listed five hot topics, as shown in Table 18.

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Table 18
Topics of Core Articles (2018-2022)

Topics	Explanations
Bitcoin Price Volatility & Forecast (24 articles)	Study the price fluctuations of Bitcoin, the predictive factors and their returns and volatility spillovers with other assets.
Investor Sentiment (17 articles)	Explore the impact of bitcoin investor attention, sentiment on bitcoin price, trading volume and volatility.
Other Cryptocurrency & NFT (10 articles)	Study the market characteristics, price fluctuations and investment value of other cryptocurrencies (such as Ethereum, Litecoin, etc.) and non-fungible tokens (NFT).
Bitcoin Environment & Energy (6 articles)	Study the energy consumption, carbon emissions and environmental impact of Bitcoin mining.
Safe-Haven Properties of Bitcoin (14 articles)	Study the safe-haven function of Bitcoin under different market conditions, and compare it with gold, currency and other assets.

Table 19
Topics of Digital Assets Articles (2022-2024)

Topics	Year	Articles
Bitcoin Environment & Energy	2022	14
	2023	60
	2024	17
Safe-Haven Properties of Bitcoin	2022	12
	2023	50
	2024	12
Bitcoin Market Efficiency	2022	15
	2023	70
	2024	14
Security & Privacy of Blockchain Technology	2022	17
	2023	40
	2024	23

Latest Research Trends 3,597

Last section analyzed 77 core articles on digital assets, reflecting the key research findings in the field from 2013 to 2022. However, articles published after 2022 are not included, failing to fully capture the latest research trends in digital assets. In this section, we focus particularly on 3,597 articles on digital assets from 2022 to 2024, aiming to explore the most cutting-edge topics.

First, these 3,597 articles were compared with the seven topics discussed in last section, and it was found that they were completely consistent with these 7 topics (Table 19).

Table 19
Topics of Digital Assets Articles (2022-2024)

Topics	Year	Articles
Bitcoin Price Volatility & Forecast	2022	31
	2023	120
	2024	55
Investor Sentiment	2022	18
	2023	80
	2024	18
Other Cryptocurrency & NFT	2022	20
	2023	100
	2024	44

In the research results in the field of digital assets from 2022 to 2024, we found seven main topics. From these seven main topics, it can be seen that the five topics: Bitcoin Price Volatility & Forecast, Investor Sentiment, Other Cryptocurrency & NFT, Bitcoin Environment & Energy, Safe-Haven Properties of Bitcoin were still received extensive attention from scholars, and the research results are constantly superimposed. The two topics (Bitcoin Market Efficiency and Security & Privacy of Blockchain Technology) have also received some attention from scholars, but there are relatively few articles on these two topics.

VI. Conclusion

This paper is a review of the evolution of digital asset research. Specifically, it collected the relevant articles and analyzed the current state of development and evolutionary trends across various sub-domains of digital assets. It assists researchers in clarifying the research landscape and grasping the orientation and forthcoming investigative endeavors. The article focuses on the research status of digital assets, highlighting which sub-domains are changing digital asset evolution, and which research is extensively utilized in socioeconomic development. Furthermore, the study provides a detailed enumeration of countries, institutions, and authors

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who have made substantial contributions to research in digital asset-related domains.

As an interdisciplinary study, digital assets consist of information technology, management, economics, and other disciplines, with an emphasis on the application of digital asset characteristics and methodologies for achieving asset preservation and appreciation. Specifically, the current topics are analyzed, including Bitcoin Price Volatility & Forecast, Investor Sentiment, Other Cryptocurrency & NFT, Bitcoin Environment & Energy, Safe-Haven Properties of Bitcoin.

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