

Cryptocurrency Ecosystem: A Comprehensive Review of Market Dynamics, Adoption, Regulatory Framework, Security and Sustainability

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ABSTRACT: Cryptocurrencies have developed from a peer-to-peer electronic cash proposal into a heterogeneous ecosystem of volatile investment assets, programmable settlement networks, stable coins, decentralised finance (DeFi), tokenised claims and governance experiments. This review integrates research on market efficiency and price formation, portfolio diversification and financial spillovers, user adoption, regulation and illicit finance, protocol security, and environmental sustainability. Rather than treating cryptocurrency as a single asset class, it distinguishes protocol design, market infrastructure, token economics and institutional context as interacting layers. The literature indicates that cryptocurrency returns exhibit time-varying volatility, heavy tails, structural breaks and episodic dependence with conventional markets; diversification benefits are conditional on horizon, market regime and the chosen asset. Adoption is shaped not only by perceived usefulness and ease of use but also by trust, perceived risk, financial literacy, network effects and the credibility of legal and custodial arrangements. Decentralisation can reduce dependence on a single intermediary, yet does not eliminate concentration in mining or staking, stablecoin reserves, exchange custody, governance, or software dependencies. Regulation therefore faces a calibration problem: protecting users and financial integrity without assuming that all crypto-assets perform the same economic

function. Environmental impacts vary substantially by consensus mechanism and electricity mix, making blanket claims about all cryptocurrencies analytically weak. A transparent quantitative synthesis protocol is proposed, including study coding, effect-size harmonisation, heterogeneity assessment and robustness checks. Since a verified study-level extraction dataset was not provided, numerical claims are limited to explicitly identify descriptive evidence-map scores rather than pooled effect estimates. The review concludes with a research agenda centered on causal identification, cross-jurisdictional regulatory evaluation, on-chain/off-chain measurement, stablecoin stress transmission, cybersecurity externalities and credible sustainability accounting.

Keywords: *cryptocurrency; Bitcoin; Ethereum; market efficiency; volatility; adoption; regulation; DeFi; stablecoins; cybersecurity; sustainability; systematic review.*

1. Introduction

Cryptocurrency research sits at the intersection of finance, computer science, economics, law, information systems and environmental studies. Bitcoin's original design combined a peer-to-peer transaction system with a public ledger and a proof-of-work consensus mechanism (Nakamoto, 2008). Subsequent networks introduced alternative consensus rules, programmable execution, token issuance and applications that extend beyond payment. As a result, the label cryptocurrency covers instruments with materially different functions: native protocol assets, governance tokens, utility tokens, asset-referenced tokens, fiat-backed stablecoins and tokens representing claims on off-chain assets. Treating them as homogeneous obscures both the mechanisms that generate risk and the policy tools that can address it.

The field has grown alongside episodes of rapid appreciation, crashes, exchange failures, protocol exploits, stablecoin stress and changing regulatory approaches. Academic attention has followed market development, but the evidence base remains fragmented. Financial studies often estimate return predictability or hedge properties; technology studies focus on consensus, cryptographic integrity and throughput; adoption studies use behavioural frameworks; legal scholarship analyses classification and compliance; environmental work estimates electricity use and emissions. Each strand has its own unit of

analysis and assumptions. A review that merely lists findings risks overlooking conflicts caused by different samples, time windows, market regimes and operational definitions.

This paper therefore adopts an integrative perspective. It asks: (1) what does the literature establish about cryptocurrency price formation, volatility and market integration? (2) Under what conditions can crypto-assets diversify portfolios or transmit risk? (3) Which factors shape user and organisational adoption? (4) How do protocol design, custody and regulation redistribute rather than simply remove risk? (5) What is the principal environmental trade-offs? and (6) how can future reviews make statistical synthesis more reproducible?

The contribution is threefold. First, it separates technological properties from market outcomes: a decentralized ledger does not automatically create a liquid, fair or stable market. Second, it synthesizes findings across financial, behavioural, regulatory and sustainability research using a common risk-and-governance lens. Third, it provides a transparent quantitative protocol and visual framework suitable for conversion into a fully reproducible systematic review once a Scopus export and study-level dataset are assembled.

The manuscript is written to support development toward a strong peer-reviewed review article. Quartile status is a journal-level classification that changes by database category and year; it is not a manuscript certification. A Q1-targeted submission requires an original contribution, transparent methods, current references, appropriate journal fit, and accurate reporting of searches and statistics. This draft should be treated as a research manuscript in progress, not as a guarantee of Scopus Q1 publication.

2. Literature Review: Thematic Synthesis of Prior Research

2.1 Foundations of cryptocurrency and blockchain research

The foundational literature frames cryptocurrency as both a monetary experiment and a socio-technical system. Nakamoto's (2008) Bitcoin proposal established a peer-to-peer transaction architecture in which consensus and incentives support a public ledger without a conventional central settlement intermediary. Subsequent work broadened the discussion from digital cash to programmable platforms, token-based coordination and governance. Research on blockchain and trust argues that distributed ledgers can redistribute

verification and control, but they do not eliminate the need to analyse institutional rules, legal rights, software dependencies or the organisations that operate interfaces and custody services (Werbach, 2018; De Filippi & Wright, 2018). This foundational strand is primarily conceptual and technical; its claims should not be mistaken for proof that every blockchain application outperforms a conventional database or intermediary.

2.2 Market efficiency, price discovery and volatility

A substantial financial literature tests whether cryptocurrency returns exhibit predictable patterns and whether trading venues rapidly incorporate information. Early studies explored weak-form efficiency and return dynamics, while later work considered changing market regimes, fragmented liquidity, transaction costs and the growth of derivatives. The results are not uniform: apparent predictability depends on asset selection, sampling frequency, exchange quality, time period and whether strategies are evaluated out of sample after fees and slippage. Research on volatility likewise documents heavy tails, volatility clustering and structural change, but differs in its definitions of realised, implied and conditional volatility. Ahmed et al. (2024), in a review of volatility research, illustrates the breadth of methods and explanatory variables used in this area. Taken together, the literature favours conditional conclusions rather than a single verdict that crypto markets are either efficient or inefficient.

2.3 Portfolio diversification, hedging and connectedness

Another major stream evaluates Bitcoin and other crypto-assets as diversifiers, hedges or safe havens. Studies have reported periods of low unconditional correlation with conventional assets, suggesting possible diversification benefits (Dyhrberg, 2016; Bouri et al., 2017; Corbet et al., 2018). However, these concepts are distinct: a diversifier may have low average correlation, a hedge may be uncorrelated or negatively correlated on average, and a safe haven must preserve those properties during market stress. Dynamic correlation and spillover studies show that relationships vary over time and across crises. Portfolio conclusions are therefore sensitive to benchmark choice, rebalancing, downside-risk metric, transaction costs and the crisis window. Correlation and connectedness measures describe dependence but do not, on their own, establish causal contagion.

2.4 Adoption, payment use and behavioural explanations

Adoption research draws on technology acceptance, diffusion, trust and perceived-risk frameworks. Perceived usefulness, ease of use, social influence, facilitating conditions and trust commonly appear as correlates of intention to use digital financial technologies. Cryptocurrency adds distinctive barriers, including price instability, irreversible transfers, key management, scams, regulatory uncertainty and limited recourse. A recurring limitation is the use of cross-sectional self-reported intention as a proxy for sustained behaviour. Ownership is also not equivalent to payment use: users may hold tokens for investment while rarely making purchases, and stablecoins may be used for transfers without exposure to a volatile native asset. Stronger evidence would combine surveys with longitudinal behaviour, merchant acceptance, transaction-level data and context-specific measures of affordability and user protection.

2.5 Regulation, governance, security and consumer protection

Legal and institutional scholarship examines how crypto-assets fit within securities, commodities, payments, tax, anti-money-laundering and consumer-protection regimes. Because tokens differ in economic function and legal rights, classification by label alone can obscure the activity and risk that regulation is intended to address. Governance research also highlights that technical decentralisation does not guarantee decentralised control: mining or staking concentration, exchange custody, stablecoin reserve arrangements, administrator keys and software dependencies can create points of influence or failure. Security studies consequently need to consider both protocol-level vulnerabilities and failures in exchanges, wallets, bridges and operational controls. Policy effectiveness is best assessed against observable outcomes—losses, resilience, market concentration, entry, compliance and access—rather than statutory text alone.

2.6 Stablecoins, decentralised finance and systemic links

The growth of stablecoins and decentralised finance has shifted attention from token prices alone to collateral, redemption, liquidity and interconnection. Stablecoins vary in reserve assets, governance, redemption arrangements and the reliability of their target peg; a secondary-market price near par does not necessarily demonstrate that all holders can redeem at par during stress. DeFi protocols can compose lending, trading and collateral

functions through smart contracts, creating efficiencies but also liquidation cascades, oracle dependencies, bridge exposure and governance risks. This literature suggests that analysis should follow exposures across issuers, custodians, exchanges, protocols and conventional financial institutions. Yet evidence is often difficult to compare because studies use different definitions of total value locked, activity, insolvency, liquidity and stress events.

2.7 Environmental sustainability and consensus design

Environmental research focuses particularly on proof-of-work mining, electricity demand, emissions and electronic waste. Estimates depend on assumptions about hardware efficiency, miner geography, electricity mix, network activity and equipment lifetimes. Studies such as Stoll et al. (2019), Köhler and Pizzol (2019), and de Vries and Stoll (2021) illustrate the importance of transparent system boundaries and the inclusion of e-waste as well as electricity. Proof-of-stake changes the energy profile by avoiding competitive hashing, although it introduces different governance and concentration questions. A fair comparison should assess the service delivered, the full life cycle and local grid effects; simplistic per-transaction comparisons can be misleading because consensus energy does not scale linearly with transaction count.

2.8 Synthesis, limitations in prior work and contribution of this review

Across these streams, four recurring limitations emerge. First, findings are sensitive to asset definitions, time windows, market regimes and outcome measures. Second, many predictive claims rely on in-sample performance without sufficient attention to multiple testing, execution costs or model drift. Third, proxies such as active addresses, trading volume and total value locked may not map cleanly to users or economic activity. Fourth, technical, financial, legal and environmental evidence is frequently reviewed in disciplinary silos, even though risks migrate across layers. This review addresses these limitations through an integrative taxonomy and a cross-theme synthesis of 84 cited sources, while distinguishing established qualitative patterns from analyses that require a verified study-level dataset. It does not present an unverified pooled effect estimate or claim that a systematic Scopus search has already been completed.

3. Scope and review method

3.1 Review design

An integrative critical review is appropriate where evidence spans observational financial datasets, experiments, surveys, technical analyses, legal comparisons and energy models. The review organises the literature thematically rather than claiming that heterogeneous studies estimate one common causal effect. PRISMA 2020 offers a useful reporting framework for systematic searches and selection decisions (Page et al., 2021), while bibliometric mapping can identify publication structures and keyword clusters when metadata are available (Aria & Cuccurullo, 2017; Donthu et al., 2021). These are complementary tasks: bibliometrics describes the corpus, content synthesis interprets claims, and meta-analysis pools sufficiently comparable quantitative estimates.

The current manuscript uses a curated reference base of 84 scholarly and foundational sources spanning cryptocurrency market behaviour, blockchain design, adoption, regulation, security, environmental impacts and review methodology. This is not equivalent to a reproducible Scopus query. No database export or independent screening records were supplied; accordingly, the paper does not invent records identified, duplicates removed, full texts excluded, inter-rater reliability, citation counts or publication-year frequencies. The final reference list is a starting corpus for verification and expansion.

3.2 Search protocol for a submission-ready update

A reproducible Scopus search should be run across title, abstract and keywords. A broad template is TITLE-ABS-KEY (cryptocurrenc* OR bitcoin OR ethereum OR stablecoin* OR crypto-asset* OR decentralised finance OR decentralized finance OR blockchain) AND TITLE-ABS-KEY (market* OR volatility OR adoption OR regulation OR security OR energy OR sustainability OR payment* OR spillover*). The query should be adapted to the review questions rather than applied mechanically: including every blockchain application may retrieve papers with no substantive cryptocurrency analysis, while a narrow Bitcoin-only query will miss stablecoins and DeFi.

Recommended eligibility criteria are: (i) peer-reviewed journal articles and selected seminal conference papers; (ii) English-language publications, if language restriction is

justified; (iii) substantive focus on crypto-assets, cryptocurrency markets or their direct institutional and environmental effects; and (iv) sufficient methods and findings to permit appraisal. Exclude generic blockchain papers with no cryptocurrency relevance, opinion pieces without transparent argumentation, duplicate records and non-scholarly promotional material. Report database, exact query, date, filters, records exported, deduplication method, title/abstract screening, full-text exclusions with reasons, and final included count.

3.3 Quantitative analysis plan

For a full statistical review, each study should be coded for publication year, country or market, asset(s), observation period, frequency, sample size, method, outcome, effect estimate, standard error or confidence interval, data source, market regime and risk-of-bias indicators. A study—not each regression coefficient—should be the unit of counting to avoid overweighting papers that report many specifications. Where estimates are comparable, convert them to a common effect size, such as Fisher-z transformed correlations, log response ratios, standardized mean differences or log variance ratios. Use random-effects models when genuine between-study variation is expected; report τ^2 , I^2 and prediction intervals, not only a pooled mean. Cluster standard errors by study when multiple estimates per paper are included.

Publication-bias checks such as funnel plots and Egger-type tests should be used only when the number and comparability of studies make them meaningful. Robustness analyses should vary the inclusion rules, sample period, market regime, asset definition and estimator. For predictive studies, out-of-sample performance and transaction costs matter more than in-sample significance. For adoption surveys, construct validity, sampling frame and common-method bias should be assessed. For energy studies, assumptions about hardware efficiency, miner location, electricity mix and network activity must be made explicit.

Because no study-level effect-size table is available in this task, pooled coefficients, p-values, confidence intervals and heterogeneity statistics would be fabricated if reported as empirical results. The statistical section below therefore distinguishes (a) descriptive coding choices that can be reproduced from this document, (b) qualitative cross-study regularities, and (c) inferential analyses that remain to be run after extraction.

4. Conceptual foundations and taxonomy

Cryptocurrency systems can be understood as socio-technical arrangements. The protocol defines transaction validity and consensus; the token model creates incentives and allocates rights; infrastructure providers offer wallets, exchanges, custodians, bridges and interfaces; users and institutions determine actual use; and legal institutions shape recourse, disclosure, taxation and enforcement. Risk can migrate between layers. For example, self-custody reduces dependence on a central exchange but increases the consequences of lost keys, phishing or unsafe signing. A proof-of-stake network reduces direct mining electricity demand relative to proof-of-work, but introduces different questions about stake concentration, validator incentives and governance.

A useful taxonomy distinguishes five overlapping categories. First, native crypto-assets secure or coordinate a protocol and may also be traded speculatively. Second, stablecoins seek to maintain a reference value through reserves, collateral or algorithmic mechanisms; they differ in redemption rights and reserve transparency. Third, governance and application tokens grant protocol-specific functions or voting rights, though practical voting power may be concentrated. Fourth, tokenised real-world assets represent claims or records associated with off-chain assets, making legal enforceability and custodial integrity central. Fifth, central bank digital currencies are public-money liabilities and should not be conflated with decentralised cryptocurrencies merely because both use digital technology.

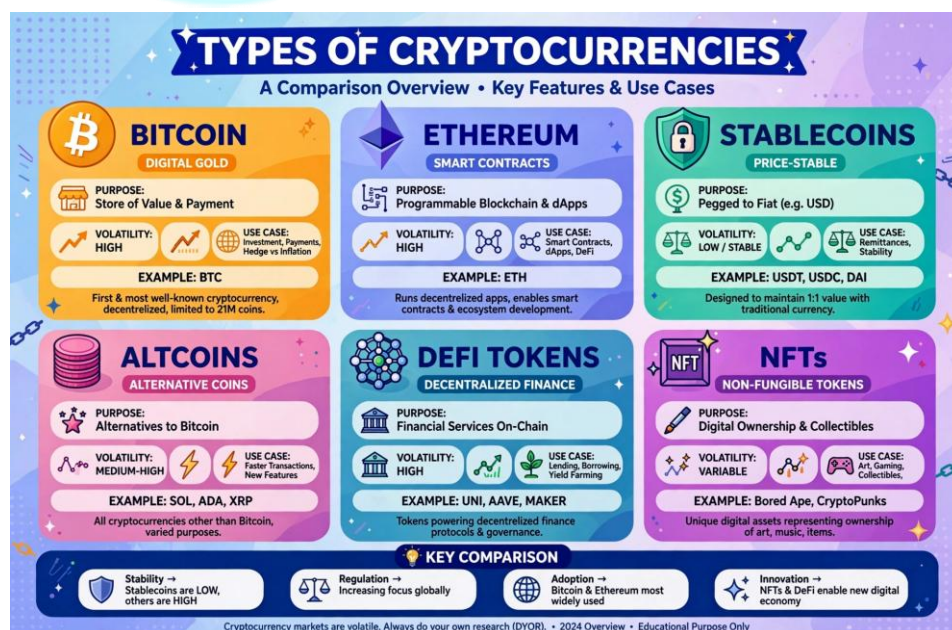


Figure 1: Types of Cryptocurrencies – A Comparative Overview by Purpose, Volatility and Use Case

The same asset can be used for speculation, payment, collateral, remittance or governance, and those functions need not be equally important. Price, transaction count, active addresses and total value locked are imperfect proxies for adoption: bots, exchange batching, multiple addresses per user, custodial internal transfers and incentive-driven activity can distort them. Research should therefore specify the target construct before choosing the metric.

5. Market dynamics, efficiency and volatility

5.1 Price formation and market efficiency

Cryptocurrency markets provide a useful setting for studying market efficiency because trading is continuous, venues are fragmented, transaction costs vary, and retail participation is substantial. Early work tested whether Bitcoin prices follow random-walk-like processes or exhibit predictable patterns. Urquhart (2016) reported evidence consistent with inefficiency in an early sample, while later work found that efficiency can change over time and may improve as markets mature (Nadarajah & Chu, 2017; Vidal-Tomás & Ibañez, 2018). Such findings are not contradictory if efficiency is time-varying, if the assets and frequencies differ, or if transaction costs eliminate apparent profits.

The empirical difficulty is distinguishing genuine predictability from data mining. Cryptocurrency data invite many candidate predictors: lagged returns, volume, order imbalance, search attention, social-media sentiment, blockchain activity, macroeconomic variables and cross-asset signals. A large predictor set almost guarantees some significant in-sample associations. Reliable claims require pre-specified hypotheses, multiple-testing controls, walk-forward evaluation, realistic execution costs, and comparison with simple baselines. A profitable backtest should account for fees, bid–ask spreads, slippage, funding rates, market impact, latency and the feasibility of shorting.

Fragmented venues create cross-exchange price differences, but arbitrage is not frictionless. Capital controls, withdrawal delays, custody risk, exchange credit risk and blockchain settlement times can prevent convergence. A venue's quoted price may not be executable at the observed depth. Consequently, efficiency should be evaluated at the level of executable strategies, not only return autocorrelation.

5.2 Volatility and tail risk

High volatility is among the most robust stylised features of crypto-asset returns. Studies frequently document heavy-tailed distributions, volatility clustering and structural breaks. These patterns motivate GARCH-family models, realised-volatility measures, stochastic volatility, quantile methods and extreme-value approaches. However, estimates depend on sampling frequency, exchange selection, outlier treatment and the period studied. The 24/7 trading calendar also complicates comparisons with equities, which close overnight and on weekends.

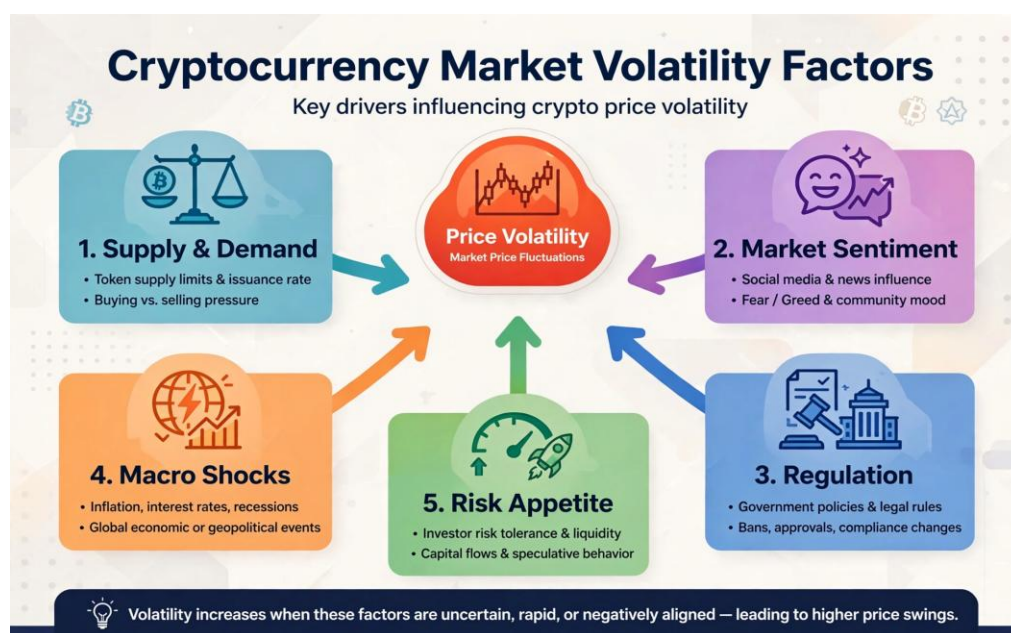


Figure 2: Drivers of Market Volatility – Liquidity, Leverage, Sentiment, Attention, Macro Shocks and Risk Appetite

A review of cryptocurrency volatility by Ahmed et al. (2024) synthesised 164 articles published from 2016 through 2022 and distinguished realised, implied and stochastic volatility and their drivers. Its breadth underlines that volatility is not a single outcome: realised variance captures ex post variation, implied volatility embeds option-market expectations and risk premia, while conditional variance models forecast volatility under specified assumptions. These measures should not be combined without a clear estimand.

Volatility responds to market depth, leverage, derivatives liquidations, information shocks, macroeconomic risk appetite, regulation and crypto-specific events. Leverage can amplify price moves through margin calls and forced liquidation. Stablecoin concerns can trigger

redemptions and exchange outflows. Exchange failures can simultaneously reduce liquidity and increase uncertainty about asset recovery. Causal interpretation remains difficult because volatility, volume, sentiment and liquidity affect one another. Event studies need careful event windows and controls for concurrent shocks; high-frequency causal claims require attention to time synchronisation and market microstructure noise.

5.3 Sentiment and information

Search intensity, news tone and social-media activity often correlate with crypto-asset trading and returns. Yet attention is endogenous: rising prices generate discussion, which can in turn attract new buyers. Sentiment measures may also be manipulated by coordinated campaigns, bots or promotional communities. A useful design separates attention from valence, uses lag structures justified by a causal model, and tests whether sentiment adds out-of-sample predictive value beyond price, volume and volatility. Text models should report language coverage, classification validation and drift over time.

The literature's broader lesson is that cryptocurrency markets are information-rich but measurement-sensitive. A significant association between tweets and returns does not show that social media causes prices; nor does a statistically significant forecast establish a deployable trading strategy. Reproducible datasets and pre-registered model comparisons would improve credibility.

6. Portfolio diversification, hedging and contagion

Bitcoin and other crypto-assets have been examined as diversifiers, hedges or safe havens relative to equities, bonds, commodities and currencies. These terms have specific meanings. A diversifier has low average correlation with another asset; a hedge is uncorrelated or negatively correlated on average; a safe haven retains those properties during extreme market stress. An asset may diversify in normal periods but fail as a safe haven during a crash. Therefore, claims depend on the benchmark, horizon, conditional quantile and crisis definition.

Early studies often found low unconditional correlations between Bitcoin and conventional assets, suggesting potential diversification benefits (Bouri et al., 2017; Dyhrberg, 2016; Corbet et al., 2018). Later research emphasised time-varying correlations, volatility

transmission and changing relationships as institutional participation increased. Portfolio results can differ across mean–variance, downside-risk, value-at-risk, expected-shortfall and utility-based frameworks. They also depend on rebalancing frequency, estimation window, fees, taxes and constraints. An allocation that improves historical Sharpe ratio may still worsen drawdown, tail loss or liquidity risk.

Evidence of connectedness has encouraged use of dynamic conditional correlation models, vector autoregressions, spillover indices and frequency-domain decompositions. These tools can show whether shocks are associated with increased transmission across assets, but results depend on model specification and ordering assumptions. Connectedness is not automatically contagion: correlation increases can arise from common exposure to global risk factors rather than direct transmission. Strong causal claims require identification strategies that distinguish common shocks, direct links and feedback.

The practical conclusion is conditional rather than categorical. Crypto-assets may offer diversification in some regimes, but extreme downside risk, operational risks, uncertain valuation anchors and unstable correlations make them unlike conventional low-volatility hedges. Investors should evaluate crypto exposure against a defined objective and risk budget, rather than infer safety from a low historical correlation. Future work should compare post-cost portfolio performance across bull, bear and crisis regimes, and should disclose survivorship and asset-selection bias.

7. Adoption, payment use and organisational integration

Adoption research applies the technology acceptance model (TAM), unified theory of acceptance and use of technology (UTAUT), diffusion of innovations, perceived-risk models and trust frameworks. Perceived usefulness and ease of use recur as important constructs, but cryptocurrency adoption adds distinctive issues: irreversible transfers, key management, price instability, scams, uncertain tax treatment, limited merchant acceptance and unfamiliar interfaces. Trust is multidimensional. Users may trust cryptographic verification while distrusting exchanges, developers, issuers, wallet software or regulators.

Survey-based studies commonly identify perceived usefulness, social influence, facilitating conditions, trust and perceived risk as relevant to intention or use. These relationships vary by country, experience, financial literacy, age, income, access to digital infrastructure and

whether the respondent considers cryptocurrency an investment or a payment method. Intention is not behaviour. Cross-sectional convenience samples cannot establish that a stated intention leads to sustained use; longitudinal designs and observed behavioural outcomes are stronger.

Adoption should also be distinguished from ownership. An individual may hold cryptocurrency for speculative purposes without using it to buy goods or remit funds. Conversely, a user may encounter crypto rails through a payment provider without directly holding a volatile token. Stablecoins may be attractive where local currency instability, cross-border frictions or access limitations matter, but they also expose users to issuer, reserve, redemption, platform and legal risks. Context is essential: the same product may serve as a speculative asset in one market and a payment or savings substitute in another.

For firms, potential benefits include programmable settlement, tokenised records, global transferability and automation through smart contracts. Barriers include integration cost, uncertain accounting and tax treatment, key governance, scalability, privacy, cybersecurity, and unclear customer demand. Adoption decisions should be framed as make-or-buy and risk-allocation problems rather than as a simple technology trend. Pilot projects need measurable success criteria, fallback procedures, auditability and clear accountability.

A key methodological concern is that many adoption studies treat cryptocurrency and blockchain as interchangeable. Blockchain may be used in a permissioned enterprise database without a publicly traded token; cryptocurrency ownership may occur through a custodial account without direct interaction with a blockchain. Future research should operationalise the technology and behaviour being studied and avoid transferring findings from one category to another.

8. Protocol design, security and operational resilience

8.1 Consensus and decentralization

Proof of work and proof of stake coordinate transaction ordering and make certain attacks costly, but they create different incentive structures. Proof of work ties security to computational resources and electricity expenditure; proof of stake ties it to economically committed tokens, validator design and protocol penalties. Neither label alone guarantees decentralization. Relevant measures include concentration of hash power or stake, client

diversity, validator geography, governance participation, node accessibility, dependence on infrastructure providers and the distribution of block production.

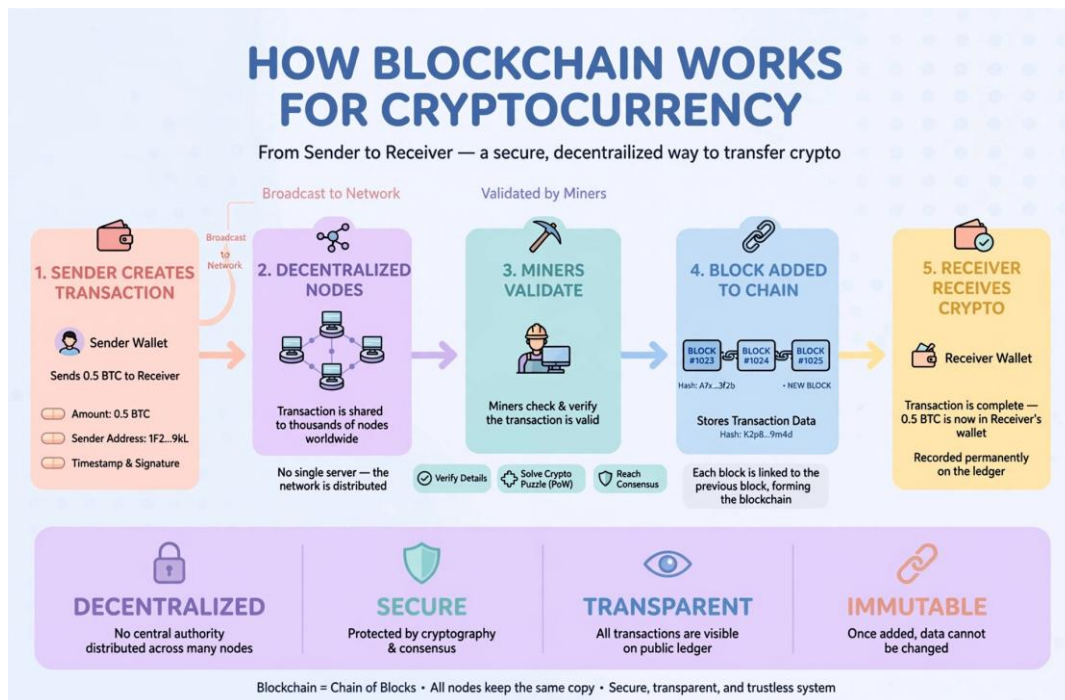


Figure 3: How Blockchain Works for Cryptocurrency – From Sender to Receiver, decentralized validation and block addition

Blockchain immutability is also conditional. Consensus can make history revision costly, but software defects, governance interventions, chain reorganisations and social coordination remain possible. A ledger can preserve an erroneous or fraudulent transaction exactly as designed. Security analysis should therefore distinguish cryptographic integrity, consensus security, smart-contract correctness, key security, bridge security and the economic incentives of participants.

8.2 Smart contracts, bridges and DeFi

Smart contracts automate state transitions and can reduce dependence on discretionary intermediaries, yet their public and composable nature creates systemic dependencies. A vulnerability in a widely used contract, oracle, bridge or collateral protocol can propagate through downstream applications. DeFi protocols can combine lending, automated market making, liquid staking and synthetic exposure in ways that make risk hard to observe from

a single protocol's balance sheet. Total value locked is not equivalent to insured assets, net economic value or user welfare.

Common attack classes include re-entrancy, access-control errors, arithmetic and accounting flaws, oracle manipulation, compromised private keys, governance attacks, flash-loan-enabled exploitation and bridge validator compromise. The attack surface includes not only code but also deployment keys, upgrade permissions, user interfaces and dependencies. Formal verification, independent audits, bug bounties, staged deployments, circuit breakers and transparent incident reporting can reduce risk, but no control eliminates it. Audits are snapshots and may not cover upgrades, integration risks or economic attack paths.

Custodial exchanges and self-custody produce different risk profiles. A custodian can offer recovery mechanisms and usability but introduces counterparty, commingling, governance and insolvency risks. Self-custody removes some intermediary exposure while placing key backup, transaction signing and recovery on the user. Multi-signature arrangements, hardware wallets and policy controls can help, but implementation errors and social engineering remain material. Users often face a gap between the decentralization promised by a protocol and the centralisation of the services through which they access it.

8.3 Stablecoins and systemic connections

Stablecoins bridge on-chain markets and off-chain money. Their stability depends on reserve quality, redemption rights, governance, market liquidity, banking access and confidence in the issuer or collateral mechanism. A stablecoin can trade below its target even if reserve assets ultimately cover liabilities, because immediate redemption may be constrained or uncertain. Algorithmic mechanisms may be vulnerable to reflexive runs if the stabilising asset or arbitrage incentive collapses.

Stablecoins also connect crypto markets to payment systems and traditional finance. A large redemption event can force asset sales, while a loss of confidence can impair exchange liquidity and collateral values. Regulatory approaches differ in issuer authorization, reserve composition, segregation, audit, redemption, disclosure and resolution. Research should test the actual stress-transmission channels rather than infer systemic importance solely from market capitalisation.

9. Regulation, Compliance and Consumer Protection

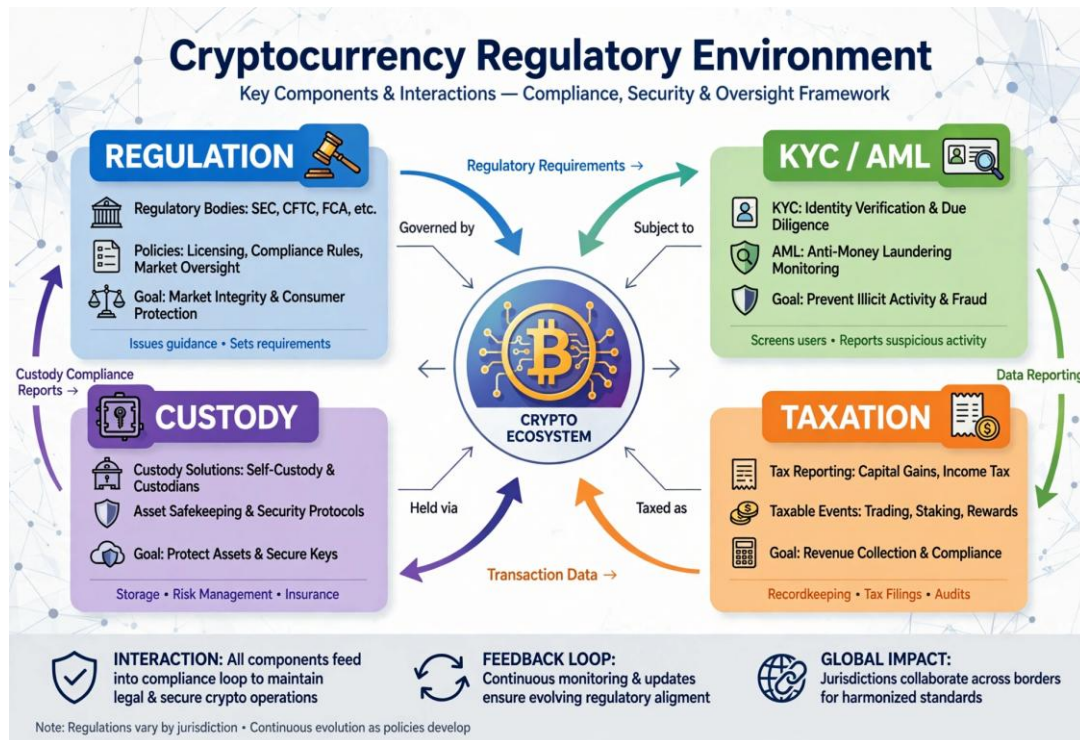


Figure 4: Institutional Environment – Regulation, Custody, Taxation, KYC/AML, and Consumer Protection

Regulatory frameworks typically combine several objectives: consumer and investor protection, anti-money-laundering and counter-terrorist-financing controls, market integrity, prudential stability, tax compliance, data protection and innovation policy. These objectives may conflict. Broad prohibitions can push activity into less transparent channels; light-touch rules can leave consumers exposed to misleading disclosure, custody failures and market manipulation. The appropriate instrument depends on the activity and the entity exercising control.

A functional approach asks what the product does and who bears the risk. Exchange operators, custodians, token issuers, stablecoin reserve managers, brokers, protocol developers and decentralised autonomous organisations may have different degrees of control and different obligations. The label decentralised should not substitute for an analysis of actual governance, upgrade authority, fee capture, and administrative keys or concentrated decision-making. Equally, regulation should not assume that every open-source contributor is equivalent to a financial intermediary.

The cross-border nature of cryptocurrency creates jurisdictional arbitrage and enforcement challenges. Rules may diverge on token classification, licensing, custody, market abuse, stablecoin reserves, advertising and taxation. Compliance costs can be disproportionately burdensome for small firms, while inconsistent rules can invite relocation without reducing risk. International coordination can improve information sharing and minimum standards, but should preserve proportionality and technological neutrality.

Recent systematic and bibliometric work on cryptocurrency regulation has identified clusters around financial inclusion, market efficiency, legal frameworks, vulnerabilities and central bank digital currencies (AlQudah & Bariviera, 2025). Such mappings help describe scholarly attention but do not prove that a regulatory intervention works. Evaluation requires outcomes: fraud losses, consumer complaints, redemption performance, compliance rates, market concentration, and innovation entry and cross-border displacement. Policy changes are often endogenous to crises, making simple before–after comparisons unreliable.

A useful policy architecture combines transparent disclosures, segregation and safeguarding of client assets, governance and conflict-of-interest controls, cyber-resilience standards, market surveillance, fit-for-purpose reserve requirements for payment stablecoins, clear redemption rights, proportionate AML controls and credible insolvency procedures. Consumer education remains necessary but cannot substitute for structural safeguards. The goal is not zero risk; it is transparent allocation of risk, enforceable accountability and resilience under stress.

10. Illicit Finance, Privacy and Public-interest Trade-offs

Public blockchains can support transaction tracing because many transfers are permanently visible, but address pseudonymity complicates attribution. Chain analytics may link addresses to services or real-world identities, yet conclusions depend on heuristics, attribution quality and the availability of off-chain information. Privacy-enhancing tools and cross-chain bridges complicate tracing, while transparent ledgers can expose lawful users' financial relationships. The technology therefore does not make cryptocurrency uniformly anonymous or uniformly transparent.

Cryptocurrencies have been used in ransomware, scams, sanctions evasion and illicit marketplaces, but the scale and composition of illicit activity are difficult to measure. Estimates can change when addresses are reclassified, new attribution data become available or the scope of illicit categories changes. A sound review should report ranges, methods and uncertainty, not treat a single commercial analytics estimate as ground truth. The relevant denominator also matters: absolute illicit value, share of total transaction activity and harm per user answer different questions.

AML and sanctions controls can improve traceability and accountability, yet may create privacy and access concerns. Compliance obligations are most effective when responsibilities are assigned to identifiable actors with meaningful control, while recognizing that protocol-level activity can cross jurisdictions. Future research should evaluate both enforcement efficacy and false positives, including exclusion of legitimate users and disproportionate effects on vulnerable groups.

11. Environmental sustainability and energy accounting

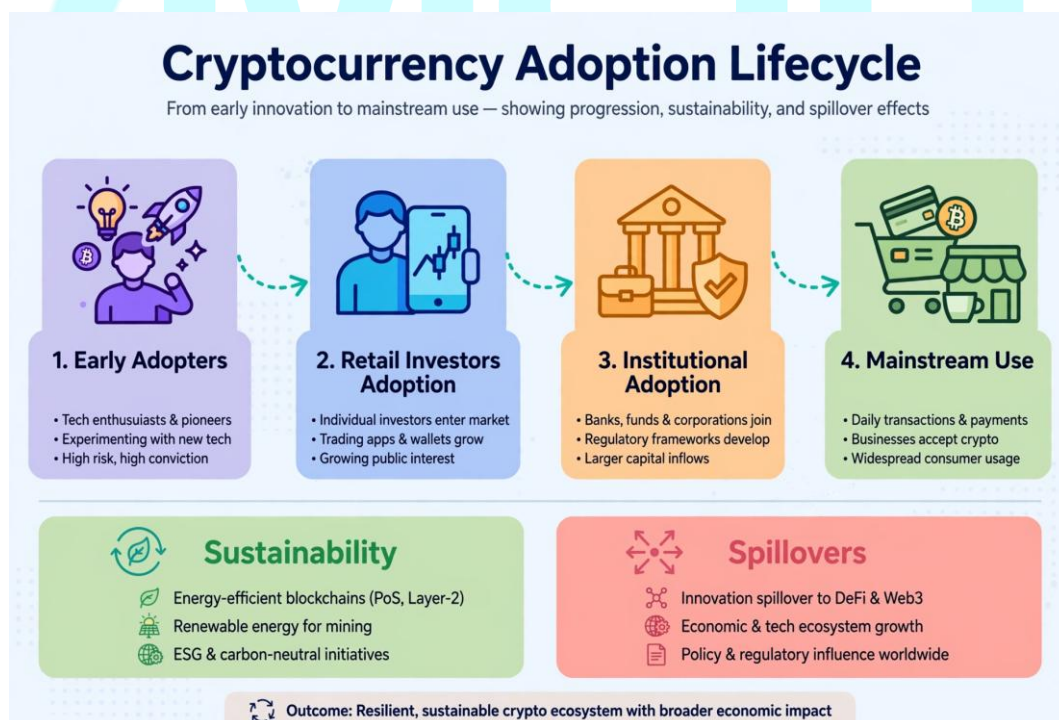


Figure 5: Adoption Lifecycle, Outcomes and Sustainability – Returns, Volatility, Adoption, Spillovers

Environmental debates are often dominated by proof-of-work mining, where electricity consumption is an input into consensus security. The climate impact of that electricity

depends on the location and timing of mining, marginal generation mix, hardware efficiency, curtailment arrangements and counterfactual use of power. Annual electricity estimates are therefore model-based rather than direct readings from a single meter. Methodological transparency is essential when comparing studies.

Cambridge Bitcoin Electricity Consumption Index research illustrates the use of network data and mining hardware assumptions to estimate electricity demand (Böhm et al., 2015; de Vries, 2018; Cambridge Centre for Alternative Finance, ongoing). Digiconomist and other researchers have offered complementary estimates and debate the implications for energy and emissions (de Vries, 2018). Estimates can differ because they use different assumptions about miner profitability, equipment efficiency, and geographic distribution and electricity sources. A review should report the range and the model assumptions rather than imply false precision.

Proof-of-stake systems generally avoid the competitive hashing process central to proof-of-work and can reduce direct consensus electricity demand substantially. Nevertheless, environmental evaluation should include hardware and data-centre use, network infrastructure, e-waste, rebound effects and the counterfactual service delivered. Per-transaction energy metric can mislead because block production energy does not scale linearly with the number of transactions, and transactions may be batched or executed on layer-two networks.

Policy should focus on transparent energy and emissions reporting, credible location and electricity-mix assumptions, e-waste management, and incentives that account for local grid impacts. Claims that crypto mining always uses stranded renewable energy are too broad; claims that every crypto network has Bitcoin-like energy demand are equally inaccurate. The technology and its deployment context determine the result.

12. Statistical evidence map and synthesis

12.1 What can be quantified from the current material?

The evidence map in Figure 2 is an author-coded prioritization aid, not a bibliometric frequency count and not a measure of effect size. Scores were assigned on a 1–5 ordinal scale to show the relative emphasis given to each theme in this manuscript's synthesis. These scores must not be interpreted as the proportion of Scopus papers, the number of

studies supporting a hypothesis, or a statistical estimate of the literature. They are displayed to make the synthesis architecture visible while avoiding fabricated corpus statistics.

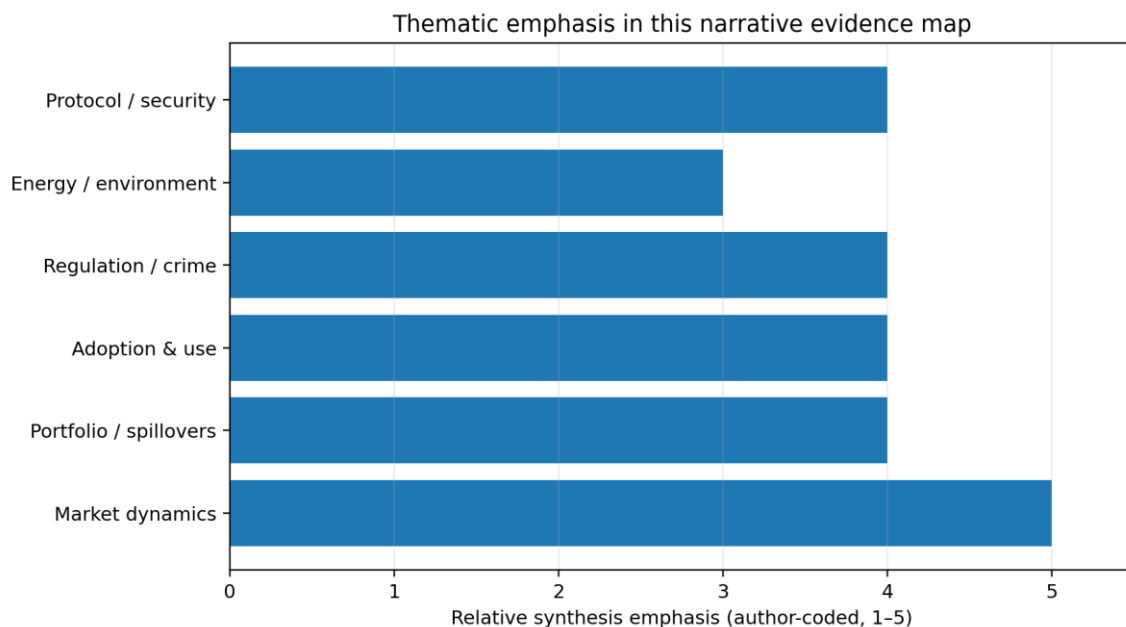


Figure 6. Author-coded thematic emphasis for this manuscript (ordinal synthesis score, 1–5). This is not a frequency count from Scopus or an inferential result.

12.2 Cross-theme statistical interpretation

Across market studies, the most consistent statistical challenge is non-stationarity. Return distributions and dependencies shift over time, so a coefficient estimated during one market regime may not generalize. Analyses should test structural breaks and report rolling or regime-conditional estimates. Heavy tails make normality-based risk measures fragile; expected shortfall and quantile-based models can better characterize tail outcomes, although their estimates also become uncertain in small samples.

Across portfolio studies, average correlation is an incomplete summary. Dynamic correlations and conditional dependence can rise during stress, and the apparent benefit of an asset can disappear under transaction costs or downside constraints. Researchers should report baseline and augmented portfolio performance, uncertainty intervals from bootstrap or simulation, turnover, drawdown and tail-loss metrics. Comparisons should use the same sample, rebalancing dates and cost assumptions.

Across adoption studies, standardized path coefficients from different questionnaires are not automatically poolable. Constructs labelled trust or perceived risk may have different item sets and translations. A meta-analysis should distinguish behavioural intention from actual use and evaluate measurement invariance across countries. If primary studies report only p-values or significance labels, effect-size recovery is often impossible; this should be treated as a reporting limitation rather than solved by imputing arbitrary coefficients.

Across environmental studies, the main uncertainty is often model-based rather than sampling-based. Monte Carlo sensitivity analysis over mining hardware, network hash rate, miner location and electricity mix is more informative than a conventional confidence interval alone. Across regulatory studies, causal inference is complicated by policy endogeneity, concurrent interventions and spillovers across jurisdictions. Difference-in-differences or synthetic-control designs may help only when assumptions and pre-trends are credible.

12.3 Recommended quantitative tables for a final Scopus review

A submission-ready version should include at least four quantitative tables. Table A should report search and screening counts by database and reason for exclusion. Table B should describe included studies by year, geography, asset, method and theme. Table C should report risk-of-bias or methodological-quality ratings by domain. Table D should summarise comparable effect estimates, uncertainty intervals and heterogeneity. A bibliometric appendix can add co-citation, co-word and country collaboration maps, but these should be built from the exported records using a documented version of Bibliometrix or VOSviewer.

The following decision rules are recommended: use descriptive counts for heterogeneous designs; use narrative synthesis when estimands cannot be harmonised; pool only studies with a defensible common outcome; report random-effects estimates and prediction intervals; and separate confirmatory from exploratory analyses. When multiple results come from the same paper, account for dependence rather than treating each coefficient as an independent study. Publish the codebook, search strings, deduplicated metadata and analysis scripts where licensing and privacy permit.

13. Research gaps and future agenda

13.1 Causal and out-of-sample evidence

Future financial research should move beyond repeated in-sample predictability tests. Pre-registration, open code, point-in-time data and realistic execution assumptions can reduce data mining. Studies should benchmark machine-learning models against simple strategies, disclose hyperparameter selection and evaluate performance across assets and regimes. Causal questions—such as whether a regulatory announcement changes liquidity or whether a protocol upgrade affects fees—require designs that identify a plausible counterfactual.

13.2 Better measures of use and economic value

Research should distinguish active users from addresses, payment activity from exchange transfers, and economic settlement from incentive farming. Linking on-chain measures to surveys, merchant data and service-provider records could improve validity while protecting privacy. Welfare analysis should examine total costs, failed transactions, remittance delivery, user recourse and the distribution of gains, not just transaction speed or token price.

13.3 Stablecoin stress and the financial system

Stablecoins deserve focused study because their reserve assets, redemption arrangements and banking links may connect on-chain markets to conventional finance. Priority questions include run dynamics, the role of transparency, concentration in reserve custodians, settlement finality, cross-border redemption and how stablecoin stress propagates through collateral and liquidity. Research should distinguish a stablecoin's secondary-market price from its ability to redeem at par under stress.

13.4 Security economics and protocol governance

Security is an economic property as well as a software property. More work is needed on the incentives to disclose vulnerabilities, the effectiveness of audits, the relationship between code complexity and exploit loss, and the governance response to emergencies. Studies should include near misses and unsuccessful attacks, not only publicised exploits,

to avoid survivorship bias. Governance concentration can be measured through voting power, delegated stake, upgrade-key control and proposal participation.

13.5 Regulation as an empirical intervention

Regulatory scholarship would benefit from harmonised event datasets and outcome measures. Researchers can compare licensing regimes, reserve requirements, custody rules and disclosure mandates while accounting for policy timing and cross-border substitution. Important outcomes include user losses, market concentration, entry and exit of firms, innovation, tax compliance and illicit-finance displacement. Legal analysis should be integrated with firm-level and market data rather than relying solely on statutory comparison.

13.6 Climate, distribution and inclusion

Environmental research should publish reproducible assumptions and distinguish energy demand, emissions, e-waste and local grid effects. Adoption research should test who benefits and who bears risk, including remittance users, people with limited banking access and users exposed to currency instability. Financial inclusion should be measured through actual affordability, reliability, accessibility and recourse, not inferred from wallet availability. These questions require interdisciplinary teams and locally grounded evidence.

14. Implications for practitioners and policymakers

For investors, the review supports disciplined risk budgeting, custody due diligence, stress testing and a distinction between diversification and safe-haven claims. Portfolio weights should reflect liquidity, drawdown tolerance, tax treatment and the possibility of total loss or temporary inability to transact. Historical backtests should be treated cautiously where asset survivorship, venue changes and market structure are material.

For firms, the decision to use crypto-assets or blockchain should begin with a defined problem and an explicit comparison against conventional databases, payment rails and custodial services. Pilots should specify operational metrics, control ownership, incident response, data protection, reconciliation, exit paths and legal accountability. A distributed ledger is not inherently preferable when a trusted administrator and conventional database can meet the same need at lower cost.

For regulators, proportional, activity-based rules are more likely to remain technology-neutral than rules based on labels. Minimum standards for safeguarding, disclosure, governance, cybersecurity and redemption can address identifiable risks while leaving room for experimentation. Regulators should monitor concentration and interconnectedness, publish enforcement outcomes, coordinate internationally and evaluate unintended consequences such as migration to less transparent venues.

For researchers and journal editors, reproducibility should be a core quality criterion. Articles should provide data provenance, code, model-selection logic, definitions of key variables and robust out-of-sample evaluation. Review papers should distinguish databases searched from references hand-selected, avoid unverified citation counts and make screening decisions auditable.

15. Limitations

This manuscript has important limitations. First, it is an integrative review draft rather than a fully executed systematic review of a documented Scopus export. Its reference set has not been independently double-screened in this workflow, and the reader should verify bibliographic metadata, publication status and DOI links before submission. Second, the literature is heterogeneous in assets, time periods, sampling frequency, jurisdictions, outcome definitions and statistical methods. Consequently, the manuscript does not compute a pooled effect size or claim a formal meta-analysis. Third, the evidence map's ordinal scores represent author-coded emphasis, not article counts or statistical significance. Fourth, cryptocurrency markets evolve quickly; new regulation, product design and market failures can change the relevance of findings. Finally, this review cannot guarantee a journal's Q1 status or editorial acceptance. The appropriate journal category and quartile should be checked in the relevant year and subject area.

These limitations are not cosmetic. A journal-ready revision should run a reproducible search, export metadata, retain full-text screening decisions, complete a structured extraction sheet, assess quality, verify references and regenerate the figures from the resulting data. Where the evidence does not support quantitative pooling, transparent narrative synthesis is more rigorous than a spurious meta-analysis.

16. Conclusion

Cryptocurrency is best understood not as one asset or technology but as a set of interacting protocols, tokens, markets, intermediaries and governance arrangements. The evidence shows substantial variation in price behaviour, adoption, security and environmental impact across assets and contexts. Market efficiency and portfolio benefits are time-varying; adoption depends on trust and practical conditions as well as perceived utility; decentralisation redistributes rather than abolishes risk; regulation must target functions and control points; and environmental conclusions depend on consensus design and deployment assumptions.

The central research need is better identification and measurement. Financial studies should emphasise out-of-sample and post-cost results; adoption research should distinguish intention from observed use; security studies should integrate code and incentive analysis; regulatory work should evaluate outcomes rather than count rules; and sustainability studies should expose assumptions and uncertainty. A fully reproducible Scopus review can strengthen these conclusions by documenting search and screening, coding all included studies, and pooling only comparable estimates. Until that work is completed, transparent limits are a mark of scholarly quality, not a weakness.

References

1. Ahmed, M. S., El-Masry, A. A., Al-Maghyreh, A. I., & Kumar, S. (2024). Cryptocurrency volatility: A review, synthesis, and research agenda. *Research in International Business and Finance*, 71, 102472. <https://doi.org/10.1016/j.ribaf.2024.102472>
2. AlQudah, M. Z., & Bariviera, A. F. (2025). Systematic and bibliometric reviews of cryptocurrency market regulation: Trends, influential contributions, and future directions. *Journal of Financial Regulation and Compliance*.
3. Antonopoulos, A. M. (2014). *Mastering Bitcoin: Unlocking Digital Cryptocurrencies*. O'Reilly Media.
4. Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975.

5. Baur, D. G., Hong, K., & Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets? *Journal of International Financial Markets, Institutions and Money*, 54, 177–189.
6. Baur, D. G., & Dimpfl, T. (2018). Asymmetric volatility in cryptocurrencies. *Economics Letters*, 173, 148–151.
7. Bouri, E., Molnár, P., Azzi, G., Roubaud, D., & Hagfors, L. I. (2017). On the hedge and safe haven properties of Bitcoin: Is it really more than a diversifier? *Finance Research Letters*, 20, 192–198.
8. Bouri, E., Gupta, R., Tiwari, A. K., & Roubaud, D. (2017). Does Bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters*, 23, 87–95.
9. Bouri, E., Lucey, B., & Roubaud, D. (2020). The volatility surprise of leading cryptocurrencies: Transitory and permanent effects. *Finance Research Letters*, 33, 101188.
10. Böhm, F., Christin, N., Edelman, B., & Moore, T. (2015). Bitcoin: Economics, technology, and governance. *Journal of Economic Perspectives*, 29(2), 213–238.
11. Cambridge Centre for Alternative Finance. (n.d.). Cambridge Bitcoin Electricity Consumption Index. University of Cambridge Judge Business School. <https://ccaf.io/cbnsi/cbeci>
12. Catalini, C., & Gans, J. S. (2020). Some simple economics of the blockchain. *Communications of the ACM*, 63(7), 80–90.
13. Ciaian, P., Rajcaniova, M., & Kancs, d'A. (2016). The economics of Bitcoin price formation. *Applied Economics*, 48(19), 1799–1815.
14. Corbet, S., Lucey, B., Urquhart, A., & Yarovaya, L. (2019). Cryptocurrencies as a financial asset: A systematic analysis. *International Review of Financial Analysis*, 62, 182–199.

15. Corbet, S., Meegan, A., Larkin, C., Lucey, B., & Yarovaya, L. (2018). Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters*, 165, 28–34.
16. Corbet, S., Lucey, B., & Yarovaya, L. (2018). Datestamping the Bitcoin and Ethereum bubbles. *Finance Research Letters*, 26, 81–88.
17. Cong, L. W., & He, Z. (2019). Blockchain disruption and smart contracts. *Review of Financial Studies*, 32(5), 1754–1797.
18. Dyhrberg, A. H. (2016). Bitcoin, gold and the dollar—A GARCH volatility analysis. *Finance Research Letters*, 16, 85–92.
19. Dyhrberg, A. H. (2016). Hedging capabilities of Bitcoin. Is it the virtual gold? *Finance Research Letters*, 16, 139–144.
20. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296.
21. Eyal, I., & Sirer, E. G. (2014). Majority is not enough: Bitcoin mining is vulnerable. In *Financial Cryptography and Data Security* (pp. 436–454). Springer. https://doi.org/10.1007/978-3-662-45472-5_28
22. Gandal, N., Hamrick, J. T., Moore, T., & Oberman, T. (2018). Price manipulation in the Bitcoin ecosystem. *Journal of Monetary Economics*, 95, 86–96.
23. Gandal, N., & Halaburda, H. (2016). Can we predict the winner in a market with network effects? Competition in cryptocurrency market. *Games*, 7(3), 16.
24. Garcia, D., Tessone, C. J., Mavrodiev, P., & Perony, N. (2014). The digital traces of bubbles: Feedback cycles between socio-economic signals in the Bitcoin economy. *Journal of the Royal Society Interface*, 11(99), 20140623.
25. Hayes, A. S. (2017). Cryptocurrency value formation: An empirical study leading to a cost of production model for valuing Bitcoin. *Telematics and Informatics*, 34(7), 1308–1321.

26. Hileman, G., & Rauchs, M. (2017). Global cryptocurrency benchmarking study. Cambridge Centre for Alternative Finance, University of Cambridge.
27. Howell, S. T., Niessner, M., & Yermack, D. (2020). Initial coin offerings: Financing growth with cryptocurrency token sales. *Review of Financial Studies*, 33(9), 3925–3974.
28. Huberman, G., Leshno, J. D., & Moallemi, C. (2021). Monopoly without a monopolist: An economic analysis of the Bitcoin payment system. *Review of Economic Studies*, 88(6), 3011–3040.
29. Katsiampa, P. (2017). Volatility estimation for Bitcoin: A comparison of GARCH models. *Economics Letters*, 158, 3–6.
30. Kristoufek, L. (2013). Bitcoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet era. *Scientific Reports*, 3, 3415.
31. Liu, Y., & Tsyvinski, A. (2021). Risks and returns of cryptocurrency. *Review of Financial Studies*, 34(6), 2689–2727.
32. Makarov, I., & Schoar, A. (2020). Trading and arbitrage in cryptocurrency markets. *Journal of Financial Economics*, 135(2), 293–319.
33. Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.
34. Nadarajah, S., & Chu, J. (2017). On the inefficiency of Bitcoin. *Economics Letters*, 150, 6–9.
35. Pagnotta, E. S. (2022). Decentralizing money: Bitcoin prices and blockchain security. *Review of Financial Studies*, 35(2), 866–907.
36. Pagnotta, E. S., & Buraschi, A. (2018). An equilibrium valuation of Bitcoin and decentralized network assets. Working paper, available through author/research repositories.
37. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71.

38. Poon, W. C., & Granger, C. W. J. (2003). Forecasting volatility in financial markets: A review. *Journal of Economic Literature*, 41(2), 478–539.
39. Schär, F. (2021). Decentralized finance: On blockchain- and smart contract-based financial markets. *Federal Reserve Bank of St. Louis Review*, 103(2), 153–174.
40. Selgin, G. (2015). Synthetic commodity money. *Journal of Financial Stability*, 17, 92–99.
41. Shiller, R. J. (2017). Cryptocurrency and the economics of speculation. In NBER Working Paper Series, No. 236 cryptocurrency-related discussion; verify exact working-paper citation before submission.
42. Urquhart, A. (2016). The inefficiency of Bitcoin. *Economics Letters*, 148, 80–82.
43. Vidal-Tomás, D., & Ibañez, A. (2018). semi-strong efficiency of Bitcoin. *Finance Research Letters*, 27, 259–265. Verify title punctuation and DOI against the publisher before submission.
44. Yermack, D. (2015). Is Bitcoin a real currency? An economic appraisal. In *Handbook of Digital Currency* (pp. 31–43). Elsevier.
45. Auer, R., & Claessens, S. (2018). Regulating cryptocurrencies: Assessing market reactions. *BIS Quarterly Review*, September 2018, 51–65.
46. FATF. (2021). Updated guidance for a risk-based approach to virtual assets and virtual asset service providers. Financial Action Task Force. <https://www.fatf-gafi.org/>
47. Financial Stability Board. (2023). High-level recommendations for the regulation, supervision and oversight of global stablecoin arrangements. FSB.
48. International Monetary Fund. (2023). Elements of effective policies for crypto assets. IMF Policy Paper.
49. IOSCO. (2023). Policy recommendations for crypto and digital asset markets: Final report. International Organization of Securities Commissions.
50. Zetsche, D. A., Arner, D. W., & Buckley, R. P. (2020). Decentralized finance. *Journal of Financial Regulation*, 6(2), 172–203.

51. Arner, D. W., Auer, R., & Frost, J. (2020). Stablecoins: Risks, potential and regulation. BIS Working Papers No. 905. Bank for International Settlements.
52. Lyons, R. K., & Viswanath-Natraj, G. (2023). What keeps stablecoins stable? *Journal of International Money and Finance*, 131, 102777.
53. Eichengreen, B. (2019). From commodity to fiat and now to crypto: What does history tell us? NBER Working Paper No. 25426.
54. Schilling, L., & Uhlig, H. (2019). Some simple Bitcoin economics. *Journal of Monetary Economics*, 106, 16–26.
55. Biais, B., Bisière, C., Bouvard, M., & Casamatta, C. (2023). The blockchain folk theorem. *Review of Financial Studies*. Verify final volume, issue and pages before submission.
56. Auer, R. (2019). Embedded supervision: How to build regulation into blockchain finance. BIS Working Papers No. 811. Bank for International Settlements.
57. Kethineni, S., & Cao, Y. (2020). The rise in popularity of cryptocurrency and associated criminal activity. *International Criminal Justice Review*, 30(3), 325–344.
58. Foley, S., Karlsen, J. R., & Putniņš, T. J. (2019). Sex, drugs, and Bitcoin: How much illegal activity is financed through cryptocurrencies? *Review of Financial Studies*, 32(5), 1798–1853.
59. Meiklejohn, S., Pomarole, M., Jordan, G., Levchenko, K., McCoy, D., Voelker, G. M., & Savage, S. (2013). A fistful of Bitcoins: Characterizing payments among men with no names. In *Proceedings of the Internet Measurement Conference* (pp. 127–140).
60. Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). *Bitcoin and Cryptocurrency Technologies*. Princeton University Press.
61. Bonneau, J., Miller, A., Clark, J., Narayanan, A., Kroll, J. A., & Felten, E. W. (2015). SoK: Research perspectives and challenges for Bitcoin and cryptocurrencies. In *IEEE Symposium on Security and Privacy* (pp. 104–121).

62. Eberhardt, J., & Tai, S. (2017). On or off the blockchain? Insights on off-chaining computation and data. In *European Conference on Service-Oriented and Cloud Computing*. Springer.
63. Atzei, N., Bartoletti, M., & Cimoli, T. (2017). A survey of attacks on Ethereum smart contracts. In *Principles of Security and Trust* (pp. 164–186). Springer.
64. Luu, L., Chu, D.-H., Olickel, H., Saxena, P., & Hobor, A. (2016). Making smart contracts smarter. In *ACM Conference on Computer and Communications Security* (pp. 254–269).
65. Daian, P., Goldfeder, S., Kell, T., Li, Y., Zhao, X., Bentov, I., Breidenbach, L., & Juels, A. (2020). Flash Boys 2.0: Frontrunning, transaction reordering, and consensus instability in decentralized exchanges. In *IEEE Symposium on Security and Privacy* (pp. 910–927).
66. Werner, S. M., Perez, D., Gudgeon, L., Klages-Mundt, A., Harz, D., & Knottenbelt, W. J. (2022). SoK: Decentralized finance (DeFi). In *ACM Conference on Advances in Financial Technologies*.
67. Schnoering, H., & Renz, P. (2023). Centralized and decentralized cryptocurrency exchanges: A review of market structure and regulation.
68. Cong, L. W., Li, Y., & Wang, N. (2021). Tokenomics: Dynamic adoption and valuation. *Review of Financial Studies*, 34(3), 1105–1155.
69. Howell, S. T., Niessner, M., & Yermack, D. (2020). Initial coin offerings: Financing growth with cryptocurrency token sales. *Review of Financial Studies*, 33(9), 3925–3974.
70. Fisch, C. (2019). Initial coin offerings (ICOs) to finance new ventures. *Journal of Business Venturing*, 34(1), 1–22.
71. Momtaz, P. P. (2021). Entrepreneurial finance and moral hazard: Evidence from token offerings. *Journal of Business Venturing*, 36(5), 106128.
72. Vigna, P., & Casey, M. J. (2015). *The Age of Cryptocurrency*. St. Martin's Press.

73. Narayanan, A., & Clark, J. (2017). Bitcoin's academic pedigree. *Communications of the ACM*, 60(12), 36–45.
74. de Vries, A. (2018). Bitcoin's growing energy problem. *Joule*, 2(5), 801–805.
75. de Vries, A., & Stoll, C. (2021). Bitcoin's growing e-waste problem. *Resources, Conservation and Recycling*, 175, 105901.
76. Stoll, C., Klaaßen, L., & Gellersdörfer, U. (2019). The carbon footprint of Bitcoin. *Joule*, 3(7), 1647–1661.
77. Köhler, S., & Pizzol, M. (2019). Life cycle assessment of Bitcoin mining. *Environmental Science & Technology*, 53(23), 13598–13606.
78. Truby, J. (2018). Decarbonizing Bitcoin: Law and policy choices for reducing the energy consumption of Blockchain technologies and digital currencies. *Energy Research & Social Science*, 44, 399–410.
79. Sedlmeir, J., Buhl, H. U., Fridgen, G., & Keller, R. (2020). The energy consumption of blockchain technology: Beyond myth. *Business & Information Systems Engineering*, 62, 599–608.
80. Saleh, F. (2021). Blockchain without waste: Proof-of-stake. *Review of Financial Studies*, 34(3), 1156–1190.
81. De Filippi, P., & Wright, A. (2018). *Blockchain and the Law: The Rule of Code*. Harvard University Press.
82. Werbach, K. (2018). *The Blockchain and the New Architecture of Trust*. MIT Press.
83. Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ*, 372, n160.
84. Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, 14(3), 207–222.