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The Digital Currency Revolution: A Survey of Its Evolution, Current Practices, and Implications

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ABSTRACT

As an emerging research field, digital currency studies have expanded rapidly over the past two decades, yet literature remains fragmented across currency types, theoretical foundations, and isolated research themes. This study systematically maps the research through a comprehensive bibliometric analysis of 187 articles published in the Web of Science database between 2006 and 2025. Utilizing VOSviewer software, the analysis identifies three thematic clusters that reflect the evolving revolution of digital currency research: overall evolution of digital currency, private sector digital currencies and central bank digital currencies. Our review of the literature suggests that while private sector digital currencies lead early innovation, their long-term viability is undermined by regulatory ambiguity and inherent limitations. Conversely, central bank digital currencies (CBDCs) are emerging as a predominant trend in the digital currency ecosystem, offering broader applications and the capacity to redefine monetary systems. By synthesizing mainstream arguments, this review identifies avenues for future research and offers important policy implications.

JEL Classification: E4, G2

1 | Introduction

We are witnessing a transformative shift toward the digitization of currency. This digital evolution, driven by emerging technologies such as blockchain and distributed ledgers, is challenging traditional notions of money, payment infrastructure, and monetary sovereignty. The 2008 Global Financial Crisis exposed systemic vulnerabilities in centralized monetary systems, eroding public trust and prompting interest in decentralized alternatives such as cryptocurrencies (Gaies et al. 2021). The sudden onset of the COVID-19 pandemic further accelerated the adoption of contactless digital payments while also heightening interest in digital alternatives to conventional currencies (Yousaf et al. 2022). As of June 2025, approximately 134 countries, representing 98% of global GDP, are exploring central bank digital currencies (CBDCs), with over one-third having reached pilot or implementation stages (Atlantic Council 2024). The global rollout of CBDC pilots, cross-border payment innovations, and the recent Stablecoin GENIUS Act[1], supporting dollar-pegged stablecoins, have intensified competition within the evolving digital currency space. Despite a growing body of research, studies on digital currencies remain fragmented across currency types (e.g., cryptocurrencies, stablecoins, and CBDCs) (Chen and Siklos 2022; Chen et al. 2025; Peng et al. 2023), underlying technologies (Narayanan et al. 2016), and discrete research themes.

Moreover, numerous interrelationships within the digital currency ecosystem require clearer definition and explanation. Most prior reviews focus narrowly on cryptocurrencies, without offering a comprehensive framework to map the broader digital

currency landscape and thematic trends. As a result, a systematic synthesis that organizes and evaluates key themes under a unified framework remains absent. This paper seeks to fill this gap by offering a structured review of the digital currency literature.

In this paper, we aim to address the following questions: How has academic research evolved across different forms of digital currency, and what are the key arguments, thematic trends, and gaps emerged within the existing literature? To this end, we conduct a bibliometric analysis of 187 academic articles published between 2006 and 2025. The literature is categorized into three thematic clusters and structured around two dominant strands: private sector digital currencies (e.g. cryptocurrencies) and public sector digital currencies (e.g. CBDCs). While research on cryptocurrencies still dominates in volume, scholarly interest in CBDCs has grown rapidly, reflecting a broader shift from privately issued digital tokens toward publicly backed forms of digital money.

This paper contributes to the growing literature in three ways. First, it extends the broader innovation literature by framing digital currencies as a novel form of digital financial innovation. While traditional innovation studies have predominantly focused on firm-level drivers such as R&D investment, managerial capabilities, and technological development (Ahamed et al. 2023; Bragoli et al. 2024; Chu et al. 2021; Douch et al. 2023), digital currencies represent a shift toward infrastructure-based, protocol-driven innovation embedded within global financial systems. Second, using a bibliometric analysis of 187 academic publications, the paper systematically maps the digital currency literature, identifying key thematic clusters, emerging trends, and underexplored areas to consolidate academic discourse and identify avenues for further research. To the best of our knowledge, this is the first study to systematically outline the distinctive characteristics and theoretical foundations of digital currencies to offer a conceptual framework for future research in this field. Finally, this study highlights important implications. Our review suggests that while private sector digital currencies have led early innovation, CBDCs are emerging as a dominant trend in the digital currency ecosystem, with broader application potential and the capacity to reshape monetary systems. From policymakers' perspective, this shift calls for a more robust legal and regulatory framework to ensure financial stability, interoperability across payment systems and protection of privacy. Policymakers should consider promoting financial inclusion through thoughtful CBDC design and remain cautious about its potential effects on banks' intermediation and monetary policy transmission.

The remainder of this paper is organized as follows. Section 2 outlines the research methodology and the bibliometric approach employed. Section 3 reviews the evolution of digital currencies and their theoretical foundations. Sections 4 and 5 provide a categorized review of existing literature on private sector and public sector digital currencies, respectively. Section 6 concludes with the key findings, implications, and potential directions for future research.

2 | Research Methodology and Preliminary Analysis

Following Ali et al. (2024), Banerjee et al. (Forthcoming) and Bariviera and Merediz-Solà (2021), this study employs bibliometric and visualization techniques to capture the intellectual structure and research hotspots in the digital currency field. These methods provide a systematic overview of the research landscape, highlighting evolving trends and thematic clusters.

2.1 | Data Collection and Processing

All bibliometric data are retrieved from the Web of Science (WOS) Core Collection database. The search is conducted using the topic keyword "digital currency" to identify relevant articles, spanning January 2006 to August 2025. A total of 2898 records is identified and imported into VOSviewer and Excel for analysis. Given the interdisciplinary nature of digital currency research—spanning finance, economics, law, computer science, and cryptography—initial data cleaning excludes literature focused primarily on technical or algorithmic aspects, ensuring alignment with the study's financial and policy-oriented perspective.

2.2 | Identifying Keywords

To identify research hotspots and thematic trends in digital currency literature, a keyword frequency analysis is conducted using the retrieved bibliometric data. By examining the most frequently occurring keywords, we gain insight into the core topics, emerging themes, and interdisciplinary linkages that characterize this field. Table 1 presents keywords with at least 30 occurrences, highlighting dominant terms within the research landscape. Apart from the general term digital currency, keywords such as CBDC, blockchain, Bitcoin, cryptocurrency dominate the list, reflecting the core focus areas. Terms like CBDC, monetary policy, regulation, and financial inclusion present a growing interest in policy implications and the evolving role of central banks. Emerging topics such as smart contracts, machine learning, and the digital economy suggest an intersection of finance and technology in the literature.

2.3 | Cluster Analysis

Cluster analysis is a bibliometric technique that groups related keywords based on their co-occurrence strength, revealing the thematic structures of a research field. Based on 2898 retrieved articles, this study constructs a keyword co-occurrence network. Only keywords with a minimum frequency of five were included. As shown in Figure 1, the results identify four major thematic clusters: (1) digital currency, (2) Bitcoin and cryptocurrency, (3) CBDC, and (4) blockchain. Given that many blockchain studies are rooted in computer science and mathematics, this paper primarily focuses on the first three clusters, which are more relevant to financial and policy-oriented research. Blockchain technologies are discussed separately in Section 3.3.3, titled Innovative Characteristics. The subsequent sections review and discuss literature based on these three core clusters.

Figure 1 illustrates a keyword co-occurrence network of digital currency research, based on 2898 WOS articles published (2006–2025) and visualized using VOSviewer software. Keywords with a frequency of five or more were included. Node size

TABLE 1 | Key words with a frequency of 30 or more (WOS database, 2016–2025).

Keyword	Occurrence	Keyword	Occurrence
Blockchain	453	Privacy	48
Bitcoin	409	Central bank digital currencies	48
Cryptocurrency	381	Digital money	44
Digital currency	291	Blockchain technology	44
Central bank digital currency	224	Smart contract	41
CBDC	147	Smart contracts	38
Cryptocurrencies	142	Machine learning	38
Digital currencies	96	Regulation	37
Monetary policy	65	Central bank	35
Virtual currency	64	Digital economy	35
Fintech	61	Stablecoins	34
Security	59	Financial stability	33
Ethereum	52	Financial inclusion	30
Money	49	Trust	30

This table displays the most frequently occurring keywords in digital currency research, offering preliminary research hotspots.

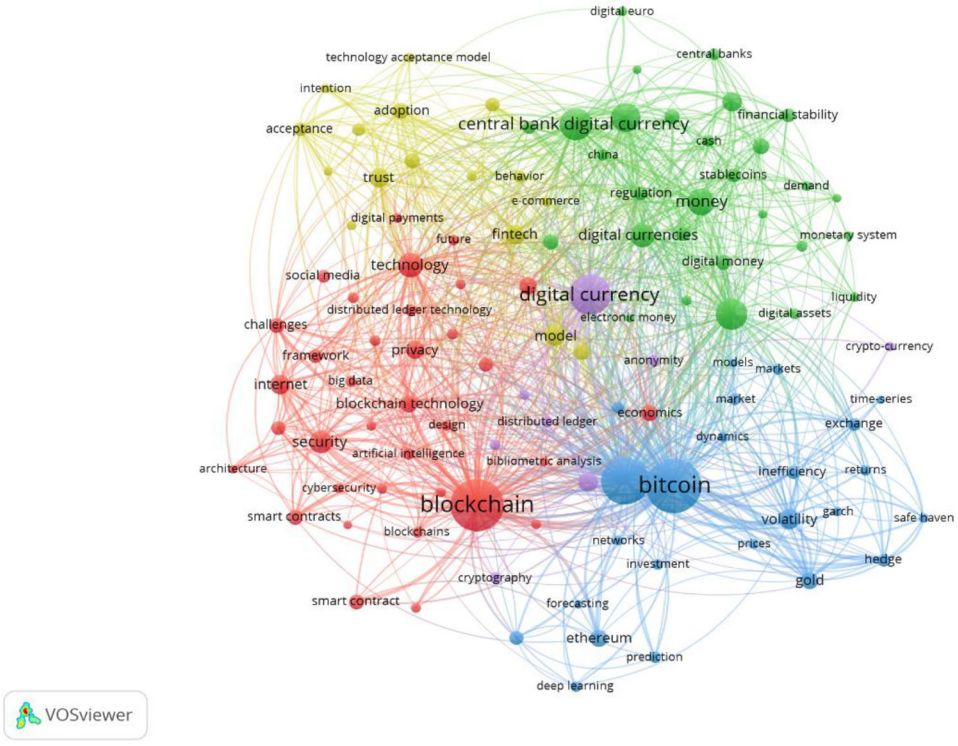

FIGURE 1 | Co-word network visualization of digital currency literature. [Colour figure can be viewed at wileyonlinelibrary.com]

indicates the keyword frequency, line thickness reflects co-occurrence strength, and color denotes distinct thematic clusters. The clusters correspond to the following research themes: digital currency (purple), Bitcoins and cryptocurrencies (blue), CBDC and monetary policy (green), blockchain and security technologies (red), and user adoption and behavioral factors (yellow).

2.4 | Emergence of Digital Currency Research

To illustrate how related research emerges over time, we present the distribution of annual publications from 2006 to 2025 in Figure 2. As shown in Figure 2, preliminary academic discussions on digital currency begin even before the introduction of Bitcoin in 2008, marking the nascent stage of digital currency research.

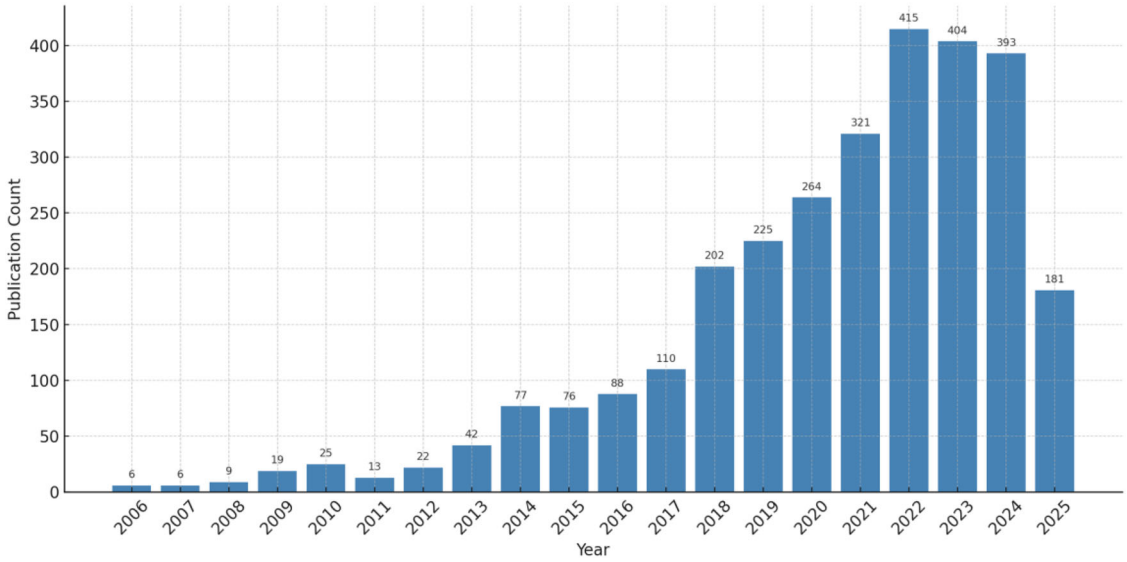

FIGURE 2 | Annual publication counts in the digital currency literature (2006–2025). [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 2 | Top 5 prolific authors in digital currency research.

Author	Articles	Citations
Nikolaos A. Kyriazis	11	289
Shaen Corbet	8	329
Larisa Yarovaya	7	450
Brian Lucey	6	264
Peterson K. Ozili	6	105

This table presents leading contributors to digital currency research within the finance field, ranked by the number of publications indexed in the WOS database. It also reports each author's citation count, reflecting both research productivity and academic influence.

While publication activity begins to increase gradually after 2008, it remains relatively low until 2017. A notable acceleration occurs from 2018 onward, with output peaking in 2022 and remaining consistently high until August 2025. This surge coincides with intensified interest from global financial institutions and central banks, which have actively engaged in digital currency research and development initiatives. In line with this growing interest, approximately 82.1% of the sample studies are published between 2018 and 2025.

Figure 2 presents the annual distribution of publications in the digital currency literature over a 20-year period, from Jan 2006 to August 2025. The data are retrieved from the WOS Core Collection using the keyword "digital currency", resulting in a total of 2898 documents.

In addition, Table 2 highlights the top five prolific authors in the finance domain, based on the number of publications and their respective citation counts within the WOS database. These scholars have published extensively on core topics such as cryptocurrency pricing, market volatility, financial regulation, and the implications of central bank digital currencies (CBDCs). The research output from these scholars provides insight into the dominant themes and prevailing perspectives in the current digital currency literature.

3 | Evolution of Digital Currency

3.1 | Digital Currency Development

3.1.1 | Pre-Bitcoin Era

Although Bitcoin is widely regarded as the pioneer of cryptocurrencies (Corbet et al. 2019), the conceptual groundwork for digital currencies emerged much earlier. Chaum's E-cash system (Chaum 1983), though lacking blockchain, is often viewed as a precursor to modern cryptocurrency for its innovative use of blind signature, which enabled user privacy alongside verifiable transaction. This innovation lays the theoretical groundwork for later systems such as DigiCash, one of the earliest attempts at digital currency (Kreltszheim 1999). Subsequent developments, such as Wei Dai's B-money (1998), introduced a peer-to-peer system based on cryptographic identities and an early proof-of-work consensus mechanism. Similarly, applied a proof-of-work to deter email spam (Back 2002). This concept was later adapted for Bitcoin's mining process, demonstrating how nonfinancial innovations contributed to the development of decentralized cryptocurrencies (Aloun 2024). Nick Szabo (2005) proposed chained proof-of-work and decentralized timestamping concepts that directly influenced Bitcoin's design, even though they were never fully implemented.

While innovative, these early efforts failed to achieve widespread adoption due to technical constraints and regulatory dependencies. DigiCash, for instance, collapsed in the late 1990s largely because it depended on a centralized issuing authority and failed to achieve broad merchant acceptance (Morris 2015). Pre-Bitcoin systems suffered from centralization, weak incentives, and no viable consensus protocol, which left them vulnerable to regulatory constraints and inefficiencies.

3.1.2 | Crypto Coins

Foundational concepts from earlier digital currencies have significantly influenced the creation of Bitcoin by shaping its core technological design. Bitcoin's open-source architecture and public visibility have disrupted traditional finance, inspiring the emergence of numerous alternative cryptocurrencies, commonly known as Altcoins. Appendix Table A1 summarizes key characteristics of representative those cryptocurrencies, including Ethereum (ETH), Ripple, EOS, and USDC. At its core, Bitcoin creatively employs a UTXO (Unspent Transaction Output) model to address the long-standing double-spending problem (Karame et al. 2012). Furthermore, the Blockchain framework enables a decentralized and peer-to-peer network secured by consensus protocol and cryptographic verification between peers, where trust is established without reliance on a central authority (Garzik and Donnelly 2018).

3.1.3 | Stablecoins

Stablecoins are designed to mitigate the high volatility associated with cryptocurrencies and operate across various blockchain infrastructures, including public, private, and consortium-based networks[2]. Recent legislative and policy developments surrounding stablecoins have begun to facilitate innovation in private sector digital currencies, while addressing potential risks to monetary sovereignty and financial stability. For instance, the United States enacted the GENIUS Act in 2025, introducing the first comprehensive federal framework for payment stablecoins. Shortly thereafter, Hong Kong released a draft Stablecoins Ordinance, which establishes a licensing regime for fiat-referenced stablecoins (FRS) and imposes requirements related to anti-money laundering (AML), risk management, and corporate governance.

3.1.4 | Central Bank Digital Currency

In recent years, CBDCs have attracted increasing global attention. As of June 2025, 94 percent of surveyed central banks are exploring CBDC projects, with most still in the research or experimentation stage (Di Iorio et al. 2024). Ecuador made one of the earliest attempts to issue a CBDC in 2014, but the initiative failed in 2018 due to hyperinflation and low public trust in its central bank. Countries with advanced electronic payment systems have been making notable progress. Norway proposes a "register-based token money" model alongside an offline-capable and account-based alternative (Norges Bank 2018, 2019). Sweden's Riksbank launched two versions of the e-krona in 2017, value-based and register-based, to complement physical cash rather than replace it (Sveriges Riksbank 2020). Singapore and Canada develop the Ubin and Jasper respectively on ETH-based private blockchains (Monetary Authority of Singapore 2017). The Bahamas became the first country to launch a nationwide retail CBDC, the Sand Dollar, in 2020, serving as an early real-world case that informed subsequent CBDC initiatives worldwide (Appendino et al. 2023). Moreover, China, Russia, Saudi Arabia, and the United Arab Emirates are among the most advanced in deployment, with large-scale CBDC pilot programs underway (Atlantic Council 2024).

Alternatively, several countries maintain a cautious or oppositional stance toward CBDC issuance. Denmark has declined to issue a CBDC due to its fixed exchange rate regime and open capital account, which constrain monetary autonomy (Denmark National Bank 2017). Germany has expressed concerns about banking sector risks, while the UK, Finland, and the European Central Bank are taking a cautious approach, warning of threats to macroeconomic stability. The United States has likewise been deliberate, initially hesitant but gradually exploring options such as the "Digital Dollar Wallet" and the "Digital Dollar Project" to preserve the dollar's global influence. However, the Federal Reserve refrained from releasing detailed plans for years (Wong and Maniff 2020). It was not until 2025 that the Trump administration declared its opposition and prohibited the Federal Reserve from issuing a digital dollar in 2025. Notably, a joint report by seven major central banks and the BIS marks a milestone in CBDC development, which outlines the core principles and potential cross-border benefits (Bank for International Settlements et al. 2020).

3.2 | Fundamental Theory

The core principles of economic theories provide valuable explanations to the behaviors of digital currencies. The Austrian School, emphasizing minimal government intervention and free-market competition, aligns with the decentralized nature of private sector digital currencies such as Bitcoin, advocating for currency evolution without state control. In contrast, the Keynesian School supports government regulation and centralized models like CBDCs to maintain economic stability through monetary and fiscal policies. The Optimal Currency Area (OCA) Theory further underpins stablecoins, suggesting that pegging to stable assets can reduce volatility and enhance economic stability, albeit with reliance on fiat currency policies. Together, these theories offer a comprehensive framework for understanding the diverse structures and implications of digital currencies.

3.2.1 | Cryptocurrency: Austrian School of Economics Theory

The decentralized nature of many private sector digital currencies aligns closely with the Austrian School of Economics, particularly its anarchist monetary theory, as championed by economists such as Hayek (1978) and Mises (2007). Contrary to the Keynesian School Theory (Keynes 1937), which advocates for substantial government intervention in regulating the money supply, the Austrian School posits that minimal governmental interference is preferable. It contends that the most effective currency should emerge organically through free-market competition.

Hayek (1978) suggests that government-backed currencies may become obsolete, potentially replaced by private sector-issued currencies. These currencies would not be bound by national borders but rather function as "super-sovereign" entities, operating independently in a global, state-free framework. Prominent examples of such decentralized digital currencies include Bitcoin.

3.2.2 | Stablecoins: OCA Theory

The mechanism of stablecoins can be explained through the OCA Theory (Mundell 1961) and the Linked Exchange Rate System Theory. The OCA Theory suggests that regions with similar economic structures benefit from sharing a common currency (Mundell 1961). Applied to stablecoins, this theory implies that digital currencies pegged to stable assets such as fiat currencies can promote economic stability and reduce exchange rate volatility. Similarly, the Linked Exchange Rate System highlights how stablecoins, such as USDC, function analogously to fixed exchange rate regimes. However, this peg mechanism constrains their autonomy, as such fiat-collateralized stablecoins cannot exercise monetary policy independently.

3.2.3 | Centralized Digital Currency: Keynesian School Theory

The Keynesian School Theory (1937) provides theoretical support for centralized digital currencies. Proponents argue that governments ought to regulate and control the circulation of digital money, leveraging monetary policy to stimulate or moderate economic activity, and maintain economic stability. By adjusting interest rates, managing money supply, and implementing fiscal policies, governments can address economic fluctuations and promote sustainable growth. The Quantity Theory of Money (Fisher 2006), which links money supply to price levels and emphasizes the role of sovereign currency issuers, provides a significant theoretical foundation for analyzing and developing CBDCs.

3.3 | Developing Connotations

Despite a relatively broad consensus on the theoretical foundations of digital currencies, there has been ongoing debate among scholars regarding their definitions and functional classifications.

3.3.1 | Varied Definitions

Despite the rise of digital currencies, disagreement over definitions and terminology still persists (Hull and Sattath 2024). Scholars have proposed multiple definitions, reflecting diverse expectations regarding the roles and evolution of digital currency. Common terms used in the literature include "private digital token," "cryptocurrency," "central bank cryptocurrency," and "central bank digital currency."

Regulatory authorities have established a preliminary conceptual framework for centralized digital currency. The European Central Bank defines digital currency as a digital representation of the central bank liabilities, functionally equivalent to physical cash. Similarly, the Committee on Payments and Market Infrastructures (2015) describes CBDCs as electronic central bank liabilities. The Bank of England (2021) views CBDC as a new form of digital money intended to complement rather than replace cash and bank deposits. Mu (2020) defines China's CBDC as a legal tender-based payment instrument. Form a technical perspective, the Federal Reserve differentiates between account-based and token-based systems (Lee et al. 2020), with the Digital Dollar Project exemplifying a token-based system, enabling peer-to-peer transfers without intermediaries.

3.3.2 | Taxonomy Controversy

The classification and functional interpretation of digital currencies remain unsettled, with scholars disagreeing on their monetary roles and asset characteristics. This lack of consensus largely stems from ambiguity surrounding their intended use and functional scope. From the monetary perspective, CBDCs are designed to perform traditional functions of money, serving as a medium of exchange, unit of account, and store of value (Committee on Payments and Market Infrastructures 2018). In some countries, digital currencies have become the preferred medium of exchange (Khiaonarong and Humphrey 2019). Alternatively, Bitcoin has emerged as a substitute currency in certain illegal markets, particularly for drugs and firearms (Foley et al. 2019). Some scholars classify Bitcoin as "synthetic commodity money," positioning it between fiat money and a crypto-commodity (Hui et al. 2020; Selgin 2015).

A growing body of literature views digital currencies as speculative financial assets due to their high volatility (Yermack 2024). As a distinct asset class with limited integration into traditional financial markets (Corbet et al. 2018), cryptocurrencies such as Bitcoin and ETH exhibit bubble-like behavior indicative of their speculative nature (Corbet et al. 2018). Their scarcity and high stock-to-flow ratios make them appealing as hedges against political and economic instability (Baur, Hong, et al. 2018). Most digital currencies, however, are still evaluated using traditional asset pricing models (Liu and Tsyvinski 2021) and operate without national backing (Marple 2021). In the United States, cryptocurrencies are treated as taxable property rather than legal tender, placing them outside the scope of central bank frameworks (John and Kumhof 2016). Yermack (2024) argues that Bitcoin holds little significance as a medium of exchange, as 80% of its transactions are speculative. Alvarez et al. (2023) view Bitcoin primarily as a speculative asset rather than viable legal tender, given its limited adoption and declining usage over time. Baur et al. (2018) argue that Bitcoin's excess returns and volatility align more closely with highly speculative assets rather than gold or the US dollar.

Comparing Bitcoin with traditional safe-haven assets like gold, some scholars argue that the rise of cryptocurrency could lead to a revival of the gold standard (Baur et al. 2018; Corbet et al. 2020; Dyhrberg 2016). To some extent, Bitcoin shares certain characteristics with gold as a hedge asset (Dyhrberg 2016) and displays safe-haven behavior under specific situations (Shahzad et al. 2019). However, the majority of evidence suggests that Bitcoin still falls short of acquiring the defining features of gold (Kyriazis 2020), and empirical findings confirm its limitations in this regard. Baur, Hong, et al. (2018) find that Bitcoin cannot be considered as a strong safe haven during crises. Its continuous 24/7 trading structure, relatively low daily volumes (Feng et al. 2018b) and absence of market circuit breakers exacerbate price instability. During the early phase of the COVID-19, cryptocurren-

cies became more correlated with traditional markets, revealing their limitations as effective safe-haven assets (Corbet et al. 2020).

Concerns have also been raised about speculation and potential frauds around cryptocurrencies. Marple (2021) contends that Bitcoin mania is fuelled by froth and fraud. Fry and Cheah (2016) describe Bitcoin as undergoing "negative bubbles" with a fundamental value close to zero. Cheung et al. (2015) identify multiple short-lived speculative episodes in the Bitcoin market. Fry (2018) further confirms such dynamic bubbles in both Bitcoin and ETH, using a model that captures the heavy-tailed price behavior. Notably, Initial Coin Offerings also raise concerns regarding illegal fundraising (Adhami et al. 2018).

3.3.3 | Innovative Characteristics

Digital currencies, underpinned by advanced digital technologies, possess novel characteristics that transcend conventional monetary functions. These characteristics include anonymity[3], transparency, traceability[4], hard to tamper, irrevocability (best effort basis)[5], programmability[6], and interoperability (Di Iorio et al. 2024; Hull and Sattath 2024; Kshetri 2021). Among these, anonymity is a defining feature of several privacy- oriented cryptocurrencies, such as Zerocash, Zerocoin, Dash, and Monero, all of which aim to safeguard user identities by concealing personal information. Given the public nature of account addresses, the design of CBDCs varies significantly in terms of anonymity (Kosse and Mattei 2022).

Interoperability represents another transformative feature that can significantly enhance the efficiency of cross-border transactions (Di Iorio et al. 2024). Early interoperability trials are being conducted on platforms such as R3's Corda and private ETH networks. Mizuho Bank and JCB, a major Japanese payment company, are jointly piloting a blockchain-based interoperability solution (Bank for International Settlements et al. 2020). As digital currency platforms become increasingly interoperable, they may offer viable alternatives to the SWIFT system and potentially challenge the dominance of the U.S. dollar (Dodgson et al. 2015). Vitalik Buterin (2016), co-founder of ETH, proposes three mechanisms for inter-blockchain communication—Notary Schemes, Side chains and Relays, and Hash Time Lock Contracts. Building on this foundation, Belchior et al. (2021) conduct a comprehensive review of blockchain interoperability of approximately 400 studies, highlighting the theoretical potential for seamless interoperability in future digital currency systems.

4 | Private Sector Digital Currency

Bitcoin represents a turning point in the evolution of private sector financial innovation, initiating a broader shift toward decentralized, non-sovereign digital currencies. In a bibliometric survey, Bariviera and Merediz-Solà (2021) map the structure of cryptocurrency research from 2009 to 2020, revealing that early studies on digital currencies primarily focused on private sector forms and micro level financial dynamics, including informational efficiency, pricing mechanisms, volatility patterns, and trading behavior. To organize the key academic debates, Table 3 synthesizes both areas of scholarly consensus and ongoing controversies across five core thematic dimensions, which align closely with the themes explored in the following subsections. These dimensions progressively incorporate broader policy and systemic perspectives and extend the analytical scope beyond cryptocurrencies to include research on stablecoins since 2006.

4.1 | Properties Discussion

4.1.1 | Price Discovery

The price formation of cryptocurrencies is shaped by multiple factors. On the supply side, Bitcoin's algorithmic scarcity plays a central role. Peng et al. (2023) and Ciaian et al. (2016) emphasize that the predetermined algorithmic supply significantly influences Bitcoin's market price. However, Budish (2025) argues that this scarcity is only relative, since new tokens can be created continuously, undermining absolute scarcity at the ecosystem level.

Market complexity also affects price formation. Competition among digital currencies complicates the supply–price relationship, and rising stablecoin issuance has been linked to short-term Bitcoin price increases (Griffin and Shams 2020). Using an ARDL model, Sovbetov (2018) identifies market beta, trading volume, and volatility as critical price determinants. Giudici and Abu-Hashish (2019) demonstrate that prices across exchanges are highly correlated, underscoring strong interdependency that amplify market dynamics.

Externally, investor behavior represents another crucial factor. Sentiment-driven trading and herding behaviors are widely recognized as important drivers of cryptocurrency price dynamics (Haykir and Yagli 2022; Papadamou et al. 2021). During the COVID-19 pandemic, global quantitative easing intensified market uncertainty, prompting investors to reallocate capital into cryptocurrencies and driving up prices (Umar and Gubareva 2020), even though the intrinsic value of most cryptocurrencies remains unclear.

Notably, the recent emergence of non-fungible tokens (NFTs) has broadened the landscape of private sector digital assets, introducing new valuation mechanisms and market dynamics. Kräussl and Tugnetti (2024) find that NFT prices are primarily driven by asset uniqueness, scarcity, market liquidity, social and cultural value, and creator reputation. Although NFT markets display speculative characteristics similar to early-stage cryptocurrencies with high price volatility and low liquidity, they also offer novel opportunities in digital art, gaming, and intellectual property monetization.

4.1.2 | Price Volatility

Cryptocurrencies are characterized by high unconditional price volatility (Chaim and Laurini 2018; Ji et al. 2019; Katsiampa 2017; Katsiampa et al. 2019). One of the earliest empirical studies, Katsiampa (2017) applies various GARCH-type models and identifies the AR-CGARCH model as most effective in capturing Bitcoin's volatility dynamic. Subsequent studies have emphasized the interconnectedness of cryptocurrency markets. Ji

TABLE 3 | Synthesis of scholarly perspectives on private-sector digital currencies.

Topic	Main Viewpoint Summary	Studies Supporting the View	Studies Contrasting the View
Price Determinants	Supporters argue that prices are mainly driven by algorithmic supply and investor sentiment; opponents highlight the role of macroeconomic shocks, market structure, and cross-currency competition.	Ciaian et al. (2016); Haykir and Yagli (2022); Papadamou et al. (2021); Peng et al. (2023); Sovbetov (2018); Umar and Gubareva (2020)	Giudici and Abu-Hashish (2019); Griffin and Shams (2020)
Price Volatility	Supporters emphasize the persistent high volatility of cryptocurrencies; opponents argue that volatility declines in mature markets and can be mitigated through arbitrage and liquidity effects.	Chaim and Laurini (2018); Katsiampa (2017)	Brauneis and Mestel (2018); Lyons and Viswanath-Natraj (2023); Makarov and Schoar (2020)
Hedging Function	Supporters find that cryptocurrencies can act as short-term hedges during periods of geopolitical risk or crises; opponents stress their high correlation with traditional markets, limiting hedging effectiveness.	Antonakakis et al. (2019); Feng et al. (2018a); Guesmi et al. (2018); Aysan et al. (2019); Mariana et al. (2021)	Kyriazis et al. (2023)
Market Efficiency	Supporters observe weak-form efficiency in Bitcoin markets; opponents point to long-memory effects and asymmetric responses to events as evidence of inefficiency.	Urquhart (2016); Nadarajah and Chu (2017)	Jiang et al. (2017); Vidal-Tomása and Ibañez (2018)
Regulatory Perspectives	Supporters argue that a lack of regulation increases risks and hinders adoption; opponents warn that overly strict regulation could stifle innovation and market vitality.	Ozili (2023); Allen et al. (2022); Bouri et al. (2019); Dierksmeier and Seele (2018); Foley et al. (2019)	Grinberg (2012); Howell et al. (2020); van der Linden and Shirazi (2023)

Note: This synthesis table provides a structured overview of the prevailing scholarly perspectives on private sector digital currencies, covering price determinants, volatility, hedging function, market efficiency, and regulatory perspectives.

et al. (2019) reveal substantial time-varying return and volatility spillovers among major cryptocurrencies. According to Hoang and Baur (2024), stablecoin returns are heteroscedastic relative to benchmarks such as fiat currencies and gold, yet display considerably lower volatility than Bitcoin.

Volatility also creates arbitrage opportunities arising from persistent price discrepancies across crypto exchanges (Makarov and Schoar 2020). Prior to 2017, arbitrage across cryptocurrency exchanges yielded considerable profits for speculators, although these opportunities are now largely automated. Such pricing discrepancies violate the law of one price for homogeneous assets (Hong Kong Financial Development Council 2021). Beyond geographic differences, cryptocurrency arbitrage may also occur across distinct blockchain ecosystems. Lyons and Viswanath-Natraj (2023) examine price differences between USDT on the Bitcoin-based Omni and the ETH-based ERC-20, finding that stablecoins frequently trade at a premium.

4.1.3 | Return and Risk

Given the high volatility and speculative characteristics, cryptocurrencies have attracted considerable attention in return forecasting. Investors are particularly concerned with investment risk and the potential role of cryptocurrencies in portfolio diversification and hedging (Feng et al. 2018a), especially during periods of geopolitical uncertainty (Su et al. 2020). Liu and Tsyvinski (2021) analyze the risk–return profile of Bitcoin, Ripple, and ETH using CAPM and extended Fama–French factor models. Zhang et al. (2018) show that cryptocurrency returns display heavy tails, pronounced volatility clustering and leverage effects.

Regarding safe-haven properties, some research suggests that cryptocurrencies can hedge risks (Antonakakis et al. 2019). Guesmi et al. (2018) find that shorting Bitcoin hedges risks across various financial markets. Aysan et al. (2019) identify Bitcoin as a hedging tool against global geopolitical risks. Mariana et al. (2021) further show that both Bitcoin and ETH acted as short-term safe-havens during the COVID-19 crisis. Nonetheless, although cryptocurrencies may serve as diversifiers similar to gold, their effectiveness in tail-hedging and overall capacity remains limited (Kyriazis et al. 2023).

Beyond market fundamentals, behavioral factors such as market time-series momentum and investor attention are significant predictors of cryptocurrency returns (Liu et al. 2021). Corbet et al. (2020) find that positive economic news tends to reduce Bitcoin returns, whereas negative news exerts an opposite effect. To enhance forecasting accuracy, Sun et al. (2020) propose a LightGBM model to predict price trends, while Lamothe-Fernández et al. (2020) develop a deep learning-based model to forecast Bitcoin's price.

4.2 | Cryptocurrency Market Analysis

4.2.1 | Order Books and Automated Market Makers (AMMs)

The global crypto market is highly concentrated, around 90% of trading volume handled by just ten platforms—Binance alone accounts for approximately half of global volume (Jones 2024). The cryptocurrency exchanges are typically categorized into Centralized Exchanges (CEXs), Decentralized Exchanges (DEXs), and Hybrid-decentralized Exchanges (HEXs). CEXs operate on a centralized limit order book (LOB), a market microstructure inherited from traditional finance, where prices are discovered through strategic bidding and offering by participants. Schnaubelt et al. (2019) examine Bitcoin's limit order book dynamics and confirm that it exhibits several "stylized facts" commonly observed in traditional financial markets, including bid–ask symmetry, volatility clustering, and order clustering around round numbers.

In contrast, blockchain-based DEXs replace traditional LOBs with Automated Market Makers protocols (Barbon and Ranaldo 2021). These protocols create distinct liquidity dynamics, where prices are determined algorithmically by the relative reserves in liquidity pools (Aoyagi and Ito 2025). Capponi and Jia (2021) investigate the market microstructure of AMMs and find that their order execution mechanism leads to value losses for liquidity providers when token exchange rates are volatile. Park (2023) argues that AMMs face fundamental limitations in price discovery, value retention for liquidity providers, and resilience against strategic exploitation. Similarly, Lehar and Parlour (2025) show that while Uniswap's AMM model lacks the strategic depth and efficiency of traditional LOB markets in information-rich contexts.

4.2.2 | Efficiency and Liquidity in Crypto Markets

Recent research highlights the role of trading platform microstructure in determining liquidity and price efficiency. Since 2016, The Efficient Market Hypothesis (Fama 1965) has attracted considerable attention in the cryptocurrencies literature. Evidence on Bitcoin's weak-form efficiency remains mixed. Urquhart (2016) first documents short-term deviations from market efficiency in Bitcoin, while Jiang et al. (2017) confirm long memory in Bitcoin returns, suggesting deviations from weak-form efficiency. By contrast, Nadarajah and Chu (2017) attribute earlier findings of inefficiency to data limitations, supporting the weak-form efficiency of Bitcoin by applying power transformations to daily returns.

Beyond weak-form tests, Bitcoin exhibits only partial efficiency at the semi-strong level. Empirical evidence suggests that Bitcoin is largely unresponsive to international monetary policy, indicating that central banks lack the ability to control its market, unlike in traditional equities (Brenner et al. 2009; Pennings et al. 2015). Similarly, Vidal-Tomása and Ibañez (2018) find that Bitcoin returns react promptly to negative events but only weakly to positive news.

CEXs feature concentrated liquidity pools, actively managed by professional traders and market makers. In contrast, liquidity in DEXs pools is provided passively by users but is in practice highly concentrated among only a few providers (Barbon and Ranaldo 2021). Aspris et al. (2021) provide empirical evidence that DEXs are characterized by substantially lower liquidity and higher trading costs compared to CEXs. Brauneis and Mestel (2018) observe a heterogeneous efficiency pattern in cryptocurrency markets, where increased liquidity and market size are linked to reduced price predictability.

4.2.3 | Market Connectedness, Spillovers and Contagion

Research consistently highlights the high degree of interconnectedness within the cryptocurrency market (Ciaian et al. 2016; Corbet et al. 2018; Karim et al. 2022). Ciaian et al. (2016) analyze the co-movements between Bitcoin and sixteen alternative cryptocurrencies, finding significant interdependence. Extending this perspective, Karim et al. (2022) show that NFTs and DeFi tokens also display varying degrees of connectedness, with implications for portfolio diversification. Beneki et al. (2019) show the Bitcoin and ETH exhibit strong co-movements with limited hedging effectiveness, underscoring their interconnectedness.

More recent research emphasizes spillovers arising from market microstructure. Aoyagi and Ito (2025) investigate both internal and cross-market spillovers within the cryptocurrency ecosystem, emphasizing that liquidity provided by AMMs generates significant spillover effects on CEX markets. The literature has also expanded to cross-market linkages. Kyriazis and Corbet (2025) examine the dynamic spillover effects between U.S. traditional assets and green cryptocurrencies, highlighting state-dependent inter-asset linkages during crises.

Scholars have expressed concern that activities conducted on cryptocurrency platforms may transmit contagion to global financial actors, amplifying the potential for financial calamity (Aliano et al. 2024). Evidence further reveals heterogeneity in contagion channels. For instance, Zhao et al. (2024) find that spillover effects vary by cryptocurrency classification, implying heterogeneous contagion channels across different token types. Similarly, Ibrahim et al. (2024) document that Bitcoin generates both short-term and long-term volatility spillovers to gold and major stock markets across the United States, United Kingdom, Japan, China, Germany, and France. During the COVID-19 crisis, Banerjee et al. (2022) uncover a nonlinear and unidirectional information transmission from COVID-19 news sentiment to cryptocurrency returns, highlighting the behavioral and sentiment-driven dynamics that characterize contagion in times of crisis. In the same context, Akhtaruzzaman et al. (2022) demonstrate that cryptocurrencies participated in systemic risk-sharing with global financial markets during the COVID-19 crisis, acting simultaneously as both transmitters and absorbers of shocks. Nevertheless, not all studies point to strong contagion. Feng et al. (2018a) suggest that under certain conditions, major cryptocurrencies remain relatively insulated from equity market contagion, implying potential safe-haven characteristics.

4.2.4 | Legality and Regulation

The global cryptocurrency ecosystem remains largely unregulated (Ozili 2023), with weak legal frameworks posing challenges for policymakers (Allen et al. 2022; Bouri et al. 2019; Dierksmeier and Seele 2018). For instance, CEXs introduce systemic risks such as hacks, insider threats, and founder fraud (Corbet et al. 2019). Between 2011 and 2021, cumulative losses from security breaches in major CEX were estimated at approximately $7 billion stolen alone (ChainSec 2023). Notable incidents include the Mt. Gox hack in 2014 (850,000 Bitcoins stolen). Subsequent breaches occurred at Bitfinex (2016), Coincheck (2018) and FTX (2022) where CEO Sam Bankman-Fried misappropriated $8 billion (Cheung et al. 2015; Stempel 2024). Most recently, the 2025 Bybit hack marked the largest crypto heist in history, involving $1.46 billion in stolen cryptocurrency (Tidy and Singleton 2025). In addition, emerging financing models such as Initial Coin Offerings (ICOs) have also attracted regulatory attention due to their potential for regulatory evasion (Howell et al. 2020).

The decentralized nature of cryptocurrencies further complicates regulatory efforts, particularly in establishing clear tax classifications and obligations (Shestak et al. 2021). This challenge is compounded by their frequent association with illicit purposes such as money laundering and illegal trade, which has prompted calls for closer regulatory scrutiny (Foley et al. 2019). Grinberg (2012) analyzes Bitcoin's intersection with central bank currency issuance, securities laws, and AML laws. However, the permissionless, pseudonymous and borderless nature of digital currency complicates tax compliance, complicates AML enforcement, and efforts to prevent financial malfeasance (Houben and Snyers 2018; Makarov and Schoar 2022).

Addressing these challenges requires both domestic oversight and coordinated cross-border regulation. Despite some jurisdictions' efforts in implementing comprehensive regulations, the lack of uniformity and consistent enforcement remains a major challenge (van der Linden and Shirazi 2023). As Claessens et al. (2024) emphasize, aligning regulations across jurisdictions is equally important, as differences can create friction in cross-border use.

4.3 | Current Limitations

Cryptocurrencies continue to face technology, security, and adoption challenges that limit their mainstream viability. The blockchain trilemma remains unresolved: It is difficult to simultaneously achieve decentralization, scalability, and security. In practice, most projects manage to satisfy only two out of these three goals (Buterin 2016; Leonardos et al. 2020). For instance, the network typically processes around 7 transactions per second, which is insufficient for large volumes and often results in delays (Alvarez et al. 2023). Conti et al. (2018) highlight a fundamental tension between Bitcoin's transparency and user privacy. Moreover, Bitcoin's public ledger poses a fundamental privacy concern: although users transact under pseudonyms, all activity is permanently recorded and traceable. Once an address is linked to a real identity, the user's full transaction history becomes traceable, making cryptocurrencies more transparent than traditional financial systems (Conti et al. 2018).

TABLE 4 | Leading countries in CBDC research by publication count.

Country	Documents	Citations
USA	148	2728
China	143	2584
England	91	1436
Germany	59	553
Italy	53	640

This table lists the top 5 countries contributing to CBDC research, based on publication counts from the WOS Core Collection between January 2006 and August 2025. The United States leads with 148 publications, followed by China (143) and England (91). These countries also represent some of the most influential stakeholders in shaping the global CBDC discourse.

Security concerns are further exacerbated by the potential threat of quantum computing (Mosca 2018). Cryptocurrencies depend on encryption, irrevocability, and traceability for security. Without a CBDC, however, authorities cannot track stolen electronic currency, since it can be converted into cash and remain untraceable (Conti et al. 2018). Paradoxically, quantum computing could also strengthen cryptocurrency security. While it may enable hackers to decrypt private keys, it cannot erase distributed ledger data, thereby preserving traceability. Even when theft occurs, blockchain's traceable distributed ledger technology (DLT) can still guarantee security, as quantum computing may crack passwords but cannot delete records if the ledger is sufficiently decentralized (Yaga et al. 2019).

5 | Central Bank Digital Currency

In response to the limitations of private sector digital currencies and growing concerns about financial stability and monetary sovereignty, increasing attention has turned to CBDCs (Raskin and Yermack 2018). To understand the scholarly landscape, Table 4 presents the leading contributing countries in CBDC research. The United States, China, and England top the list.

Policy responses to CBDC development vary across major economies. In January 2025, the Trump Administration signed an executive order, instructing all federal agencies to suspend work on the digital dollar. In contrast, China has made rapid strides through its e-CNY pilot since 2019. By 2025, E-CNY pilot has expanded to 17 provincial-level regions, with approximately 260 million wallet users. China is also active in cross-border CBDC experimentation, notably through *mBridge*, a multi-CBDC initiative with Thailand, the UAE, and Hong Kong. In Europe, the United Kingdom has entered the design phase for a potential "digital pound," with rapid development underway since 2024, led by the Bank of England and HM Treasury. Within the Eurozone, the ECB spearheads the development of a digital euro, with active participation from countries like France and Italy. The Bank of France has played a central role in wholesale CBDC trials in collaboration with Switzerland, Hong Kong, and Singapore. Italy views the digital euro to enhance monetary sovereignty, promote financial inclusion, and support the transition toward a less cash-reliant economy. Germany, by contrast, has adopted a more cautious approach, focusing on evaluating the risks,

TABLE 5 | Comparative overview of major national CBDC projects.

Country	Project Name	Use Case	Current Status	Motivations
United States	—	—	Banned	Preserve U.S. dollar dominance; concerns over state-led monetary innovation.
China	e-CNY	Retail, Wholesale	Pilot	Improve payment system efficiency, financial inclusion, redundancy support.
United Kingdom	Digital pound	Retail, Wholesale	Development	Ensure financial stability, privacy protection, and financial inclusion.
Germany	Digital Euro	Retail, Wholesale	Development	Conservative ECB-led cautious approach.
Italy	Digital Euro	Retail, Wholesale	Pilot	Advance monetary sovereignty.
India	Digital rupee (e₹)	Retail, Wholesale	Pilot	Promote financial inclusion; reduce cash storage, printing, and logistics costs.

Note: This table is based on the Atlantic Council CBDC Tracker (accessed August 2025). It summarizes the use cases, project status, and key motivations behind the CBDC initiatives of leading research-contributing countries. While the U.S. has suspended CBDC development for strategic reasons, other jurisdictions, including China, the U.K., Eurozone countries, and India, have moved forward with pilot or development-stage projects. Source: Atlantic Council (https://www.atlanticcouncil.org/cbdctracker/).

opportunities, and broader implications of introducing a digital euro Table 5.

5.1 | Top Designs of CBDC

5.1.1 | Retail and Wholesale Use

A foundational distinction in CBDC model design lies in its intended user base. Following Christian and Henry (2019), CBDCs are typically categorized as retail for the general public and wholesale for financial institutions (Auer et al. 2023). Retail CBDCs are designed to support high-frequency and low-value payments, while wholesale models function similarly to clearing accounts held with central banks.

5.1.2 | Interest-Bearing Features

A key design consideration is whether a CBDC should bear interest. China's e-CNY is designed as a non-interest-bearing CBDC to avoid competition with commercial bank deposits and disintermediation risks (Mu 2020). However, some studies suggest that an interest-bearing CBDC may improve bank intermediation by improving deposit and lending dynamics (Wu and Zhang 2024), though excessively high interest rates may lead to disintermediation (Andolfatto 2021). In a working paper by Bank of England, John and Kumhof (2016) define CBDC as a universally accessible and interest-bearing central bank liability that competes with bank deposits as a medium of exchange. Additionally, Kim and Kwon (2023) argue that the CBDC issuance could enable central banks to implement negative interest rates, thereby overcoming the zero-lower bound and expanding monetary policy options.

5.1.3 | Operational Mechanism

Recent designs in CBDC operational modeling have further formalized the structural dynamics of CBDCs under different institutional architectures. According to Bindseil and Senner (2025), the choice between a one-tier and a two-tier CBDC delivery system fundamentally influences liquidity distribution, credit creation, and the composition of the central bank's balance sheet. Their model suggests that a one-tier issuance framework, in which the central bank directly provides CBDC to the public, enhances monetary policy control and transmission precision. However, such a structure may also reduce commercial banks' profitability, increase the risk of financial disintermediation by diverting deposits away from commercial banks, and weaken monetary policy transmission (Bindseil and Senner 2025; Chen and Siklos 2022). In contrast, a two-tier design, as exemplified by the Digital Dollar and China's e-CNY projects, has become the mainstream design[7]. Under central bank oversight, this framework retains existing banking intermediation, mitigates the risk of financial disintermediation, and leverages the established financial infrastructure, thereby supporting systemic stability (Chen and Siklos 2022). The two-tier model also maintains the central bank's role as issuer while relying on financial institutions to distribute CBDC to individuals and nonfinancial entities. This structure helps preserve the existing banking system and minimizes the risk of financial disintermediation. The projects of Digital Dollar and China's e-CNY follow a two-tier delivery system to avoid disintermediation and leverage the existing financial system.

5.2 | Potential Macro-Financial Impacts

5.2.1 | Reshaping Payments and Financial Infrastructure

CBDCs are expected to exert far-reaching influence on existing payment systems and financial infrastructures. Domestically, they may strengthen resilience by ensuring continued public access to central bank money. For instance, Sweden's Riksbank has explored whether an e-krona could safeguard access to central bank money while improving the resilience of the payment system (Sveriges Riksbank 2020). In the cross-border context, traditional SWIFT-based cross-border transfers rely on multiple

intermediaries, resulting in higher costs, long settlement times, and low transparency (Ghasseminejad and Jahan-Parvar 2021). By contrast, wholesale CBDCs allow direct, token-based transactions between central banks (Auer et al. 2023). Nevertheless, scholars caution that a thriving CBDC system may generate international spillovers, including challenges to U.S. dollar dominance (Georgieva 2022).

Beyond their impact on payments, CBDCs are poised to fundamentally reshape both financial institutions and broader international infrastructures. National settlement infrastructures may need to be reconfigured to support 24/7 settlement, programmable money, and identity-linked wallets. These changes will also alter institutional roles: commercial banks may face reduced dominance in payments and deposits, while non-bank financial institutions (NBFIs) and fintech firms may expand their role in wallet services and retail distribution (Auer and Böhme 2021). Internationally, regions lacking advanced technological infrastructure may face significant implementation hurdles, raising concerns over data security, privacy, and uneven access (Alora et al. 2024).

5.2.2 | Concerns of Deposit Crowding-Out

Since CBDCs constitute direct liabilities of central banks, individuals may convert funds from commercial bank deposits to CBDCs, potentially crowding out deposits and increasing the risk of bank disintermediation (Andolfatto 2021; Bian et al. 2021; Keister and Sanches 2023; Rehman et al. 2023). Bian et al. (2021) develop a payment portfolio model to illustrate how consumers allocate funds between CBDCs and traditional deposits. Their findings suggest that the availability of CBDC may reduce deposits held by commercial banks. Scholars also warn that the CBDC may heighten depositor runs (Agur et al. 2022; Wilkins 2022), and central banks may become deposit monopolists (Fernández-Villaverde et al. 2021), then threatening financial stability (Brunnermeier and Niepelt 2019). To mitigate disintermediation risks, central banks in England, Sweden, and Norway have restricted instant CBDC transfers from commercial bank accounts (England & Treasury, 2023; Sveriges Riksbank 2023). Agur et al. (2022) recommend imposing a holding cap, as exemplified by the Bank of Denmark 's proposal, although the exact threshold remains undecided. The European Central Bank proposes a tiered interest rate system, offering positive rates for balances below a certain threshold and negative rates for those above (European Central Bank 2020).

5.2.3 | Enhancing Traditional Monetary Policy

If carefully designed, CBDCs have the potential to enhance the effectiveness of traditional monetary policy implementation through multiple transmission channels. First, by increasing the traceability and programmability of money, CBDCs may offer central banks greater control over the money supply and payment behavior, thereby improving the precision of policy interventions (Lukonga 2023; Raskin and Yermack 2018). Second, studies suggest that CBDCs can accelerate payment velocity and reduce frictions in interbank settlements, thereby amplifying the monetary multiplier, enhancing the efficiency of monetary policy transmission, and strengthening monetary control through precise liquidity management and reduced reliance on reserve requirements (Bank for International Settlements et al. 2020). Third, empirical research shows that CBDCs could alter key monetary aggregates. Wu and Zhang (2024) argue that replacing physical banknotes with CBDCs could reduce M0 and bank deposit reserves, while increasing the currency multiplier. However, such structural shifts may also pose challenges. Chen and Siklos (2023) find that retail CBDCs could lead to currency substitution in some economies, potentially weakening the effectiveness of domestic monetary policies. In addition, CBDCs may reduce financial crises by providing a safer and more efficient payment system, thereby strengthening the central bank's ability to conduct monetary policy (Tercero-Lucas 2023).

5.2.4 | Potential Macroeconomic Impacts

CBDCs are expected to have far-reaching macroeconomic implications, particularly in enhancing the scope and effectiveness of central bank interventions (Bech and Garratt 2017). If CBDCs were to fully replace physical cash, central banks could gain greater flexibility in implementing unconventional policy tools, such as negative interest rates, to combat recession, unemployment, and deflation (Cochrane 2017; Rogoff 2016). From a structural perspective, CBDC may resemble a form of financial socialism by narrowing the relationship between the public and central banks, thereby granting states a greater control over monetary policy (Raskin and Yermack 2018). CBDCs may also contribute to financial stability by reducing financial frictions in the deposit market, promoting financial inclusion, and improving monetary policy (Lukonga 2023). Hoque et al. (2024) show that even announcements related to CBDCs can significantly affect the performance of digital economy exchange-traded funds (ETFs), underscoring the importance of CBDC-related communication in shaping market expectations. The programmable and traceable features of CBDCs could help central banks combat money laundering, tax evasion, and other illicit financial activities (Wang 2023).

5.3 | Operational Challenges

5.3.1 | Privacy Security

CBDCs face significant operational challenges, with data privacy emerging as one of the most critical (Choi et al. 2025). Privacy spans multiple dimensions, from user identity protection and data security to its relationship with anonymity. A fundamental design dilemma lies in the trade-offs between individual privacy and the regulatory requirements of traceability and compliance. Soana and de Arruda (2024) emphasize this evolving privacy–traceability trade-off, arguing the need to renegotiate the balance in light of growing datafication and intensified financial supervision. Tronnier et al. (2022) show that privacy concerns and trust strongly shape acceptance of the digital euro, while Choi et al. (2025) find that stronger privacy features and clear communication of benefits significantly increase willingness to adopt CBDCs, especially for privacy-sensitive purchases.

5.3.2 | Legal Frameworks

The inadequacy of existing regulatory and legal frameworks to address the complexities and risks associated with CBDCs has been widely acknowledged (Alora et al. 2024; Claessens et al. 2024). While digital finance promotes financial inclusion, it can also give rise to systemic risk when regulatory frameworks are underdeveloped, especially relevant in the context of CBDCs (Ozili 2018). Furthermore, the use of CBDCs may circumvent conventional reporting systems, increasing the risk of tax evasion and underscoring the need for updated tax administration protocols (van der Linden and Shirazi 2023).

5.3.3 | International Cooperation

Recent trials such as the BIS-led mBridge project (Bank for International Settlements 2024) and the MAS–HKMA Project Ubin–LionRock demonstrate the feasibility of multi-CBDC platforms while revealing challenges in governance arrangements and legal enforceability. Establishing joint oversight bodies and shared compliance frameworks could address these risks while enhancing mutual trust among participating central banks. However, it is a complex issue that requires unified technical standards and protocols (Alora et al. 2024). Without coordinated technical design, such as harmonized messaging formats and settlement procedures, CBDCs risk fragmenting into regional silos, limiting their benefits (Auer et al. 2021). International cooperation is also needed to mitigate digital currency spillovers, where foreign CBDCs threaten monetary sovereignty in smaller economies (Adrian and Mancini-Griffoli 2021).

5.3.4 | User Adoption Barriers

Privacy concerns have long been recognized as a key barrier to the widespread adoption of CBDCs. At the macro level, Ngo et al. (2023) examine how governance quality and monetary policy conditions, and cultural norms shape public acceptance of CBDCs. Their cross-country analysis shows that stronger institutions, reflected in transparency, rule of law, and monetary stability, are associated with higher levels of trust and CBDC uptake, while weaker governance and unstable policies undermine adoption. At the micro level, behavioral and sociological studies provide additional interesting insights. Evidence from China's e-CNY pilot demonstrates that privacy concerns significantly reduce adoption, and these effects diminish when privacy-friendly features and clear communication of benefits are implemented (Tronnier and Qiu 2024). Similarly, based on survey and empirical evidence, Jabbar et al. (2023) find that if CBDCs provide substantial benefits, such as faster payments and enhanced financial security, users are willing to accept them despite the risks of privacy breaches.

6 | Conclusion

To summarize, this study systematically reviews and synthesizes the fragmented literature on digital currencies published between 2006 and 2025. It traces the rise of digital currency and the current practices, from early prototypes to definitional debates, contested characteristics, and theoretical foundations, culminating in the two major strands of development: private sector cryptocurrencies and central bank digital currencies. Based on the results of bibliometric clustering analysis, this review places particular emphasis on central bank digital currencies and offers important policy implications.

Early research centered on cryptocurrencies, especially Bitcoin. However, frequent negative events in crypto markets shifted attention toward their risks, limitations, and use in illicit activities. As a result, cryptocurrencies face persistent doubts about their viability as stable stores of value or reliable means of exchange. Stablecoins were introduced to mitigate volatility, yet research on their systemic role, legal treatment, and cross-border transactions remains limited. By contrast, CBDCs have attracted growing academic and policy attention since 2014. As institutionally backed digital currencies, CBDCs with broader potential applications are emerging as a dominant trend in the evolving digital currency ecosystem. A comparative overview of the functional distinctions among cryptocurrencies, stablecoins, and CBDCs is presented in Appendix Table B1.

Based on a review of the mainstream themes, we identify several research gaps for future studies. First, equilibrium-based analyzes of CBDCs remain underdeveloped. Current studies provide useful starting points, including the exploration of cash-like versus deposit-like CBDC designs within a general equilibrium framework (Chiu and Davoodalhosseini 2023), as well as a CBDC model within the New Keynesian framework to evaluate macroeconomic effects on monetary transmission, deposit dynamics, and central bank operations (Abad et al. 2025). Despite these advances (Mishra and Prasad 2024), further work is still needed to calibrate design features that balance stability with innovation. Second, empirical evidence on the macro-financial effects of CBDCs remains scarce due to data limitations, particularly regarding global financial stability and reserve currency diversification. As pilot programs expand, comprehensive empirical analyzes will become feasible. Third, the existing literature has yet to adequately address how digital currencies affect firm behavior, financial inclusion, and the transmission of monetary policy. Addressing these gaps will help firms adapt to technological change, expand access to financial services, and enable trade-off between innovation and stability within digital financial ecosystem. For policymakers, these findings underscore the urgency of developing regulatory frameworks that support emerging digital currency revolution while safeguarding financial stability and public trust.

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Conflicts of Interest

The authors declare no conflicts of interest.

Endnotes

[1] Source from U.S. Congress. (2025). Guiding and Establishing National Innovation for U.S. Stablecoins Act of 2025, S. 1582, 119th Cong.

[2] Stablecoins are typically categorized into three types: (1) fiat-collateralized stablecoin pegged to traditional currencies (e.g. USDT & USDC); (2) crypto-collateralized stablecoin that are backed by other cryptocurrencies (e.g. DAI); (3) algorithmic collateral-free stablecoin, which maintain price stability through protocol-driven supply adjustments without collateral backing (e.g. UST and AMPL).

[3] Asymmetric encryption algorithm ensures transaction security and anonymity, which can protect users' privacy without exposing any real personal information.

[4] Peer-to-Peer network mechanism enhance the transparency and traceability of digital currency transactions. Transaction and mining information are broadcast to the blockchain network for verification by multiple nodes, and packaged information is stored across the community, making it readily traceable.

[5] Irrevocability is ensured by widely used consensus mechanisms that all nodes in the P2P network maintain the longest legal blockchain, requiring verification by over 51% of nodes.

[6] In blockchain systems, DLT can be public or private, such as Bitcoin's UTXO (unspent transaction output) or Hyperledger Fabric as a private distributed ledger within a consortium.

[7] The two-tier CBDC delivery system design preserves the central bank's role as issuer while allowing financial institutions to distribute CBDC to individuals and nonfinancial entities.

References

Abad, J., G. Nuño, and C. Thomas. 2025. "CBDC and the Operational Framework of Monetary Policy." *Journal of Monetary Economics* 151: 103762.

Adhami, S., G. Giudici, and S. Martinazzi. 2018. "Why Do Businesses Go Crypto? An Empirical Analysis of Initial Coin Offerings." *Journal of Economics and Business* 100: 64–75.

Adrian, T., and T. Mancini-Griffoli. 2021. "The Rise of Digital Money." *Annual Review of Financial Economics* 13, no. 1: 57–77.

Agur, I., A. Ari, and G. Dell'Ariccia. 2022. "Designing Central Bank Digital Currencies." *Journal of Monetary Economics* 125: 62–79.

Ahamed, M. M., K. B. Luintel, and S. K. Mallick. 2023. "Does Local Knowledge Spillover Matter for Firm Productivity? The Role of Financial Access and Corporate Governance." *Research Policy* 52, no. 8: 104837.

Akhtaruzzaman, M., S. Boubaker, D. K. Nguyen, and M. R. Rahman. 2022. "Systemic Risk-Sharing Framework of Cryptocurrencies in the COVID-19 Crisis." *Finance Research Letters* 47: 102787.

Ali, W., S. Bekiros, N. Hussain, S. A. Khan, and D. K. Nguyen. 2024. "Determinants and Consequences of Corporate Social Responsibility Disclosure: A Survey of Extant Literature." *Journal of Economic Surveys* 38, no. 3: 793–822.

Aliano, M., M. Ferrara, and S. Ragni. 2024. "The Dynamics of Crypto Markets and the Fear of Risk Contagion." In *Systemic Risk and Complex Networks in Modern Financial Systems*, edited by V. Pacelli, 323–342. Springer Nature.

Allen, F., X. Gu, and J. Jagtiani. 2022. "Fintech, Cryptocurrencies, and CBDC: Financial Structural Transformation in China." *Journal of International Money and Finance* 124: 102625.

Alora, A., P. Sahoo, and A. Sasidharan. 2024. "Central Bank Digital Currency Adoption Challenges—The Case of an Emerging Nation." *Finance Research Letters* 59: 104756.

Aloun, D. M. 2024. "Commercial Applications of Electronic Currencies." *International Journal of Religion* 5, no. 10: 2126–2137.

Alvarez, F., D. Argente, and D. Van Patten. 2023. "Are Cryptocurrencies Currencies? Bitcoin as Legal Tender in El Salvador." *Science* 382, no. 6677: eadd2844.

Ammous, S. 2018. "Can Cryptocurrencies Fulfil the Functions of Money?" *Quarterly Review of Economics and Finance* 70: 38–51.

Andolfatto, D. 2021. "Assessing the Impact of Central Bank Digital Currency on Private Banks." *Economic Journal* 131, no. 634: 525–540.

Antonakakis, N., I. Chatziantoniou, and D. Gabauer. 2019. "Cryptocurrency Market Contagion: Market Uncertainty, Market Complexity, and Dynamic Portfolios." *Journal of International Financial Markets, Institutions and Money* 61: 37–51.

Aoyagi, J., and Y. Ito. 2025. "Coexisting Exchange Platforms: Limit Order Books and Automated Market Makers." *Journal of Political Economy Microeconomics* 3, no. 3: 611–648.

Appendino, M., O. Bespalova, M. R. Bhattacharya, et al. 2023. *Crypto Assets and CBDCs in Latin America and the Caribbean: Opportunities and Risks*. International Monetary Fund.

Arner, D., R. Auer, and J. Frost. 2020. "Stablecoins: Potential, Risks and Regulation." *BIS Working Paper No. 905*. https://www.bis.org/publ/work905.pdf.

Aspris, A., S. Foley, J. Svec, and L. Wang. 2021. "Decentralized Exchanges: The 'Wild West' of Cryptocurrency Trading." *International Review of Financial Analysis* 77: 101845.

Atlantic Council. 2024. Central Bank Digital Currencies Status. https://cbdctracker.org/.

Auer, R., and R. Böhme. 2021. "Central Bank Digital Currency: The Quest for Minimally Invasive Technology." *BIS Working Paper No. 948*, Bank for International Settlements.

Auer, R., G. Cornelli, and J. Frost. 2023. "Rise of the Central Bank Digital Currencies." *International Journal of Central Banking* 19, no. 4: 185–214.

Auer, R., P. Haene, and H. Holden. 2021. "Multi-CBDC Arrangements and the Future of Cross-Border Payments." *BIS Working Paper No. 115*. Bank for International Settlements.

Aysan, A. F., E. Demir, G. Gozgor, and C. K. M. Lau. 2019. "Effects of the Geopolitical Risks on Bitcoin Returns and Volatility." *Research in International Business and Finance* 47: 511–518.

Back, A. 2002. Hashcash - A Denial of Service Counter-Measure. http://hashcash.org/papers/hashcash.pdf.

Banerjee, A. K., M. Akhtaruzzaman, A. Dionisio, D. Almeida, and A. Sensoy. 2022. "Nonlinear Nexus Between Cryptocurrency Returns and COVID-19 News Sentiment." *Journal of Behavioral and Experimental Finance* 36: 100747.

Banerjee, A. K., S. Das, A. Sensoy, and J. W. Goodell. Forthcoming. "Sustainable ETFs: A Systematic Bibliometric Analysis." *Journal of Economic Surveys*. https://doi.org/10.1111/joes.70017.

Bank for International Settlements, Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors Federal Reserve System, & Federal Reserve System. 2020. Central Bank Digital Currencies: Foundational Principles and Core Features. BIS Working Paper, Report No 1. https://www.bis.org/publ/othp33.pdf.

Bank for International Settlements. 2024. "Project mBridge Reached Minimum Viable Product Stage." BIS Working Paper.

Barbon, A., and A. Ranaldo. 2021. "On the Quality of Cryptocurrency Markets: Centralized Versus Decentralized Exchanges." https://dx.doi.org/10.2139/ssrn.3984897.

Bariviera, A. F., and I. Merediz-Solà. 2021. "Where Do We Stand in Cryptocurrencies Economic Research? A Survey Based on Hybrid Analysis." *Journal of Economic Surveys* 35, no. 2: 377–407.

Baur, D. G., T. Dimpfl, and K. Kuck. 2018. "Bitcoin, Gold and the US Dollar: A Replication and Extension." *Finance Research Letters* 25: 103–110.

Baur, D. G., K. Hong, and A. D. Lee. 2018. "Bitcoin: Medium of Exchange or Speculative Assets?" *Journal of International Financial Markets, Institutions and Money* 54: 177–189.

Bech, M., and R. Garratt. 2017. "Central Bank Cryptocurrencies." *Bank of International Settlements Quarterly Review*, 55–70.

Belchior, R., A. Vasconcelos, S. Guerreiro, and M. Correia. 2021. "A Survey on Blockchain Interoperability: Past, Present, and Future Trends." *ACM Computing Surveys (CSUR)* 54, no. 8: 1–41.

Beneki, C., A. Koulis, N. A. Kyriazis, and S. Papadamou. 2019. "Investigating Volatility Transmission and Hedging Properties Between Bitcoin and Ethereum." *Research in International Business and Finance* 48: 219–227.

Bian, W., Y. Ji, and P. Wang. 2021. "The Crowding-Out Effect of Central Bank Digital Currencies: A Simple and Generalizable Payment Portfolio Model." *Finance Research Letters* 43: 102010.

Bindseil, U. 2020. Tiered CBDC and the Financial System. https://dx.doi.org/10.2139/ssrn.3513422.

Bindseil, U., and R. Senner. 2025. "Modeling Central Bank Digital Currencies." *Journal of Economic Surveys* 39, no. 5: 2088–2105.

Bouri, E., R. Gupta, and D. Roubaud. 2019. "Herding Behaviour in Cryptocurrencies." *Finance Research Letters* 29: 216–221.

Bragoli, D., F. Cortelezzi, and M. Rigon. 2024. "Firms' Innovation and University Cooperation. New Evidence From a Survey of Italian Firms." *Oxford Economic Papers* 76, no. 1: 136–161.

Brauneis, A., and R. Mestel. 2018. "Price Discovery of Cryptocurrencies: Bitcoin and Beyond." *Economics Letters* 165: 58–61.

Brenner, M., P. Pasquariello, and M. Subrahmanyam. 2009. "On the Volatility and Comovement of US Financial Markets Around Macroeconomic News Announcements." *Journal of Financial and Quantitative Analysis* 44, no. 6: 1265–1289.

Brunnermeier, M. K., and D. Niepelt. 2019. "On the Equivalence of Private and Public Money." *Journal of Monetary Economics* 106: 27–41.

Budish, E. 2025. "Trust at Scale: The Economic Limits of Cryptocurrencies and Blockchains." *Quarterly Journal of Economics* 140, no. 1: 1–62.

Buterin, V. 2016. "Chain Interoperability." *R3 Reports*. https://r3.com/wp-content/uploads/2016/09/Chain_Interoperability_R3.pdf.

Capponi, A., and R. Jia. 2021. The Adoption of Blockchain-Based Decentralized Exchanges. https://warwick.ac.uk/fac/soc/wbs/subjects/finance/gillmore/seminar/previous/2021-12-15/capponijia2021.pdf.

Chaim, P., and M. P. Laurini. 2018. "Volatility and Return Jumps in Bitcoin." *Economics Letters* 173: 158–163.

ChainSec. 2023. *A Comprehensive List of Confirmed Cryptocurrency Exit Scams*. https://chainsec.io/exit-scams/.

Chaum, D. 1983. "Blind Signatures for Untraceable Payments." *Advances in Cryptology: Proceedings of Crypto*, edited by D. Chaum, R. L. Rivest, and A. T. Sherman, 82. Springer.

Chen, H., and P. L. Siklos. 2022. "Central Bank Digital Currency: A Review and Some Macro-Financial Implications." *Journal Of Financial Stability* 60: 100985.

Chen, H., and P. L. Siklos. 2023. "Currency Substitution in a World of Looming Retail CBDCs: Suggestive Currency Substitution-Based Evidence." *Journal of International Financial Markets, Institutions and Money* 88: 101828.

Chen, M., Y. Wei, and S. Wang. 2025. "Past and Future of Cryptocurrencies: A Survey Using Bibliometric Methods." *Journal of Economic Surveys*. https://doi.org/10.1111/joes.12700.

Cheung, A., E. Roca, and J.-J. Su. 2015. "Crypto-Currency Bubbles: An Application of the Phillips–Shi–Yu (2013) Methodology on Mt. Gox Bitcoin Prices." *Applied Economics* 47, no. 23: 2348–2358.

Chiu, J., and S. M. Davoodalhosseini. 2023. "Central Bank Digital Currency and Banking: Macroeconomic Benefits of a Cash-Like Design." *Management Science* 69, no. 11: 6708–6730.

Choi, S., B. Kim, Y. S. Kim, and O. Kwon. 2025. "Central Bank Digital Currency and Privacy: A Randomized Survey Experiment." *International Economic Review* 66, no. 2: 823–847.

Christian, B., and H. Henry. 2019. "Proceeding With Caution—A Survey on Central Bank Digital Currency (January 8, 2019)." *BIS Working Papers No*. 101.

Chu, A. C., Y. Furukawa, S. Mallick, P. Peretto, and X. Wang. 2021. "Dynamic Effects of Patent Policy on Innovation and Inequality in a Schumpeterian Economy." *Economic Theory* 71, no. 4: 1429–1465.

Ciaian, P., M. Rajcaniova, and d. A. Kancs. 2016. "The Economics of Bitcoin Price Formation." *Applied Economics* 48, no. 19: 1799–1815.

Claessens, S., L. W. Cong, F. Moshirian, and C.-Y. Park. 2024. "Opportunities and Challenges Associated With the Development of FinTech and Central Bank Digital Currency." *Journal of Financial Stability* 73: 101280.

Cochrane, J. H. 2017. "The New-Keynesian Liquidity Trap." *Journal of Monetary Economics* 92: 47–63.

Committee on Payments and Market Infrastructures. 2015. "Digital Currencies." *BIS Working Paper*.

Committee on Payments and Market Infrastructures. 2018. "Central Bank Digital Currencies." *BIS Working Paper*.

Conti, M., E. S. Kumar, C. Lal, and S. Ruj. 2018. "A Survey on Security and Privacy Issues of Bitcoin." *IEEE Communications Surveys & Tutorials* 20, no. 4: 3416–3452.

Corbet, S., C. Larkin, and B. Lucey. 2020. "The Contagion Effects of the COVID-19 Pandemic: Evidence From Gold and Cryptocurrencies." *Finance Research Letters* 35: 101554.

Corbet, S., C. Larkin, B. M. Lucey, A. Meegan, and L. Yarovaya. 2020. "The Impact of Macroeconomic News on Bitcoin Returns." *European Journal of Finance* 26, no. 14: 1396–1416.

Corbet, S., B. Lucey, A. Urquhart, and L. Yarovaya. 2019. "Cryptocurrencies as a Financial Asset: A Systematic Analysis." *International Review of Financial Analysis* 62: 182–199.

Corbet, S., B. Lucey, and L. Yarovaya. 2018. "Date Stamping the Bitcoin and Ethereum Bubbles." *Finance Research Letters* 26: 81–88.

Corbet, S., A. Meegan, C. Larkin, B. Lucey, and L. Yarovaya. 2018. "Exploring the Dynamic Relationships Between Cryptocurrencies and Other Financial Assets." *Economics Letters* 165: 28–34.

Dai, W. 1998. *b-money*. Santoshi Nakamoto Institute. https://nakamotoinstitute.org/library/b-money/.

Dell'Erba, M. 2019. "Stablecoins in Cryptoeconomics From Initial Coin Offerings to Central Bank Digital Currencies." *New York Journal of Legislation & Public Policy* 22: 1.

Denmark National Bank. 2017. *Central Bank Digital Currency in Denmark?*. https://www.nationalbanken.dk/media/rgqompbp/analysis-central-bank-digital-currency-in-denmark.pdf.

Dierksmeier, C., and P. Seele. 2018. "Cryptocurrencies and Business Ethics." *Journal of Business Ethics* 152: 1–14.

Di Iorio, A., A. Kosse, and I. Mattei. 2024. "Embracing Diversity, Advancing Together-Results of the 2023 BIS Survey on Central Bank Digital Currencies and Crypto." *BIS Working Paper No. 147*.

Dodgson, M., D. Gann, I. Wladawsky-Berger, N. Sultan, and G. George. 2015. "Managing Digital Money." *Academy of Management Journal* 58, no. 2: 325–333.

Douch, M., H. Edwards, and S. Mallick. 2023. "Productivity Debacle in the UK: Do Post-Crisis Firm Cohorts Explain the Performance Puzzle?" *British Journal of Management* 34, no. 3: 1459–1487.

Dyhrberg, A. H. 2016. "Bitcoin, Gold and the Dollar: A GARCH Volatility Analysis." *Finance Research Letters* 16: 85–92.

Bank of England. 2021. "Bank of England Statement on Central Bank Digital Currency." Bank of England Announcement.

https://www.bankofengland.co.uk/news/2021/april/bank-of-england-statement-on-central-bank-digital-currency.

European Central Bank. 2020. Report on A Digital Euro. https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf.

Fama, E. 1965. "The Behavior of Stock-Market Prices." *Journal of Business* 38, no. 1: 34–105.

Feng, W., Y. Wang, and Z. Zhang. 2018a. "Can Cryptocurrencies Be a Safe Haven: A Tail Risk Perspective Analysis." *Applied Economics* 50, no. 44: 4745–4762.

Feng, W., Y. Wang, and Z. Zhang. 2018b. "Informed Trading in the Bitcoin Market." *Finance Research Letters* 26: 63–70.

Fernández-Villaverde, J., D. Sanches, L. Schilling, and H. Uhlig. 2021. "Central Bank Digital Currency: Central Banking for All?" *Review of Economic Dynamics* 41: 225–242.

Fisher, I. 2006. *The Purchasing Power of Money: Its Determination and Relation to Credit Interest and Crises*. Cosimo, Inc.

Foley, S., J. R. Karlsen, and T. J. Putniņš. 2019. "Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed Through Cryptocurrencies?" *Review of Financial Studies* 32, no. 5: 1798–1853.

Fry, J. 2018. "Booms, Busts and Heavy-Tails: The Story of Bitcoin and Cryptocurrency Markets?" *Economics Letters* 171: 225–229.

Fry, J., and E.-T. Cheah. 2016. "Negative Bubbles and Shocks in Cryptocurrency Markets." *International Review of Financial Analysis* 47: 343–352.

Gaies, B., M. S. Nakhli, J. M. Sahut, and K. Guesmi. 2021. "Is Bitcoin Rooted in Confidence? Unraveling the Determinants of Globalized Digital Currencies." *Technological Forecasting and Social Change* 172: 121038.

Garzik, J., and J. C. Donnelly. 2018. "Blockchain 101: An Introduction to the Future." In *Handbook of Blockchain, Digital Finance, and Inclusion*, Vol. 2, edited by D. L. K. Chuen and R. Deng, 179–186. Elsevier.

Georgieva, K. 2022. "The Future of Money: Gearing up for Central Bank Digital Currency." *IMF Speech*. https://www.imf.org/en/news/articles/2022/02/09/sp020922-the-future-of-money-gearing-up-for-central-bank-digital-currency.

Ghasseminejad, S., and M. R. Jahan-Parvar. 2021. "The Impact of Financial Sanctions: The Case of Iran." *Journal of Policy Modeling* 43, no. 3: 601–621.

Giudici, P., and I. Abu-Hashish. 2019. "What Determines Bitcoin Exchange Prices? A Network VAR Approach." *Finance Research Letters* 28: 309–318.

Griffin, J. M., and A. Shams. 2020. "Is Bitcoin Really Untethered?" *Journal of Finance* 75, no. 4: 1913–1964.

Grinberg, R. 2012. "Bitcoin: An Innovative Alternative Digital Currency." *Hastings Science & Technology Law Journal* 4: 160.

Guesmi, K., S. Saadi, I. Abid, and Z. Ftiti. 2018. "Portfolio Diversification With Virtual Currency: Evidence From Bitcoin." *International Review of Financial Analysis* 63: 431–437.

Hayek, F. A. 1978. *Denationalisation of Money—The Argument Refined: An Analysis of the Theory and Practice of Concurrent Currencies*, 2nd ed. Institute of Economic Affairs.

Haykir, O., and I. Yagli. 2022. "Speculative Bubbles and Herding in Cryptocurrencies." *Financial Innovation* 8, no. 1: 78.

Hoang, L. T., and D. G. Baur. 2024. "How Stable Are Stablecoins?" *The European Journal of Finance* 30, no. 16: 1984–2000.

Hong Kong Financial Development Council. 2021. *Recent Development of Central Bank's Digital Currency*. Financial Services Development Council.

Hoque, M. E., M. Billah, M. R. Alam, and B. Lucey. 2024. "Does News Related to Digital Economy and Central Bank Digital Currency Affect Digital Economy ETFs? Evidence From TVP-VAR Connectedness and Wavelet Local Multiple Correlation Analyses." *Global Finance Journal* 30: 100992.

Houben, R., and A. Snyers. 2018. *Cryptocurrencies and Blockchain: Legal Context and Implications for Financial Crime, Money Laundering and Tax Evasion*. European Parliament.

Howell, S. T., M. Niessner, and D. Yermack. 2020. "Initial Coin Offerings: Financing Growth With Cryptocurrency Token Sales." *Review of Financial Studies* 33, no. 9: 3925–3974.

Hui, C.-H., C.-F. Lo, P.-H. Chau, and A. Wong. 2020. "Does Bitcoin Behave as a Currency? A Standard Monetary Model Approach." *International Review of Financial Analysis* 70: 101518.

Hull, I., and O. Sattath. 2024. "The Properties of Contemporary Money." *Journal of Economic Surveys* 38, no. 4: 1132–1155.

Ibrahim, B. A., A. A. Elamer, T. H. Alasker, M. A. Mohamed, and H. A. Abdou. 2024. "Volatility Contagion between Cryptocurrencies, Gold and Stock Markets Pre- and During COVID-19: Evidence Using DCC-GARCH and Cascade-Correlation Network." *Financial Innovation* 10, no. 1: 1–28.

Jabbar, A., A. Geebren, Z. Hussain, S. Dani, and S. Ul-Durar. 2023. "Investigating Individual Privacy Within CBDC: A Privacy Calculus Perspective." *Research in International Business and Finance* 64: 101826.

Ji, Q., E. Bouri, C. K. M. Lau, and D. Roubaud. 2019. "Dynamic Connectedness and Integration in Cryptocurrency Markets." *International Review of Financial Analysis* 63: 257–272.

Jiang, Y., H. Nie, and W. Ruan. 2017. "Time-Varying Long-Term Memory in Bitcoin Market." *Finance Research Letters* 25: 280–284.

John, B., and M. Kumhof. 2016. "The Macroeconomics of central Bank Issued Digital Currencies." Bank of England Working Paper. No. 605. https://www.bankofengland.co.uk/working-paper/2016/the-macroeconomics-of-central-bank-issued-digital-currencies.

Jones, H. 2024. "Crypto Trading Concentration A 'Considerable Concern', EU Watchdog Says." *Reuters*, April 11. https://www.reuters.com/markets/currencies/crypto-trading-concentration-considerable-concern-says-eu-watchdog-2024-04-10/.

Karame, G. O., E. Androulaki, and S. Capkun. 2012. "Double-Spending Fast Payments in Bitcoin." *Proceedings of the 2012 ACM Conference on Computer and Communications Security*. Raleigh, NC, United States, 2012.

Karim, S., B. M. Lucey, M. A. Naeem, and G. S. Uddin. 2022. "Examining the Interrelatedness of NFTs, DeFi Tokens and Cryptocurrencies." *Finance Research Letters* 47: 102696.

Katsiampa, P. 2017. "Volatility Estimation for Bitcoin: A Comparison of GARCH Models." *Economics Letters* 158: 3–6.

Katsiampa, P., S. Corbet, and B. Lucey. 2019. "Volatility Spillover Effects in Leading Cryptocurrencies: A BEKK-MGARCH Analysis." *Finance Research Letters* 29: 68–74.

Keister, T., and D. Sanches. 2023. "Should Central Banks Issue Digital Currency?" *Review of Economic Studies* 90, no. 1: 404–431.

Keynes, J. M. 1937. "The General Theory of Employment." *The Quarterly Journal of Economics* 51, no. 2: 209–223.

Khiaonarong, T., and D. Humphrey. 2019. "Cash Use Across Countries and the Demand for Central Bank Digital Currency." *IMF Working Paper No. 2019/046*.

Kim, Y. S., and O. Kwon. 2023. "Central Bank Digital Currency, Credit Supply, and Financial Stability." *Journal of Money, Credit and Banking* 55, no. 1: 297–321.

Kosse, A., and I. Mattei. 2022. Gaining momentum—Results of the 2021 BIS survey on central bank digital currencies. BIS Working Paper. No. 125. https://www.bis.org/publ/bppdf/bispap125.htm.

Kräussl, R., and A. Tugnetti. 2024. "Non-fungible Tokens (NFTs): A Review of Pricing Determinants, Applications and Opportunities." *Journal of Economic Surveys* 38, no. 2: 555–574.

Kreltszheim, D. 1999. "Identifying the Proceeds of Electronic Money Fraud." *Information Management & Computer Security* 7, no. 5: 223–231.

Kshetri, N. 2021. "Blockchain and Sustainable Supply Chain Management in Developing Countries." *International Journal of Information Management* 60: 102376.

Kyriazis, N., and S. Corbet. 2025. "Understanding the Connectedness Between US Traditional Assets and Green Cryptocurrencies During Crises." *North American Journal of Economics and Finance* 80: 102474.

Kyriazis, N. A. 2020. "Is Bitcoin Similar to Gold? An Integrated Overview of Empirical Findings." *Journal of Risk and Financial Management* 13, no. 5: 88.

Kyriazis, N. A., S. Papadamou, and P. Tzeremes. 2023. "Are Benchmark Stock Indices, Precious Metals or Cryptocurrencies Efficient Hedges Against Crises?" *Economic Modelling* 128: 106502.

Lamothe-Fernández, P., D. Alaminos, P. Lamothe-López, and M. A. Fernández-Gámez. 2020. "Deep Learning Methods for Modeling Bitcoin Price." *Mathematics* 8, no. 8: 1245.

Lee, A., B. Malone, and P. Wong. 2020. "Tokens and Accounts in the Context of Digital Currencies." FEDS Notes No. 2020-12-23.

Lehar, A., and C. Parlour. 2025. "Decentralized Exchange: The Uniswap Automated Market Maker." *The Journal of Finance* 80, no. 1: 321–374.

Leonardos, S., D. Reijsbergen, and G. Piliouras. 2020. "Presto: A Systematic Framework for Blockchain Consensus Protocols." *IEEE Transactions on Engineering Management* 67, no. 4: 1028–1044.

Liu, M., G. Li, J. Li, X. Zhu, and Y. Yao. 2021. "Forecasting the Price of Bitcoin Using Deep Learning." *Finance Research Letters* 40: 101755.

Liu, Y., and A. Tsyvinski. 2021. "Risks and Returns of Cryptocurrency." *The Review of Financial Studies* 34, no. 6: 2689–2727.

Lukonga, I. 2023. "Monetary Policy Implications of Central Bank Digital Currencies." *IMF Working Paper No. 2023/060*.

Lyons, R. K., and G. Viswanath-Natraj. 2023. "What Keeps Stablecoins Stable?" *Journal of International Money and Finance* 131: 102777.

Makarov, I., and A. Schoar. 2020. "Trading and Arbitrage in Cryptocurrency Markets." *Journal of Financial Economics* 135, no. 2: 293–319.

Makarov, I., and A. Schoar. 2022. "Cryptocurrencies and Decentralized Finance (DeFi)." *Brookings Papers on Economic Activity* 2022, no. 1: 141–215.

Mariana, C. D., I. A. Ekaputra, and Z. A. Husodo. 2021. "Are Bitcoin and Ethereum Safe-Havens for Stocks during the COVID-19 Pandemic?" *Finance Research Letters* 38: 101798.

Marple, T. 2021. "Bigger Than Bitcoin: A Theoretical Typology and Research Agenda for Digital Currencies." *Business and Politics* 23, no. 4: 439–455.

Mises, L. 2007. *The Historical Setting of the Austrian School of Economics*. Ludwig von Mises Institute.

Mishra, B., and E. Prasad. 2024. "A Simple Model of a Central Bank Digital Currency." *Journal of Financial Stability* 101282.

Monetary Authority of Singapore. 2017. Project Ubin Phase 2. https://www.mas.gov.sg/-/media/mas/projectubin/project-ubin-phase-2-reimagining-rtgs.pdf.

Morgan, J. 2022. "Systemic Stablecoin and the Defensive Case for Central Bank Digital Currency: A Critique of the Bank of England's Framing." *Research in International Business and Finance* 62: 101716.

Morris, L. 2015. *Anonymity Analysis of Cryptocurrencies*. Rochester Institute of Technology.

Mosca, M. 2018. "Cybersecurity in an Era With Quantum Computers: Will We Be Ready?" *IEEE Security & Privacy* 16, no. 5: 38–41.

Mu, C. 2020. "Complying With the Technological Evolution and Economic Development Trend: Actively Promote the Legal Digital Currency Dominated by China." *Journal of Qizhi* 11: 65–66.

Mundell, R. A. 1961. "A Theory of Optimum Currency Areas." *American Economic Review* 51, no. 4: 657–665.

Nadarajah, S., and J. Chu. 2017. "On the Inefficiency of Bitcoin." *Economics Letters* 150: 6–9.

Narayanan, A., J. Bonneau, E. Felten, A. Miller, and S. Goldfeder. 2016. *Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction*. Princeton University Press.

Ngo, V. M., P. Van Nguyen, H. H. Nguyen, H. X. T. Tram, and L. C. Hoang. 2023. "Governance and Monetary Policy Impacts on Public Acceptance of CBDC Adoption." *Research in International Business and Finance* 64: 101865.

Norges Bank. 2018. "Central Bank Digital Currencies." *Norges Bank Papers. No.1*.

Norges Bank. 2019. "Central Bank Digital Currencies." *Norges Bank Papers, No.2*.

Ozili, P. K. 2018. "Impact of Digital Finance on Financial Inclusion and Stability." *Borsa Istanbul Review* 18, no. 4: 329–340.

Ozili, P. K. 2023. "CBDC, Fintech and Cryptocurrency for Financial Inclusion and Financial Stability." *Digital Policy, Regulation and Governance* 25, no. 1: 40–57.

Papadamou, S., N. A. Kyriazis, P. Tzeremes, and S. Corbet. 2021. "Herding Behaviour and Price Convergence Clubs in Cryptocurrencies During Bull and Bear Markets." *Journal of Behavioral and Experimental Finance* 30: 100469.

Park, A. 2023. "The Conceptual Flaws of Decentralized Automated Market Making." *Management Science* 69, no. 11: 6731–6751.

Peng, S., C. Prentice, S. Shams, and T. Sarker. 2023. "A Systematic Literature Review on the Determinants of Cryptocurrency Pricing." *China Accounting and Finance Review* 26, no. 1: 1–30.

Pennings, S., A. Ramayandi, and H. C. Tang. 2015. "The Impact of Monetary Policy on Financial Markets in Small Open Economies: More or Less Effective During the Global Financial Crisis?" *Journal of Macroeconomics* 44: 60–70.

Raskin, M., and D. Yermack. 2018. "Digital Currencies, Decentralized Ledgers and the Future of Central Banking." In *Research Handbook on Central Banking*, edited by P. Conti-Brown and R. M. Lastra, 474–486. Edward Elgar Publishing.

Rehman, M. A., M. Irfan, M. A. Naeem, B. M. Lucey, and S. Karim. 2023. "Macro-Financial Implications of Central Bank Digital Currencies." *Research in International Business and Finance* 64: 101892.

Rogoff, K. 2016. *The Curse of Cash: How Large-Denomination Bills Aid Crime and Tax Evasion and Constrain Monetary Policy*, 1st ed. Princeton University Press.

Schnaubelt, M., J. Rende, and C. Krauss. 2019. "Testing Stylized Facts of Bitcoin Limit Order Books." *Journal of Risk and Financial Management* 12, no. 1: 25.

Selgin, G. 2015. "Synthetic Commodity Money." *Journal of Financial Stability* 17: 92–99.

Shahzad, S. J. H., E. Bouri, D. Roubaud, L. Kristoufek, and B. Lucey. 2019. "Is Bitcoin a Better Safe-Haven Investment Than Gold and Commodities?" *International Review of Financial Analysis* 63: 322–330.

Shestak, V., A. Kiseleva, and Y. Kolesnikov. 2021. "Taxation Issues for Digital Financial Assets." *Social Science Computer Review* 08944393211003919. https://doi.org/10.1177/08944393211003919.

Soana, G., and T. de Arruda. 2024. "Central Bank Digital Currencies and Financial Integrity: Finding a New Trade-off between Privacy and Traceability Within a Changing Financial Architecture." *Journal of Banking Regulation* 25, no. 4: 467–486.

Sovbetov, Y. 2018. "Factors Influencing Cryptocurrency Prices Evidence From Bitcoin, Ethereum, Dash, Litcoin, and Monero." *Journal of Economics and Financial Analysis* 2, no. 2: 1–27.

Stempel, J. 2024. "FTX Auditor Settles US SEC Negligence Case, Pays Fine." *Reuters*, September 18. https://www.reuters.com/business/finance/ftx-auditor-settles-us-sec-negligence-case-pays-fine-2024-09-17/.

Su, C.-W., M. Qin, R. Tao, X.-F. Shao, L. L. Albu, and M. Umar. 2020. "Can Bitcoin Hedge the Risks of Geopolitical Events?" *Technological Forecasting and Social Change* 159: 120182.

Sun, X., M. Liu, and Z. Sima. 2020. "A Novel Cryptocurrency Price Trend Forecasting Model Based on LightGBM." *Finance Research Letters* 32: 101084.

Sveriges Riksbank. 2020. The Riksbank's e-krona pilot. Sveriges Riksbank Report. Reg.No 2019-0029. https://www.riksbank.se/globalassets/media/rapporter/e-krona/2019/the-riksbankse-krona-pilot.pdf.

Sveriges Riksbank. 2023. E-krona Pilot Phase 3.Sveriges Riksbank Report. https://www.riksbank.se/globalassets/media/rapporter/e-krona/2023/e-krona-pilot-phase-3.pdf.

Szabo, N. 2005. *Bit Gold*, 251–260. Satoshi Nakamoto Institute. https://nakamotoinstitute.org/bit-gold/TVerpágina.

Tercero-Lucas, D. 2023. "Central Bank Digital Currencies and Financial Stability in a Modern Monetary System." *Journal of Financial Stability* 69: 101188.

Tidy, J., and T. Singleton. 2025. "Crypto Sleuths Join Hunt for $1.5bn Stolen in Biggest Ever Heist." *BBC News*, February 26. https://www.bbc.com/news/articles/ckgdy5e3neko.

Tronnier, F., D. Harborth, and P. Hamm. 2022. "Investigating Privacy Concerns and Trust in the Digital Euro in Germany." *Electronic Commerce Research and Applications* 53: 101158.

Tronnier, F., and W. Qiu. 2024. "How Do Privacy Concerns Impact Actual Adoption of Central Bank Digital Currency? An Investigation Using the E-CNY in China." *Quantitative Finance and Economics* 8, no. 1: 126–152.

Umar, Z., and M. Gubareva. 2020. "A Time–Frequency Analysis of the Impact of the Covid-19 Induced Panic on the Volatility of Currency and Cryptocurrency Markets." *Journal of Behavioral and Experimental Finance* 28: 100404.

Urquhart, A. 2016. "The Inefficiency of Bitcoin." *Economics Letters* 148: 80–82.

van der Linden, T., and T. Shirazi. 2023. "Markets in Crypto-Assets Regulation: Does It Provide Legal Certainty and Increase Adoption of Crypto-Assets?" *Financial Innovation* 9, no. 1: 22.

Vidal-Tomása, D., and A. Ibañez. 2018. "Semi-Strong Efficiency of Bitcoin." *Finance Research Letters* 27: 259–265.

Wang, Z. 2023. "Money Laundering and the Privacy Design of Central Bank Digital Currency." *Review of Economic Dynamics* 51: 604–632.

Wilkins, C. A. 2022. "Discussion of "Designing Central Bank Digital Currency" by Agur, Ari and Dell'Ariccia." *Journal of Monetary Economics* 125: 80–84.

Wong, M. C. S., E. K. H. Chan, and I. Yousaf. 2025. "CBDCs, Regulated Stablecoins and Tokenized Traditional Assets Under the Basel Committee Rules on Cryptoassets." *Journal of Financial Regulation and Compliance* 33, no. 1: 31–47.

Wong, P., and J. L. Maniff. 2020. "Comparing Means of Payment: What Role for A Central Bank Digital Currency?" *FEDS Notes*, 08–13.

Wu, B., and M. Zhang. 2024. "The Impact of Central Bank Digital Currency on Monetary Policy Effectiveness." *Economic Change and Restructuring* 57, no. 3: 135.

Yaga, D., P. Mell, N. Roby, and K. Scarfone. 2019. Blockchain Technology Overview. *arXiv preprint arXiv:1906.11078*.

Yermack, D. 2024. "Is Bitcoin a Real Currency? An Economic Appraisal." In *Handbook of Digital Currency*, 29–40. Elsevier.

Yousaf, I., R. Nekhili, and M. Gubareva. 2022. "Linkages between DeFi Assets and Conventional Currencies: Evidence From the COVID-19 Pandemic." *International Review of Financial Analysis* 81: 102082.

Zhang, W., P. Wang, X. Li, and D. Shen. 2018. "Some Stylized Facts of the Cryptocurrency Market." *Applied Economics* 50, no. 55: 5950–5965.

Zhao, Y., J. W. Goodell, and D. Shen. 2024. "Spillover Effects According to Classification of Cryptocurrency." *Finance Research Letters* 65: 105629.

Appendix A

TABLE A1 | Representative cryptocurrencies worldwide

Items	BTC	ETH	EOS	USDC
Time of Block	10 minutes	15 seconds	3 seconds	Not available
Money supply	21 million	72 + 18.72 million per year	1 billion	Stablecoin pegged dollar
Distributed Consensus	POW	Aiming from POW to POS	DPOS	POW
Ledger	Transaction-based Ledger	Account-based Ledger	—	—
Data Structure	Merkle Tree	Merkle Patricia Tree	—	—
Blockchain Type	Public Blockchain	Public Blockchain	Public Blockchain	Private Blockchain
Technical framework	Decentralized	Decentralized	Semi- Decentralized	Semi- Decentralized
Cost of Use	Service fee 0.001 BTC	Gas fee 0.005 ETH	Free	Almost free
Payment Scenario	Few	Smart Contract	Operating System	Cross Border Transfer
Execution Time	60 Minutes	6 Minutes	Near-instant	Near-instant

This table summarizes the key technological and operational characteristics of representative cryptocurrencies, including Bitcoin (BTC), Ethereum (ETH), EOS, and USDC. The following concepts define the principal consensus mechanisms and data structures underpinning major cryptocurrency systems:Proof of Work (POW): A mechanism relying on computational power for mining, where miners with greater resources are more likely to mine blocks.
Proof of Stake (POS): A mechanism that uses the amount of cryptocurrency held for voting and mining, akin to shareholder voting in companies.
Delegated Proof of Stake (DPOS): A consensus algorithm for consortium blockchains where nodes vote to select super nodes responsible for block generation.
Merkle Tree: A data structure used to securely verify the integrity of large sets of data. It is a tree in which every leaf node is a hash of a data block, and every non-leaf node is a hash of its child nodes, enabling quick verification of data integrity.
Merkle Patricia Tree: A modified version of the Merkle tree. It is used in ETH to store key-value pairs, providing a compact and efficient way to represent and validate the state of the blockchain.

Appendix B

TABLE B1 | Comparative performance of major digital currency types

Evaluation Dimension	Bitcoin & Altcoins	Stablecoins	CBDCs
Store of Value	Yes	Yes, pegged to certain assets	Yes, backed by sovereign credit
Volatility Resistance	High	Relatively low due to asset backing	Low
User Base	Limited	Limited but gradually expanding	Large
Payment Scenarios	Limited real-world usage	Mainly used in cross-border settlements	Extensive
Regulatory Clarity	Regulatory uncertainty in many jurisdictions	Emerging legislation in some countries	Legal framework under governance

This table presents a comparative overview of three major categories of digital currencies—cryptocurrencies, stablecoins, and CBDCs—across key functional dimensions. It highlights how their value stability, usability, and regulatory clarity differ due to their underlying design and institutional backing. Cryptocurrencies such as Bitcoin and altcoins are known for their decentralized architecture and speculative appeal but suffer from extreme price volatility and limited practical payment use for everyday transactions (Ammous 2018). Stablecoins, pegged to fiat or commodities, aim to mitigate price instability and are increasingly used in cross-border settlements (Arner et al. 2020). However, stablecoins remain vulnerable to regulatory uncertainty and systemic risks (Dell'Erba 2019; Morgan 2022). In contrast, CBDCs demonstrate significantly greater resistance to volatility, as their value is directly backed by central banks and pegged to legal tender (Bindseil 2020). CBDCs also offer superior functionality within payment systems, enabling faster, more secure, and programmable transactions with lower costs, benefiting both domestic and cross-border financial infrastructures (Wong et al. 2025). Designed for widespread public adoption, CBDCs are better suited to diverse payment scenarios and support a broader user base.