

MAPPING THE CONNECTEDNESS BETWEEN DIGITAL ASSETS AND TRADITIONAL FINANCE: A BIBLIOMETRIC ANALYSIS

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Abstract

This bibliometric study provides a comprehensive mapping research on digital assets connectedness with traditional finance, through multi dimensional analysis of 500 WoS documents, from 2018 to 2025. Thematic mapping distinguished 4 research domains: motor themes (connectedness, spillovers, risk), emerging topics (DeFi, tokenization, spot ETFs), niche specializations (GARCH modeling, TVP-VAR), and declining themes (basic Bitcoin-gold correlations). Collaboration world map demonstrates strong Asia-Pacific research corridors, particularly with Vietnam – China – Korea as principals, alongside Atlantic USA – UK partnerships. Source dynamics analysis shows Energy Economics and Financial Innovation journals experiencing rapid growth trajectories. Word frequency evolution tracking reveals declining emphasis of static hedging properties coinciding with the rising focus on dynamic connectedness and impulse-response frameworks. Affiliation temporal analysis identified the emerging research centers at Southwestern University of Finance and Economics and Wenzhou Kean University. Bradford's Law application confirms research concentration following typical bibliometric patterns with core-periphery structure. The field exhibits negative annual growth rate (-21.59%) suggesting the world has entered a consolidation phase after the initial surge during the exploration period, with an average of 29.33 citations per document indicating substantial academic contributions within this specific research domain.

Keywords: *Bibliometric Analysis, Digital Assets, Cryptocurrency, Traditional Financial Markets, Decentralized Finance, Connectedness.*

Classification JEL: *G10, G15, O33, O36.*

1. Introduction and context of the study

The number of digital assets rising, since Bitcoin's creation post 2009, leads the way to a more diverse capital markets environment. Even though the initial impact was low, at a retail level, with implications in the black and grey markets, the technological development and financial markets integration created new opportunities and added value to traditional sectors.

In the last decade and a half, digital assets have significantly impacted financial markets, increasing the focus of academic study on interconnections with traditional finance. The integration of Bitcoin in portfolios that have a traditional composition was a key point of interest to generate academic research opportunities regarding risk and volatility spillovers between the traditional and digital markets. (Klein et al., 2018; Guesmi et al., 2019). This bibliometric analysis systematically analyzes the discourse on digital assets interconnectivity with traditional finance using 500 documents extracted from Web of Science, dated 2018-2025, with a total of 1081 authors and 147 sources.

The literature explores the complex relationship between digital asset markets and conventional asset classes, including equity, commodities, securities, and foreign exchange markets. Academic research investigated whether digital assets can be regarded as safe-haven

instruments during turbulent periods, their hedging properties against traditional assets and their diversification characteristics within a portfolio (Yi et al., 2018).

The objective of this study is to identify dominating research themes, geographic distribution of the contributors, collaboration networks, and trace the evolution of concepts within the connected domains. The analysis will address the following questions: What are the principal thematic clusters in research on digital assets interconnectedness? Which journals, countries, and institutions lead academic production in the field? How have the research priorities evolved in time? What citation patterns reveal about the intellectual foundation and emerging aspects of this domain?

This bibliometric study aims towards a contribution to the literature through providing a systematic quantitative synthesis of the expanding research on digital assets integration with traditional finance, identifying research gaps and suggesting future research directions at the intersection of financial innovation and systemic risk analysis.

2. Literature review

Top ten cited papers reveal a narrative covering the following concepts:

- Bitcoin's market dominance and network centrality;
- Portfolio diversification debates;
- Market microstructure insights;
- Traditional finance integration patterns;
- Collective implications for risk architecture.

The digital assets literature uncovers a sophisticated understanding of the cryptocurrency market structure, risk characteristics and integration with traditional financial markets. Additionally fundamental questions about digital assets' role in portfolios and safe-haven properties are contested. Early research assumptions resulted in Bitcoin's "digital gold" labeling, while other cryptocurrencies were not placed in the same category. Later on, documentation showed a higher degree of connectivity between digital assets and traditional finance, with digital assets emerging in a large proportion after 2015.

Multiple studies concluded that Bitcoin is a dominant asset in cryptocurrency networks. Klein, Pham Thu and Walther (2018) demonstrate that Bitcoin lacks the safe-haven character of gold, showing positive coupling with equity markets during downturns instead of providing a protection during a crisis. Their findings challenge the findings that Bitcoin would be a hedging asset in portfolios, revealing its highly volatile behaviour and unstable correlation structure. Yi et al. (2018) strengthens Bitcoin's centrality by researching its role as a primary volatility lead in the cryptocurrency markets, while Ji et al. (2019) established Bitcoin's leadership through connectedness analysis revealing how its innovations impact significant parts of altcoins' price movements. Ciaian, Tajcaniova and Kancs (2018) expand this documentation through cointegration analysis, demonstrating long-standing equilibrium relationship between Bitcoin and major altcoins that limits the diversification possibility among the cryptocurrency market.

Guesmi et al. (2019) provides evidence that Bitcoin's inclusion can reduce risk in a traditional portfolio, employing multivariate GARCH specifications to model dynamic correlations and volatility spillovers. The findings suggest that short positions in Bitcoin enable hedging across multiple asset classes, with effectiveness varying with risk aversion levels. The optimistic view requires qualification: the diversification benefits depend on market regimes, with an integration intensification coming when diversification is most valuable, during crisis periods.

Bouri et al. (2019) document significant volatility relationship, finding that returns predict future transaction activity more than transactions predict returns. This causality, confirmed by Koutmos (2018) analysing the Bitcoin transaction patterns, suggests that speculative dynamics dominate fundamental adoption-drive valuation, challenging the currency narrative of Bitcoin.

The connection between cryptocurrency and traditional finance markets is an evolving research frontier with considerable risk management implications and impact. Gli-Alana, Abakah and Rojo (2020) looked into cryptocurrency – equity market relationships, contributing to the understanding if digital assets function as isolated assets or if digital assets exhibit systematic links to traditional markets. COVID-19 crisis provided a critical natural experimenting environment for testing asset behaviour in extreme circumstances, with Yousaf et al. (2022) document gold’s performance related to Asian equity markets, establishing a benchmark for evaluating cryptocurrency safe haven properties. Similar crisis-period research confirmed that cryptocurrency market integration with traditional finance becomes strong during turbulent periods, thus actually limiting diversification effectiveness when demand would be at a high point.

As a whole, the top ten studies reveal that cryptocurrency markets exhibit complex risk architectures, with a high internal integration and emerging connection with traditional finance, Bitcoin having a dominant network position. Cryptocurrencies primarily function as speculative assets with commodity-like characteristics rather than currencies of stable store of value. Application in portfolio investment require a complex understanding of correlations, volatility spillovers, unstable correlation structures and tendencies of increased integration with traditional markets during crisis periods. These findings have important implications for risk management frameworks and application, as cryptocurrencies exposure create systemic risk and vulnerabilities different from traditional asset classes, while offering limited benefits. Future research directions emerging from the current literature include investigation of stablecoin integration patterns, decentralized finance ecosystem risk transmission, regulatory impact on cryptocurrency-traditional finance spillovers, and evolving institutional adoption effects on market structure and integration dynamics.

3. Methodology

Dominant research themes are identified in the paper, alongside geographic distribution, networks of collaboration, and temporal evolution of digital assets interconnecting with traditional finance. The analysis used the Core Collection – Web of Science database, with a comprehensive search query combining terminologies from digital assets spectrum (cryptocurrency, Bitcoin, Ethereum, stablecoins, DeFi, tokenization) with connectedness indications (spillovers, contagion, interdependence, integration) and traditional finance terms (stock markets, commodities, bonds, forex). The search query resulted in 500 documents from 2018 to 2025.

The data analysis from Bibliometrix R package extracted publication trends, citation patterns, thematic structure. The performance analysis also examined productivity, geographic distribution and institutional contributions. Science mapping techniques included co-occurrence network analysis and thematic evolution assessment.

4. Results

4.1. Dataset overview & publication performance

Table No. 1. Main information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2018-2025
Sources (Journals, Books, etc)	147
Documents	500
Annual Growth Rate %	-21,59
Document Average Age	2,23
Average citations per doc	29,33
References	12021
DOCUMENT CONTENTS	
Keywords Plus (ID)	470
Author's Keywords (DE)	1344
AUTHORS	
Authors	1081
Authors of single-authored docs	51
AUTHORS COLLABORATION	
Single-authored docs	58
Co-Authors per Doc	3,13
International co-authorships %	49,6
DOCUMENT TYPES	
article	458
article; book chapter	1
article; early access	40
article; retracted publication	1

The bibliometric analysis examines a comprehensive corpus of 500 academic documents, spanning over a nine-year period from 2018 to 2025. This period captures an essential phase in the evolution of digital assets and digital assets research itself, confirming a maturing period of cryptocurrency markets, the apparition of decentralized protocols and integration of blockchain based instruments in the traditional finance infrastructure. The data set marks contributions from 1081 authors across 147 scholarly sources, peer-reviewed journals predominative, reflecting the multidisciplinary nature of the research at the intersection of financial economics, computer science and regulatory studies.

With an average of 2.23 years for documents age, the temporal distribution reveal an acceleration in research output following the initial exploration phase. The average citation of 29.33 suggests substantial academic impact, while the collective reference pool includes 12,021 citations, offering a strong foundation for the examination of knowledge flows within the industry.

International collaboration stands at 49.6% of the total academic output, with an average of 3.13 co-authors per document. The high degree of international collaboration marks the global nature of the research on digital assets and strengthens the transnational characteristics of cryptocurrency markets and blockchain technologies.

From the content analysis perspective, there is a diverse terminology, with 1,344 author-supplied keywords and 470 Keyword Plus identifiers, reflecting both the interdisciplinary nature of the field and the evolution of conceptual frameworks needed to understand the digital asset phenomena.

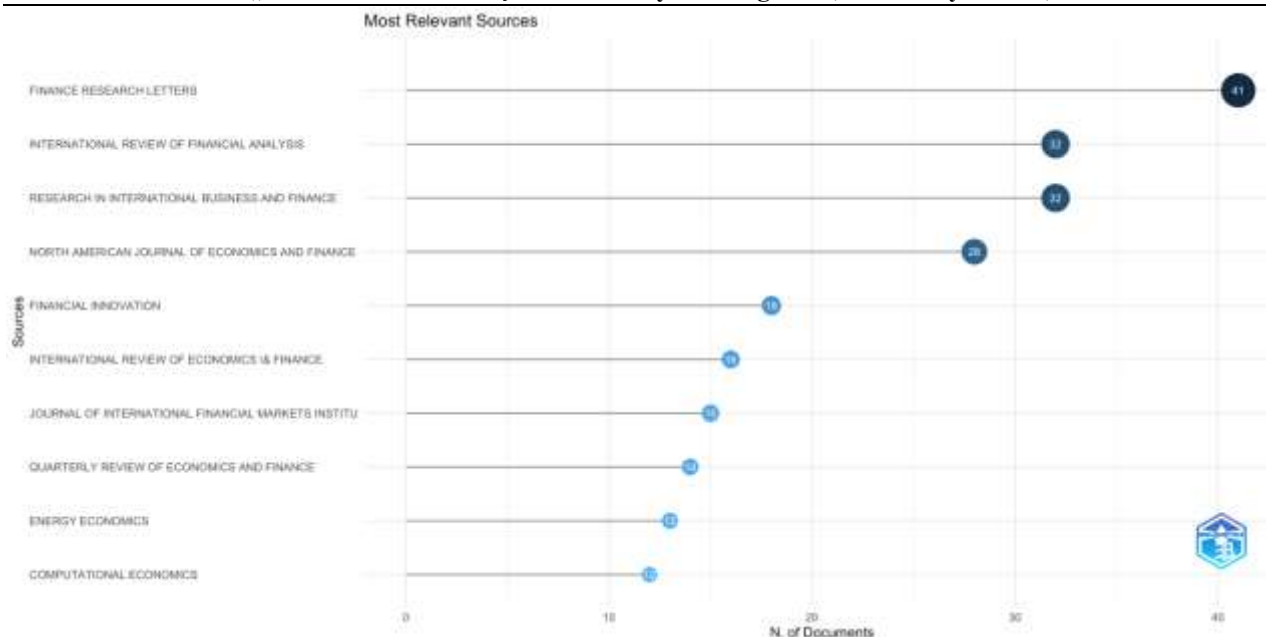


Figure No. 1. Most relevant sources

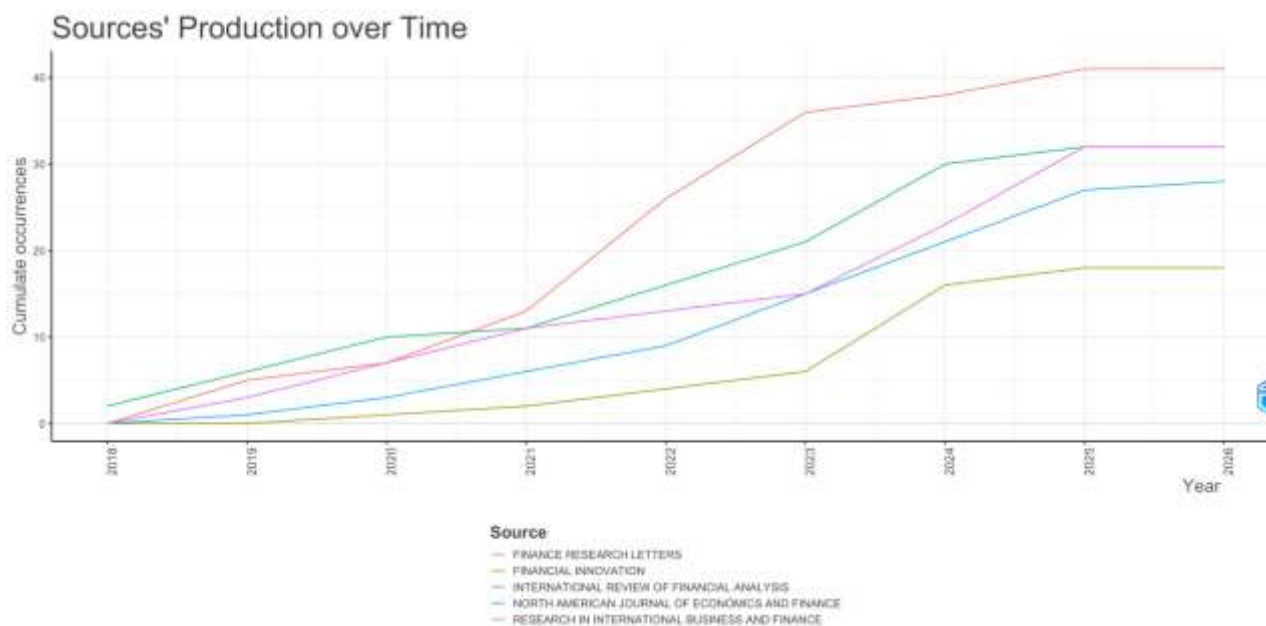


Figure No. 2. Source dynamics

The distribution of research output across scholarly outlets reveals a concentration among a select group of journals, specialized in financial economics and related fields. Finance Research Letters emerges as the most prolific publication with 41 articles (8.2% of total corpus), becoming a primary source for research on digital asset and traditional finance linkages.

The next productivity level is assigned to three journals, publishing 32 articles: International Review of Financial Analysis, Research in International Business and Finance, and North American Journal of Economics and Finance collectively contribute to 19.2% of the corpus. The North American Journal of Economics and Finance’s considerable contribution of 5.6% highlights the significant engagement of USA with the digital assets industry, while the international origin of the other two journals highlights the global nature.

Around 80% of the remaining articles exhibit lower publication frequencies, with 85 journals only contributing one article to the corpus. This distribution is a characteristic of emerging research fields where contributors appear across diverse disciplinary journals. Such a pattern suggests the consolidation of digital assets as a recognized field within finance and economy alongside other academic domains including computer science, management and mathematics.

The analysis of publication patterns reveals an intensification of academic productivity related to digital assets interconnection with traditional finance over the observed period. The timeline highlights three phases:

1. Exploratory phase (2018-2019);
2. Consolidation phase (2020-2021);
3. Acceleration phase (2022-2025).

Phase one was marked by low levels of activity, with Finance Research Letters contributing with their first 5 articles in 2019, while the International Review of Financial Analysis produced 2 articles in 2018 and 6 in 2019. This period corresponds with the effects of the 2017 bull market all time high of Bitcoin and the retracing of the market correction, leading the academic research prospects to volatility dynamics and portfolio diversification potential. The limited output in this phase however, reflects the start of considerable attention to the digital assets' environment.

The consolidation phase marked a considerable increase in academic interest, also due to the institutional adoption potential, the appearance of decentralized finance protocols and the regulatory attention that was cast to the stablecoin frameworks. Some of the highly reviewed journals almost doubled their article output, thus witnessing the emergence of more sophisticated analysis frameworks, including systemic risk assessment and cross-market integration research.

The third, and actual phase, marked by a significant growth in the most recent years corresponds with several developments in digital asset markets: *Central bank digital currency initiatives; The integration of cryptocurrency derivatives within mainstream financial institutions; The maturity of regulatory frameworks in major jurisdictions.*

The 2022 expansion is related to the academic attention to stablecoin regulatory proposals, decentralized finance systemic risks, and the macroeconomic implications of cryptocurrency adoption.

The concentration of academic research in economic, financial journals, rather than computer science or information system publications, indicates that the academic discourse evolved beyond the technological aspect of digital assets towards a more sophisticated interrogation within the economic and financial global systems. This consolidation places digital assets research within financial economics paradigms.

4.2. Geographic distribution & scientific collaboration

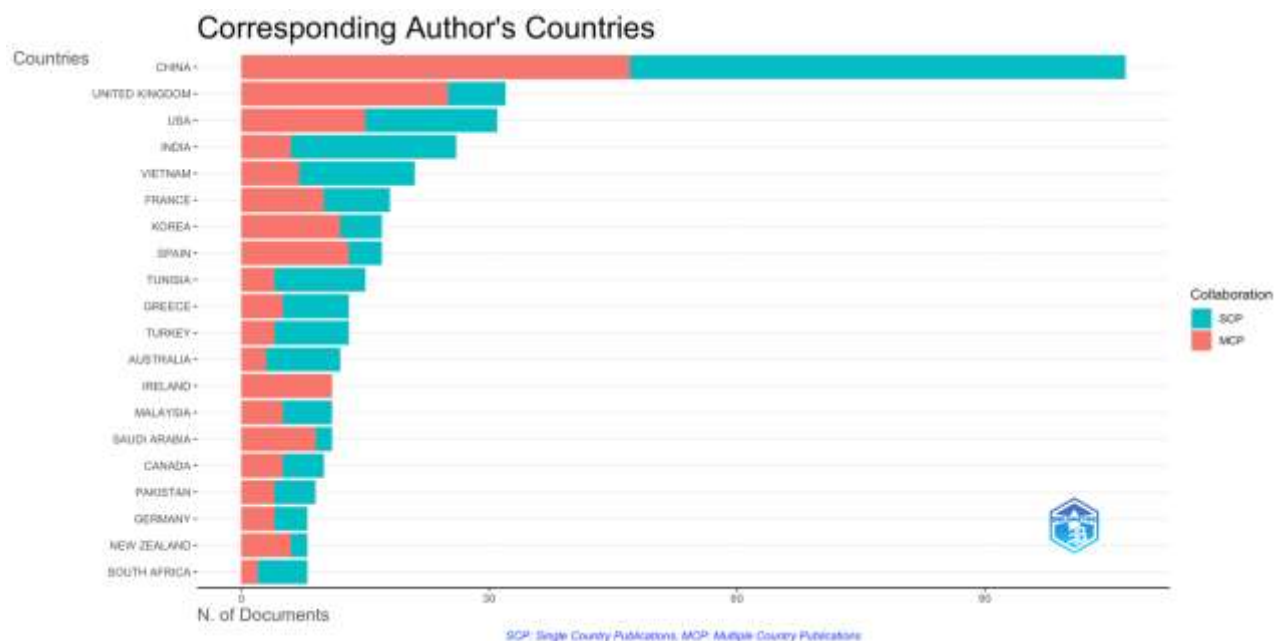


Figure No. 3. Most relevant countries

Country Scientific Production

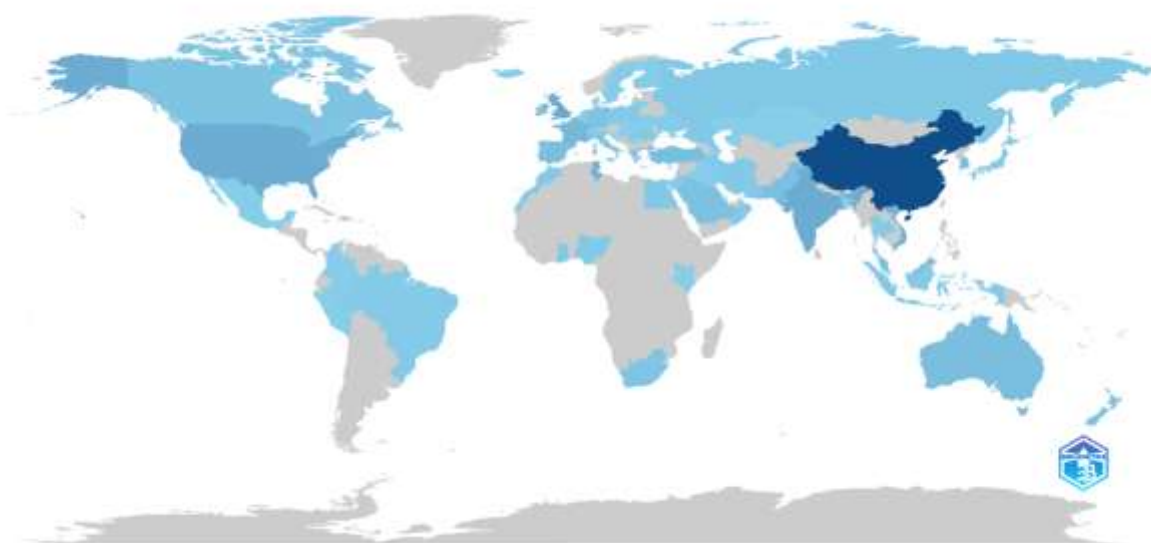


Figure No. 4. Country scientific production

China is the dominating force in research output covering 21.4% of the academic corpus, with 107 articles, followed by United Kingdom and United States with 32 and 31 articles, both amounting to 12.6% of the corpus. Emerging economies demonstrate a considerable engagement, with India, Vietnam covering around 10% of the corpus, challenging the assumptions that research originates from advanced economies exclusively. International collaboration patterns reveal an impressive heterogeneity: Ireland relies heavily on international partnerships (100%) while UAE, Portugal and Saudi Arabia are partnering outside their jurisdictions on more than 80% of their output. China's 43.9% MCP rate reflects balanced domestic output and selective international partnerships.

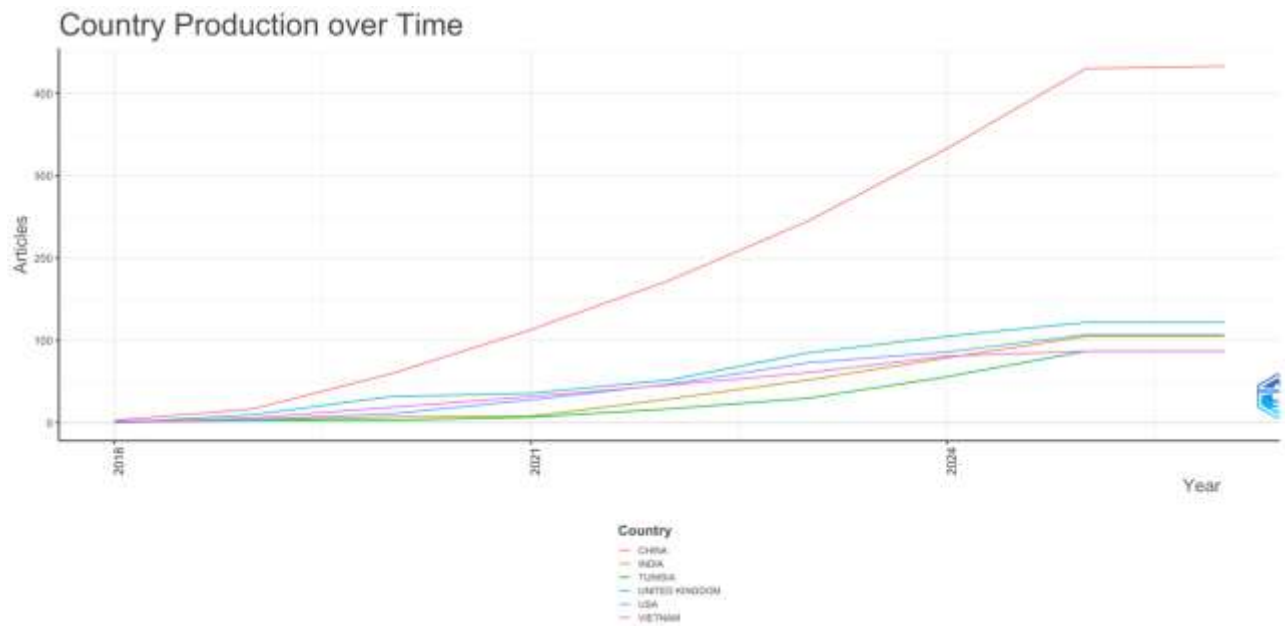


Figure No. 5. Country over time

Temporal analysis reveals an exponential growth post 2020. China expanded from 3 articles in 2018 to 433 in 2025, while the UK when from 0 articles in 2018 to 122 in 2025. India and Vietnam demonstrate parallel trajectories, confirming rapid developing economy engagement with digital asset academic output.

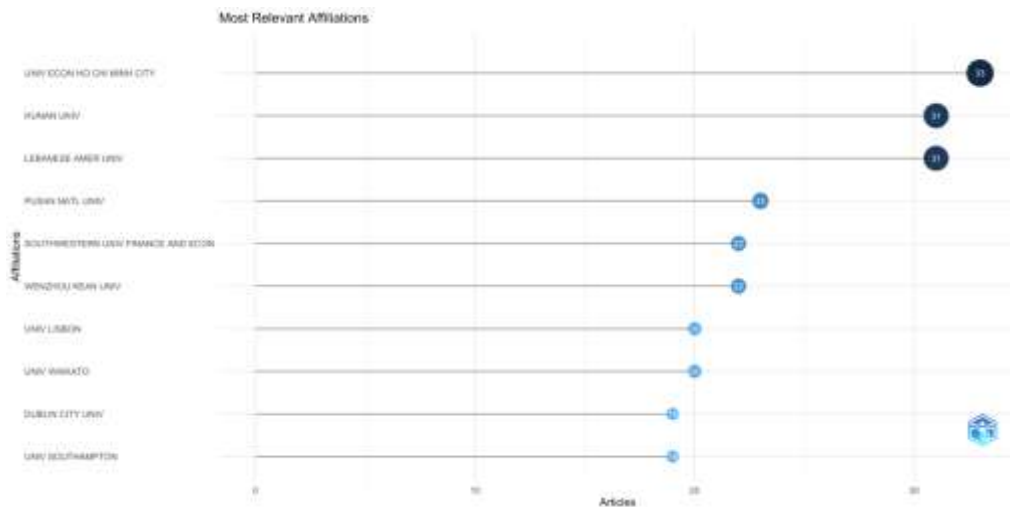


Figure No. 6. Most relevant affiliations

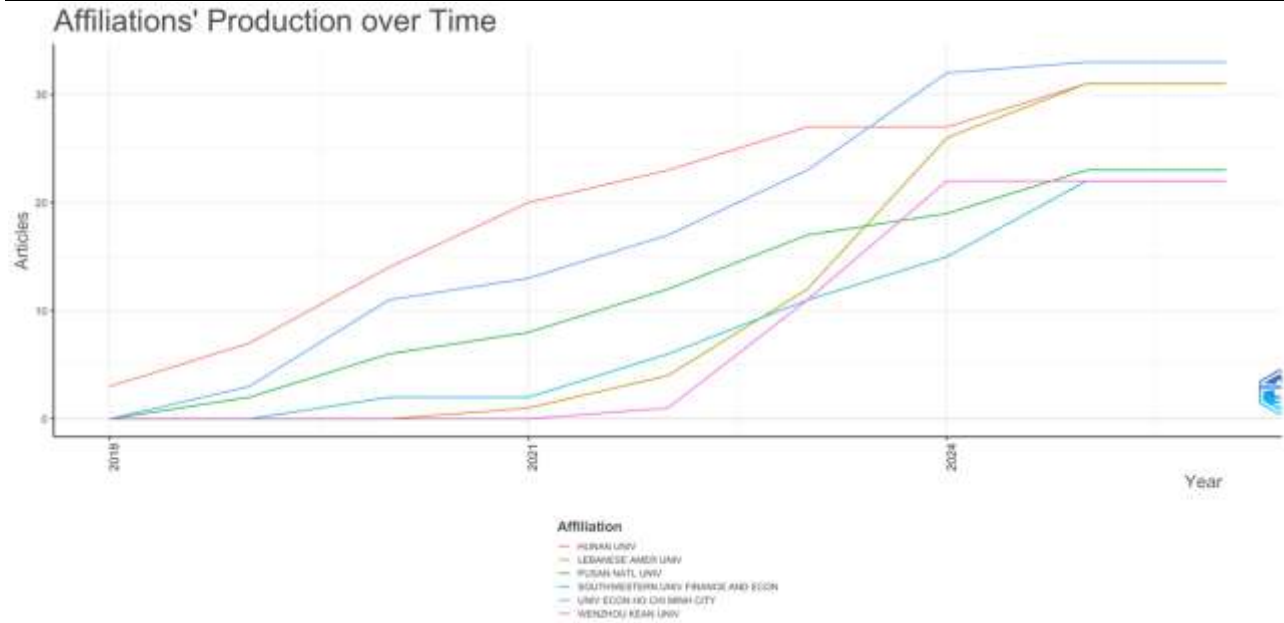


Figure No. 7. Affiliation over time

Institutional productivity shows substantial concentration within a select cohort of universities, with the University of Economics Ho Chi Minh City leading with 33 articles, followed by Hunan University and Lebanese American University, with 31 articles each, and Pusan National University (23 articles). This distribution highlights the impact of Asian institutions, particularly Chinese universities that dominate the top rankings. Southwestern University of Finance and Economics and Wenzhou Kean University, both with 22 articles, further reinforce the Chinese leadership.

European institutional contributions include University of Lisbon (20 articles), University of Southampton (19 articles), and Dublin City University (19 articles), demonstrating sustained engagement from European research centres. Temporal analysis reveals that the leading institutions grew their output post 2020.

Country Collaboration Map

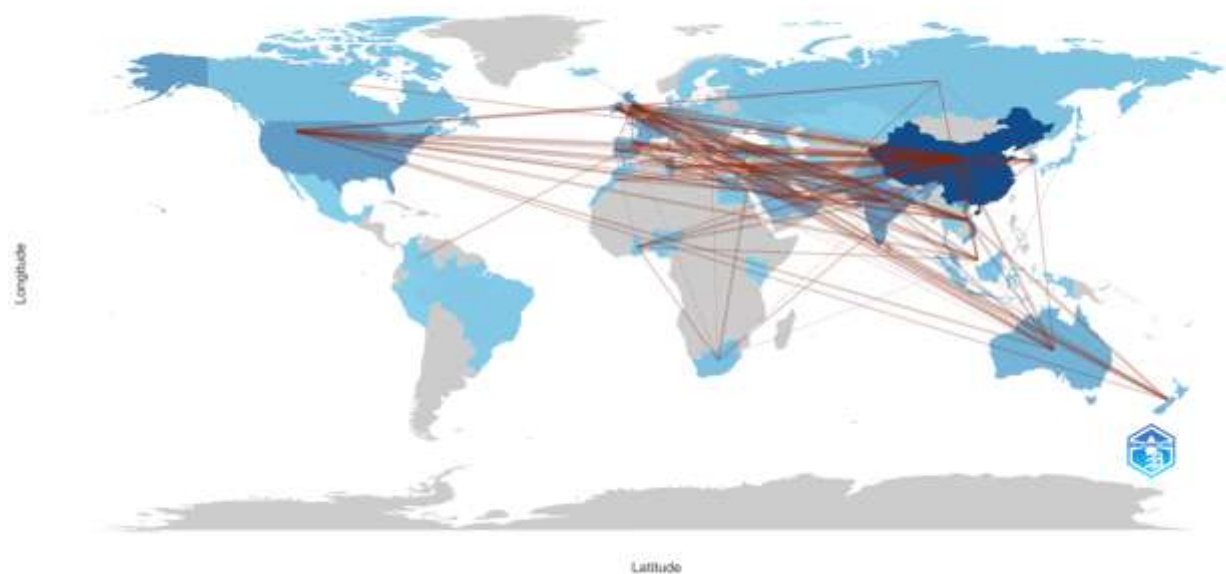


Figure No. 8. Country collaboration map

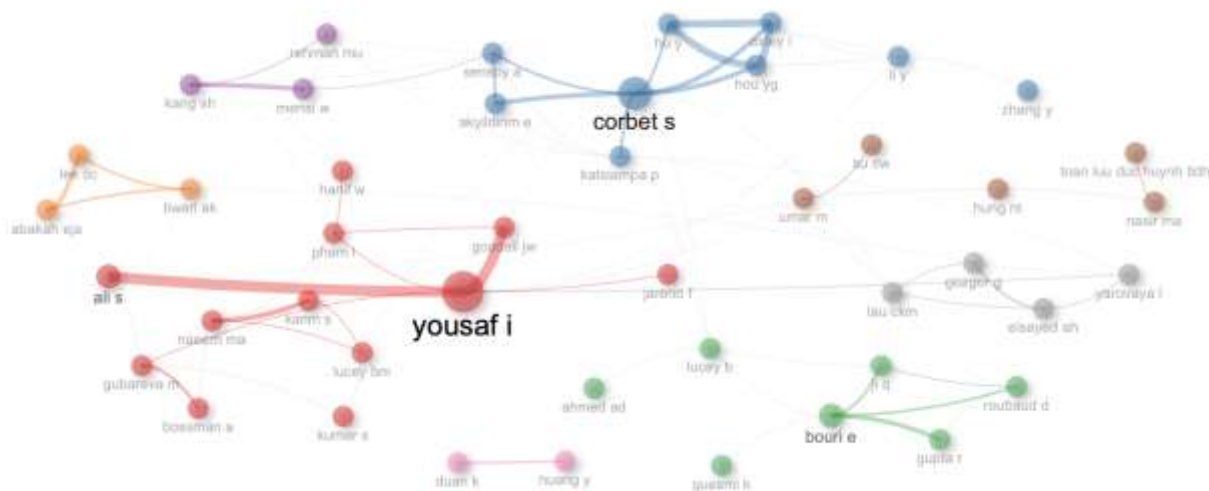


Figure No. 9. Collaboration network

International collaboration networks reveal multi nodal structures centred on several key hubs. China is a leading collaboration node, maintaining partnerships across Asia-Pacific, Europe, and North America. China is also intensively collaborating within their regional reach, particularly with New Zealand, Japan, Korea and Vietnam, revealing a geographical proximity and shared interest in digital asset research and integration.

The main European global bridge is the United Kingdom, facilitating collaborations between European institutions and partners in Asia, Middle East, and Oceania. This positioning highlights the UK's role in facilitating digital asset development into international frameworks. United States has similar collaboration patterns, with a particular focus on the European and Asian sides.

Regional collaboration clusters retain distinctive characteristics. Middle Eastern research demonstrates a high connectivity in the region, while maintaining open connections with European and Asian centres. Southeast Asian networks have been sharing the same policy concerned for cryptocurrency adoption and regulatory frameworks. European collaborations are concentrated within the Western institutions, while extending selectively to Central Europe partners.

4.3. Citation analysis & intellectual structure

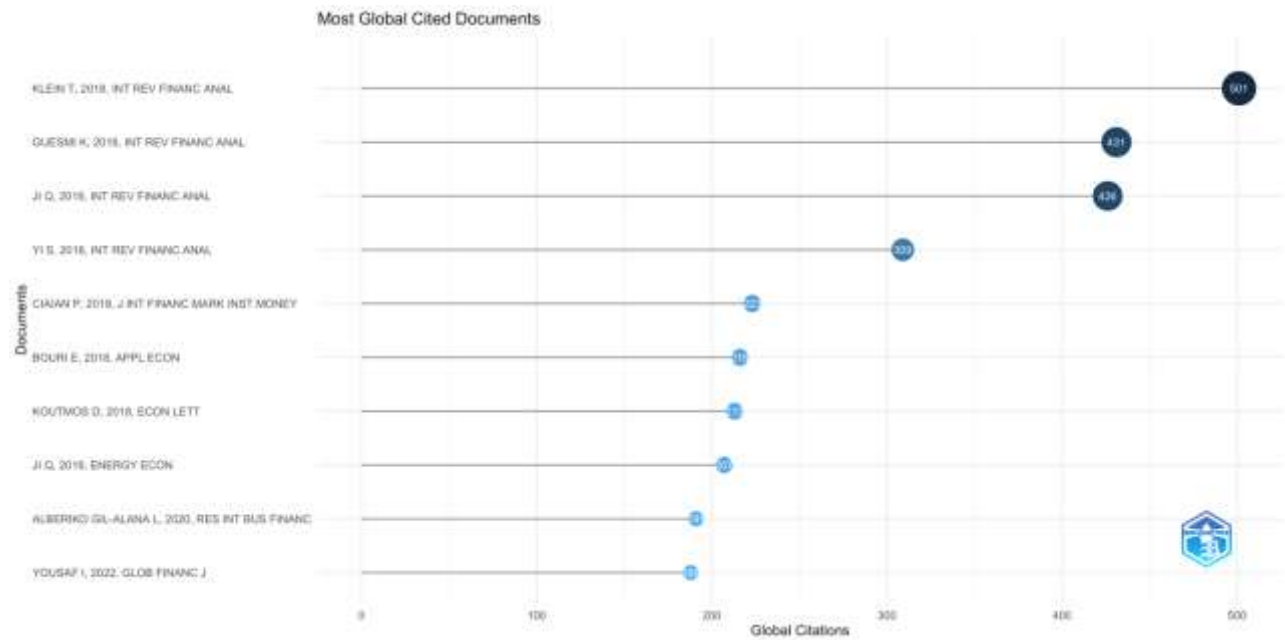


Figure No. 10. Most global cited documents

Citation analysis reveals Klein’s (2018) seminal work “Bitcoin is not the new gold” as the most influential contribution with 501 citations, challenging early narratives through rigorous volatility and correlation analysis. Guesmi et al. (2019) and Ji et al. (2019) occupy subsequent positions with 431 and 426 citations, both published in the International Review of Financial Analysis, looking into portfolio diversification properties and dynamic connectedness partners. The concentration of highly cited works within 2018-2019 indicates this period’s importance in establishing analytical frameworks and empirical baselines.

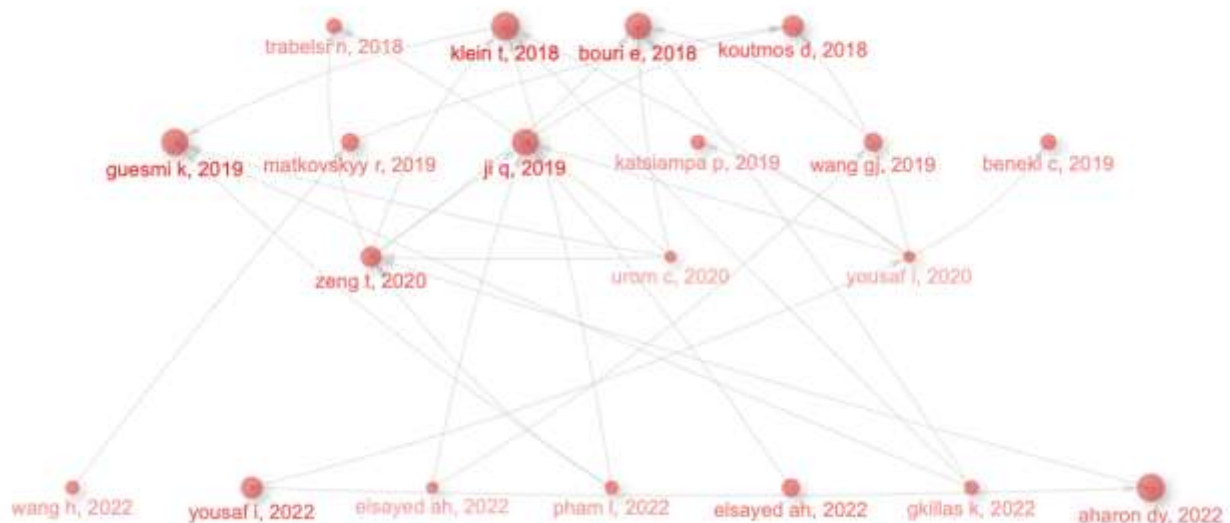


Figure No. 11. Historiograph

The historiographic network traces intellectual evolution from initial volatility spillover studies (Tabelsi 2018, Klein 2018, Bouri 2018) through cryptocurrency market integration analysis (Ji 2019, Zeng 2020) to recent investigations of NFTs, DeFi, and carbon markets (Yousaf 2022,

Aharon 2022, Pham 2022). This progression demonstrates the process of maturation from basic characterization to complex ecosystem analysis.

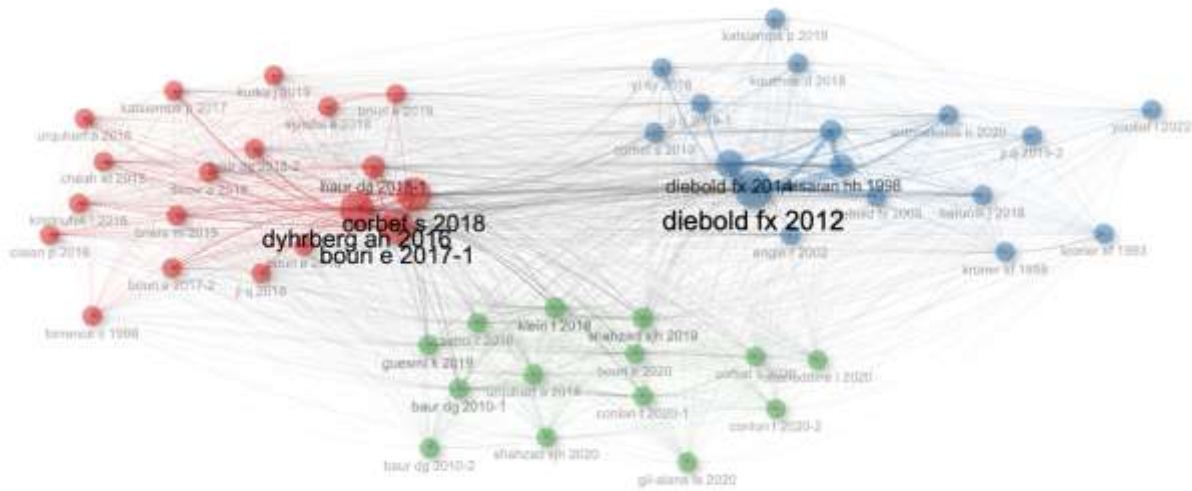


Figure No. 12. Co-citation network

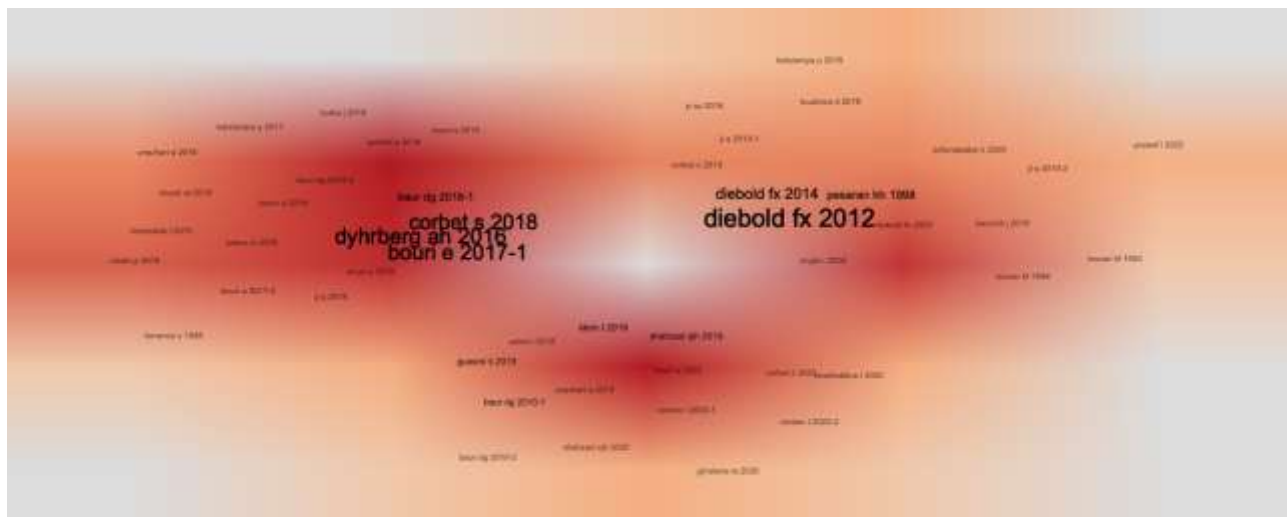


Figure No. 13. Co-citation network density

Co-citation network analysis reveals two principal clusters: a clustered centred on Bitcoin-gold comparison and safe have properties (Dyhrberg 2016, Bouri 2017, Corbet 2018), and a methodological cluster anchored in Diebold-Yilmaz spillover frameworks (Diebold & Yilmaz 2012, 2014), highlighting the dominance of network based econometric approaches in digital asset research.

4.4. Conceptual structure & content analysis

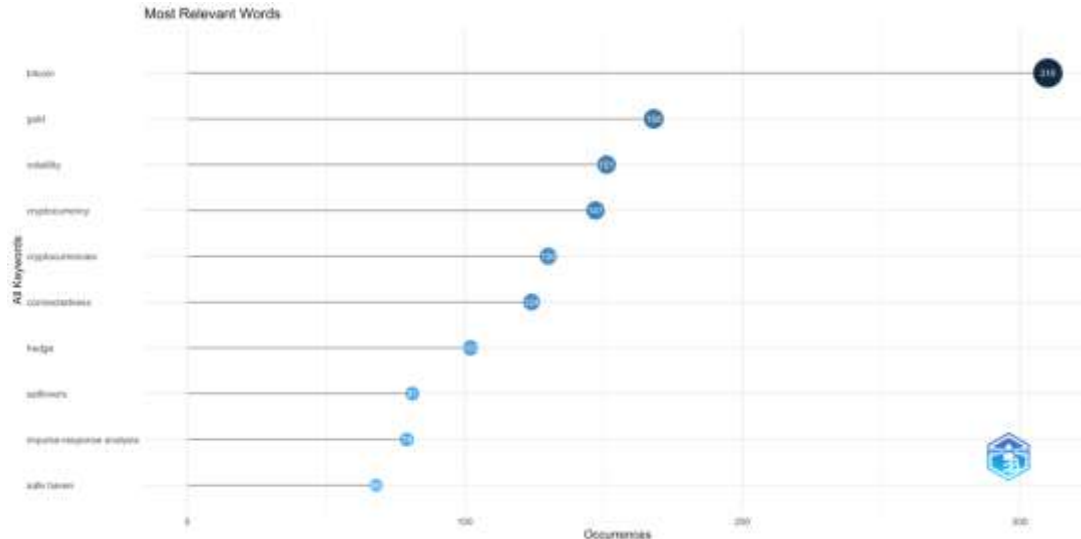


Figure No. 14. Most relevant words



Figure No. 15. Word cloud

Lexical analysis reveals Bitcoin’s dominance with 310 occurrences, exceeding generic cryptocurrency references (147), indicating persistent academic focus on the pioneering digital asset rather than broader taxonomic categories. Gold emerges as the second most frequent term (168 occurrences), showing sustained research interest in comparing asset characteristics and in the Bitcoin’s “digital gold” narrative. Volatility related terminology shows significant presence, underscoring the association of digital assets with risk dynamics and analytical concern.



Figure No. 16. Treemap

Methodological terminology reveals preferences, with *connectedness* (124 occurrences), *spillovers* (81), and *impulse response analysis* (79), signifying widespread adoption of network based and dynamic econometric frameworks. *Hedge* (102) alongside *safe have* (46) demonstrate persistent investigation into the postfolio diversification narrative. *COVID-19*'s presence (60 occurrences) confirms the pandemic's role in reshaping research, while oil, commodity and energy highlight the cross-market integration studies.

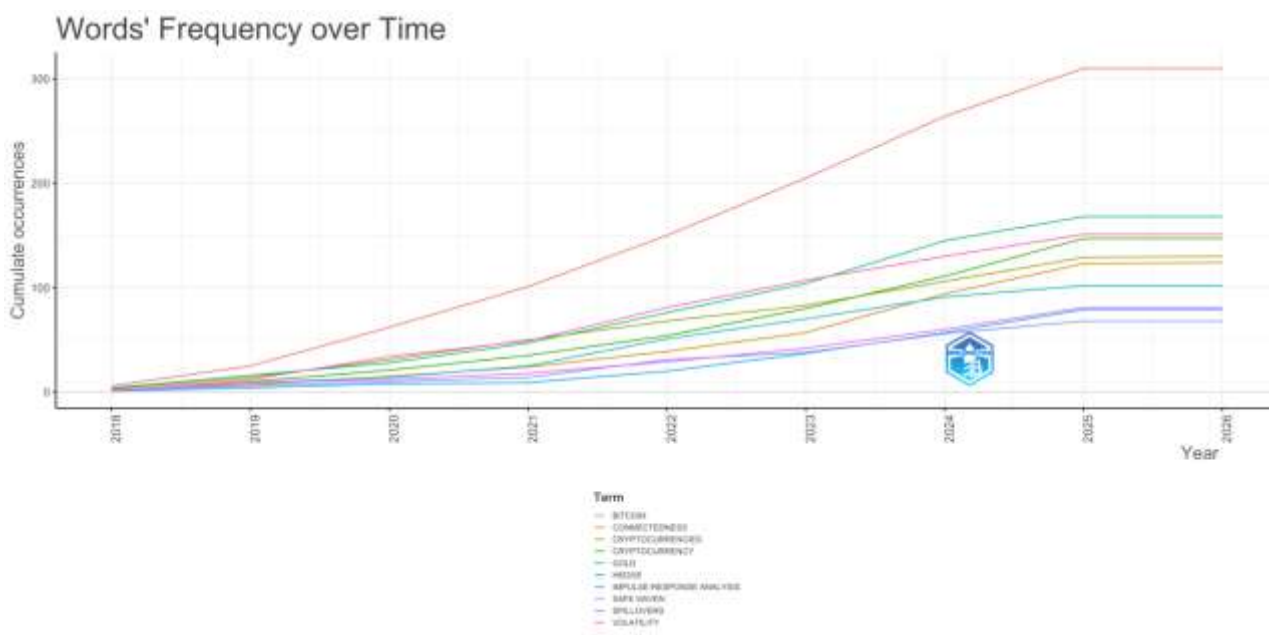


Figure No. 17. Word frequency over time

Temporal keyword dynamics reveal exponential terminology growth across all main concepts, reflecting field expansion and analytical complexity. Bitcoin reference increased from 6 occurrences in 2018 to 310 by 2025, while gold comparisons increased from 4 to 168, demonstrating sustained comparative analysis despite other empirical evidence challenging such a narrative. Volatility terminology shows parallel acceleration, confirming risk measurement as a constant priority.

Methodological terminology demonstrates pronounced evolution. Connectedness, spillovers, and impulse-response have been increasing exponentially, as this trajectory signals an

adoption of dynamic network analysis. The *safe haven* terminology (68 in 2025) reflects continued investigation into crisis period diversification properties. Between 2020 and 2022 it is noticeable how growth across all terms coincides with the COVID-19 pandemic and the following years institutional adoption narrative.

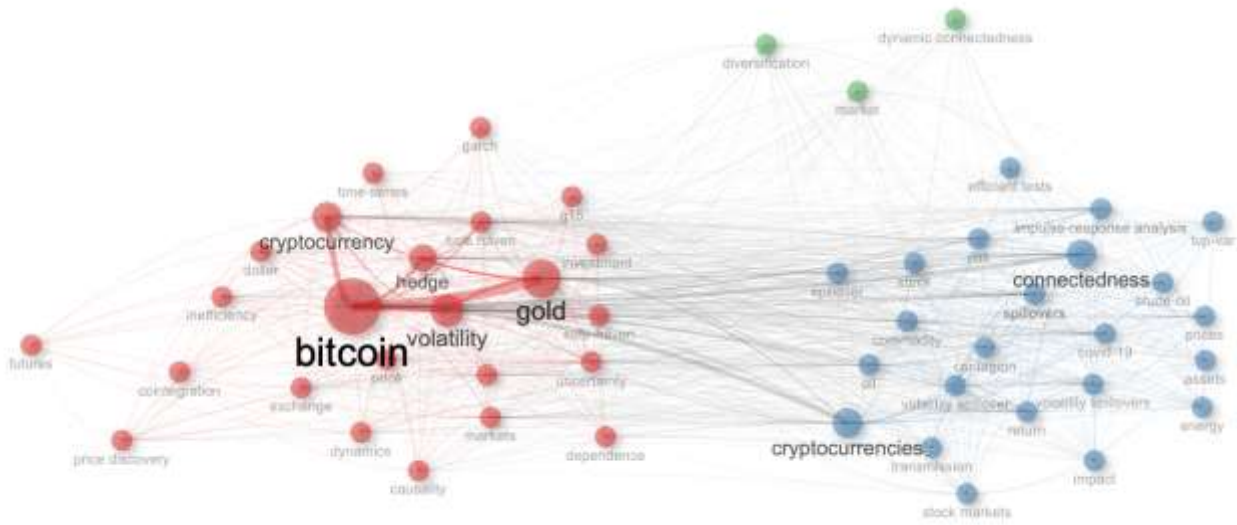


Figure No. 18. Co-occurrence network

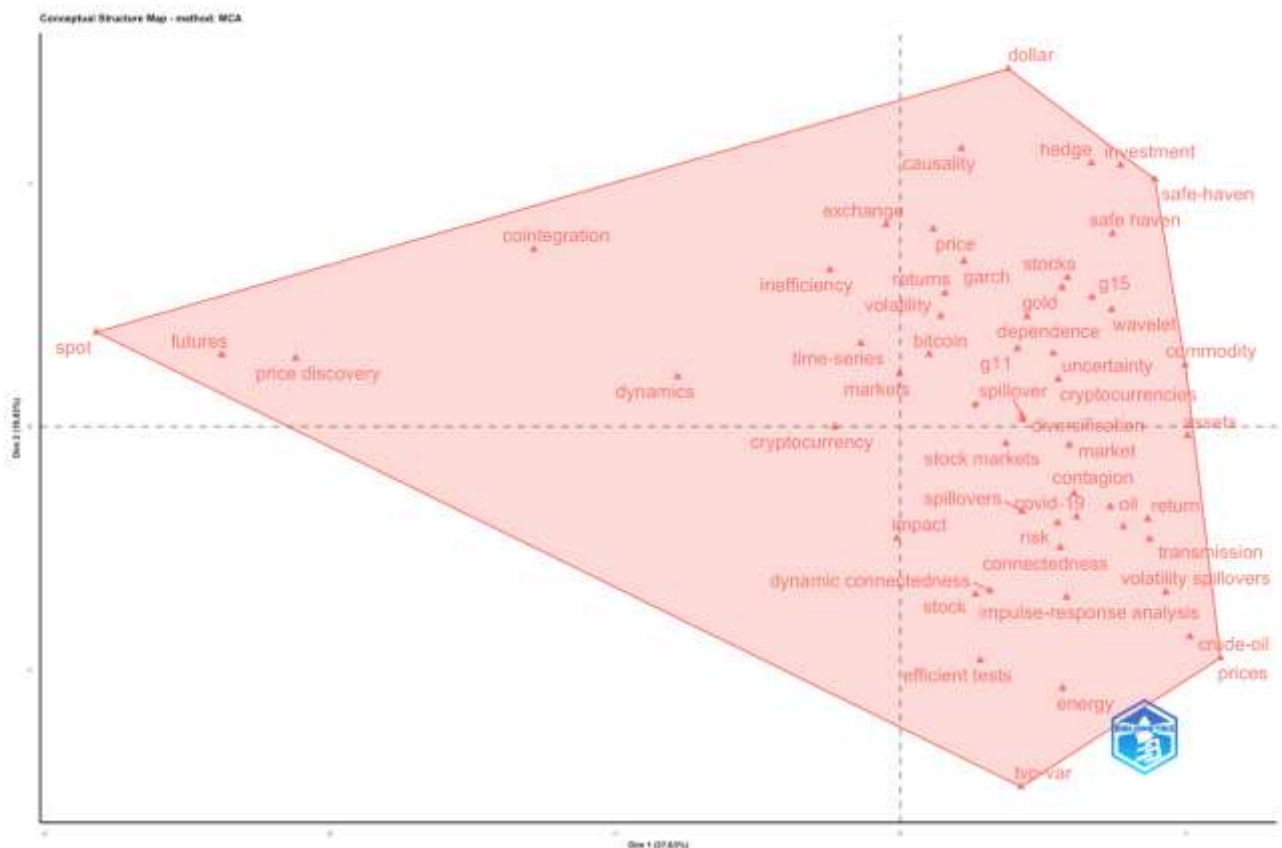


Figure No. 19. Factorial map

Co-occurrence network analysis reveals six principal thematic clusters showing varying degrees of centrality and density within the research domain. The *Bitcoin* cluster emerges as the

most substantial with 1,650 keyword occurrences, high callon centrality (11.462) and moderate density (27.811), positioning it as a motor theme that drives broader research while maintaining internal adherence. This cluster encompasses core asset characterization research, volatility analysis, and comparative studies with traditional financial instruments.

The *cryptocurrency* cluster (916 occurrences) shows lower centrality (7.449) but the highest density (23.784), indicating a well developed yet relatively isolated research stream focusing on broader digital asset taxonomies beyond Bitcoin. The *oil* cluster (736 occurrences, centrality 8,399) reflects substantial cross-market integration studies examining energy-cryptocurrency links, particularly relevant considering the mining energy consumption and commodity market spillover.

Hierarchical clustering analysis reveals conceptual bifurcation between asset-focused themes (Bitcoin, gold, cryptocurrency) and methodological-analytical themes (connectedness, spillovers, volatility measurement). Secondary divisions distinguish crisis period investigations (*COVID-19, uncertainty, safe haven*) from market integration studies (*oil, commodity, energy*).

4.5. Thematic analysis & emerging trends

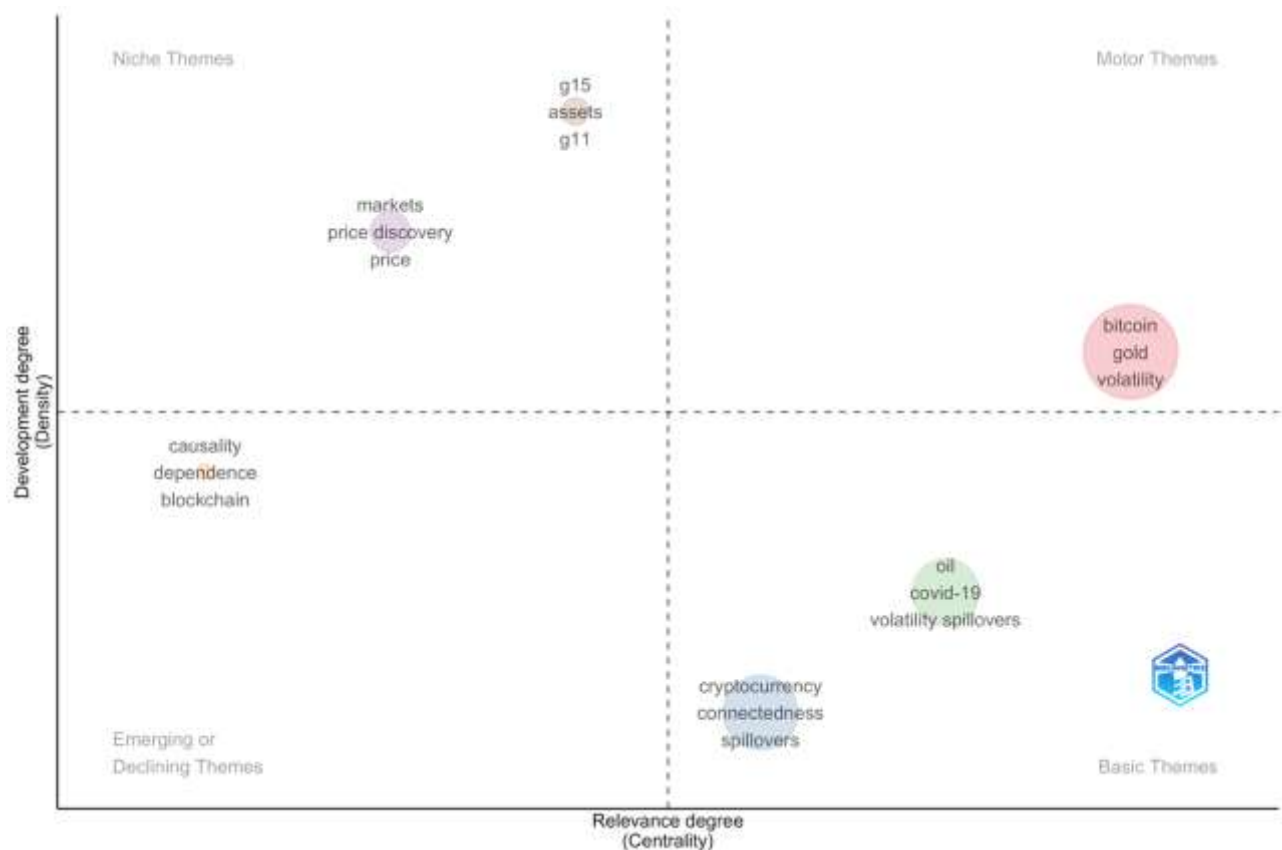


Figure No. 20. Thematic map

Thematic mapping positions research topics across four strategic quadrants based on internal development and external influence. Motor themes like Bitcoin, gold, and volatility occupy the upper right quadrant as the field's intellectual engine, showing a well-developed internal structure and strong connections to broader research discourse.

Niche themes (markets, price discovery, g15 classifications) concentrate in the upper-left quadrant, representing highly specialized research streams with sophisticated methodologies but limited cross research with other themes. Basic themes like oil, COVID-19, volatility spillovers, cryptocurrency, connectedness function as transversal concepts that connect multiple research areas

without forming independent research studies. Most notably is “blockchain” whose position in the lower left emerging quadrant alongside causality and dependence is revealing a notable disconnect between the technology behind digital assets and their position in the financial research priorities.

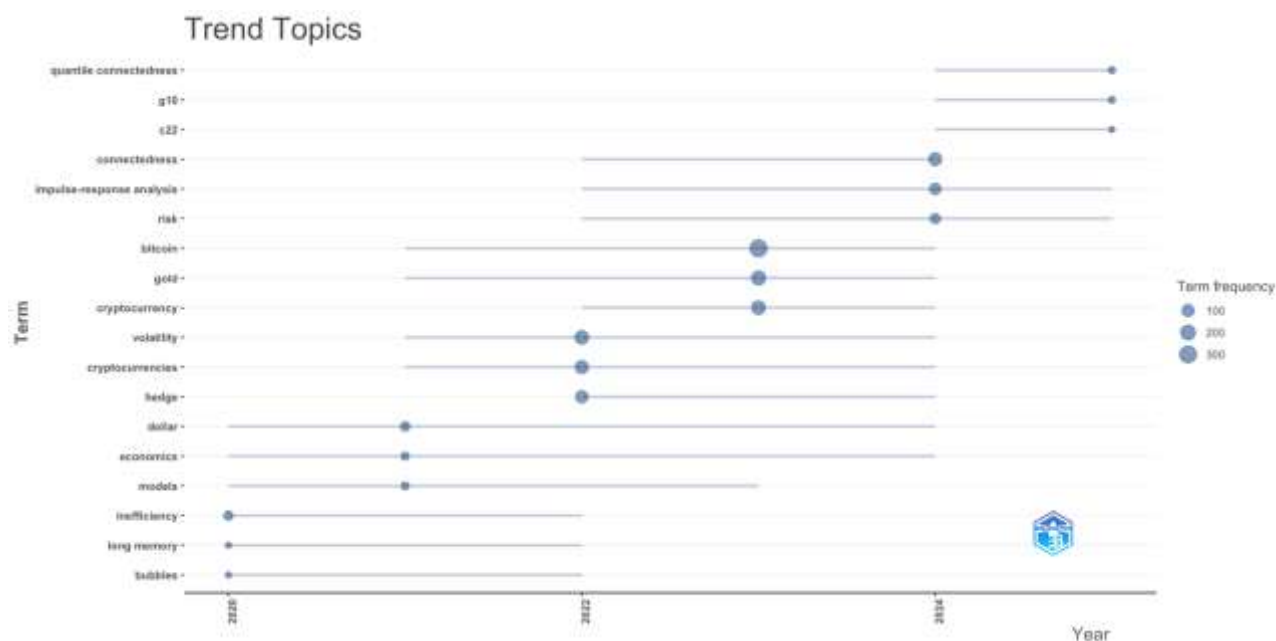


Figure No. 21. Trend topics

Temporal trend analysis reveals clear shifts in research focus. Topics clustered around 2020 (bubbles, long memory, inefficiency) represent early-stage debates about market maturity and fundamental cryptocurrency properties. The progression towards 2024-2025 shows methodological advancing, with emerging techniques like quantile connectedness enabling more sophisticated tail-risk assessment and distributional analysis beyond traditional mean-variance frameworks. This evolution signals the transition from fundamental asset characterization towards complex systemic risk modeling and cross-market integration analysis.

5. Conclusions

This bibliometric study investigated 500 scholarly research manuscripts published between 2018 and 2025 to address the interrelations between digital assets and conventional financial markets. By extracting data from 147 distinct sources and contributions from 1,081 scholars across 65 nations, the results indicate a swift expansion, geographic concentration, methodological standardization, and burgeoning analytical sophistication, which collectively reflect the maturation of cryptocurrency markets alongside an increasing integration with traditional global financial systems.

Publication dynamics reveal a marked exponential increase, particularly between 2022 and 2025, with the annual output escalating from fewer than 20 documents in 2018 to over 400 cumulative publications by 2025. This surge mirrors a heightened academic interest subsequent to the disruptions caused by the COVID-19 pandemic, which acted as a catalyst for the exploration of digital assets as hedging instruments during periods of crisis, alongside narratives of institutional adoption that have legitimized academic investigation. The concentration of scholarly output within specialized financial economics journals, spearheaded by *Finance Research Letters* (41 articles), *International Review of Financial Analysis* (32 articles), and *Research in International Business and Finance* (32 articles), indicates a consolidation of focus within empirical finance methodologies while revealing potential obstacles to interdisciplinary integration with fields such as computer science, regulatory studies, and macroeconomic policy analysis. High rates of international

collaboration (49.6%) highlight the global character of digital asset phenomena; however, geographic analysis uncovers stark asymmetries that challenge simplistic narratives of democratization.

China's quantitative preeminence (107 articles, 21.4% of the corpus) delineates a clear leadership in research; however, citation impact analysis reveals considerable discrepancies between quality and quantity. Smaller contributors, notably Ireland (106.6 citations per article), Lebanon (75.9), and the United Arab Emirates (56.6), significantly surpass China's 29.1 citations per article, suggesting that research influence transcends productivity metrics and is critically dependent on topic selection, methodological sophistication, and integration within mainstream scholarly networks. This trend may imply the existence of Western-centric citation practices or, alternatively, the superior strategic positioning of European and Middle Eastern scholarship.

Citation and intellectual structure analysis designates the years 2018 to 2019 as the foundational phase, with Klein's (2018) comparative analysis of Bitcoin and gold emerging as the most influential work in the field (501 citations), fundamentally contesting digital gold narratives through rigorous empirical scrutiny. The historiographic trajectory from initial investigations into volatility spillovers (Trabelsi 2018, Bouri 2018) toward contemporary studies in DeFi, NFTs, and carbon markets (Yousaf 2022, Aharon 2022, Pham 2022) illustrates a progressive thematic diversification. Nonetheless, co-citation clustering uncovers a persistent methodological concentration around Diebold-Yilmaz spillover frameworks, indicative of both analytical standardization facilitating cross-study comparability and potential methodological path dependence that constrains theoretical innovation.

Conceptual network analysis reveals critical disciplinary tensions that necessitate strategic resolution. The theme of Bitcoin-gold-volatility occupies the central theme quadrant, propelling mainstream discourse through sustained comparative analysis, whereas blockchain technology remains conspicuously relegated to the emerging/declining quadrant despite its foundational technological significance this disconnect underscoring the prioritization of asset pricing inquiries over examinations of technological substrates within financial research. The temporal evolution from efficiency testing (bubbles, long memory, inefficiency prevalent in 2020) toward advanced network techniques (quantile connectedness, distributional analysis emerging in 2024-2025) signifies a maturation of the field from mere descriptive characterization toward predictive systemic risk modeling and frameworks for tail-risk assessment.

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