

BLOCKCHAIN AND FINANCIAL REGULATION: A CRITICAL REVIEW OF LEGAL APPROACHES**Dr Mrityunjai Pandey*¹ and Dr Dharmendra Kumar Dubey²**

Abstract: Blockchain technology has rapidly transformed the architecture of modern financial systems by introducing decentralised, transparent, and cryptographically secure mechanisms for recording and validating transactions. Initially conceptualised as the underlying technology for cryptocurrencies, blockchain has evolved into a foundational infrastructure supporting a wide range of financial innovations, including decentralised finance (DeFi), smart contracts, stablecoins, tokenised securities, and cross-border payment systems. These developments challenge traditional financial regulatory frameworks that are premised on centralised intermediaries, jurisdictional boundaries, and institutional accountability. As blockchain-based financial activities continue to expand globally, regulators face the complex task of balancing technological innovation with the imperatives of financial stability, consumer protection, market integrity, and regulatory compliance. The decentralised and borderless nature of blockchain technology creates significant legal and regulatory challenges. Unlike conventional financial systems, blockchain networks often operate without identifiable intermediaries, making it difficult to assign legal responsibility, enforce compliance, and apply existing licensing and supervisory mechanisms. Issues related to jurisdiction, governance, accountability, and dispute resolution are further complicated by the pseudonymous or anonymous nature of blockchain participants. Additionally, blockchain-based financial platforms raise concerns regarding anti-money laundering and counter-terrorism financing, data protection and privacy, cybersecurity risks, and systemic financial instability. High-profile failures of cryptocurrency exchanges, algorithmic stablecoins, and decentralised protocols have underscored the urgent need for effective regulatory oversight while simultaneously revealing the limitations of traditional legal approaches when applied to decentralised systems.

The paper further explores the tension between innovation and regulation, emphasising the risks of both regulatory overreach and under-regulation. Excessively restrictive regulatory frameworks may stifle innovation, deter investment, and undermine the potential benefits of blockchain technology, including enhanced efficiency, financial inclusion, and transparency. Conversely, insufficient regulation exposes consumers and markets to fraud, manipulation, and systemic risk. The paper concludes by advocating for adaptive, technology-neutral, and risk-based regulatory frameworks that recognise the distinctive features of blockchain technology while upholding core principles of financial regulation. It emphasises the importance of international regulatory coordination, regulatory sandboxes, and flexible compliance mechanisms to ensure effective oversight without hindering innovation. By critically evaluating existing legal approaches, this study contributes to ongoing scholarly and policy debates on how law can evolve to govern blockchain-enabled financial systems in a manner that promotes innovation, safeguards fundamental rights, and preserves financial stability in an increasingly digital global economy.

Keywords: Blockchain, Financial Regulation, Cryptocurrencies, DeFi, Legal Frameworks, Comparative Regulation

Introduction: Blockchain technology has emerged as one of the most disruptive innovations in the contemporary financial ecosystem. Originally introduced in 2008 through Bitcoin as a peer-to-peer electronic cash system, blockchain has evolved far beyond cryptocurrencies to become a foundational infrastructure for a wide range of financial applications. These include decentralised finance (DeFi), smart contracts, tokenisation of assets, stablecoins, and cross-border payment systems. By enabling decentralised, transparent, and tamper-resistant transactions without reliance on traditional intermediaries, blockchain challenges the core assumptions upon which conventional financial regulation is built. Traditional financial regulatory frameworks are designed around centralised institutions such as banks, stock exchanges, clearing houses, and payment service providers. These frameworks rely on identifiable intermediaries, territorial jurisdiction, licensing mechanisms, and hierarchical supervision. Blockchain-based financial systems, by contrast, operate on decentralised networks that often lack a central controlling authority and function across multiple jurisdictions simultaneously. This structural divergence creates significant legal and regulatory challenges related to jurisdiction, accountability, enforcement, and compliance with existing financial laws.

The rapid expansion of blockchain-based financial activities has exposed gaps in regulatory oversight, particularly in areas such as consumer and investor protection, market integrity, anti-money laundering (AML) and counter-terrorism financing (CTF), data protection, and financial stability. High-profile

incidents involving cryptocurrency exchange failures, market manipulation, cyberattacks, and fraudulent token offerings have intensified concerns among regulators and policymakers worldwide. At the same time, overly restrictive regulatory responses risk stifling innovation and undermining the potential benefits of blockchain technology, including financial inclusion, operational efficiency, and transparency. In response to these challenges, jurisdictions have adopted divergent regulatory approaches. Some, such as the European Union, have sought to establish comprehensive and harmonised frameworks through instruments like the Markets in Crypto-Assets Regulation (MiCA). Others, including the United States, rely on fragmented, agency-driven enforcement under existing financial laws, leading to regulatory uncertainty. Emerging economies such as India have adopted cautious and evolving approaches, balancing innovation with systemic risk concerns. These varying responses highlight the absence of a uniform global regulatory framework for blockchain-based finance.

This paper undertakes a critical review of blockchain and financial regulation by examining the conceptual foundations of blockchain technology, identifying key regulatory challenges, and comparing legal approaches adopted by major jurisdictions. It evaluates the effectiveness of existing regulatory models in addressing blockchain-specific risks while preserving innovation. The study argues that effective regulation of blockchain-based financial systems requires adaptive, risk-based, and internationally coordinated legal frameworks that reconcile technological innovation with fundamental principles of financial stability, consumer protection, and the rule of law.

Literature Review: The existing body of literature on blockchain and financial regulation reflects the interdisciplinary nature of the subject, encompassing legal theory, financial regulation, economics, and computer science. Scholars have extensively examined the transformative potential of blockchain technology while simultaneously highlighting the

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regulatory challenges it poses to traditional financial systems. The literature can broadly be categorised into studies focusing on the technological foundations of blockchain, regulatory responses to cryptocurrencies and decentralised finance, consumer and investor protection concerns, and comparative and international regulatory approaches.

Early scholarly work on blockchain technology primarily emphasised its technical architecture and disruptive potential. Nakamoto's foundational work introduced blockchain as a decentralised, trustless system capable of enabling peer-to-peer financial transactions without intermediaries. Subsequent studies expanded on this concept by exploring how distributed ledger technology could reduce transaction costs, increase transparency, and enhance efficiency in financial markets. Legal scholars later began to examine how this technological shift challenges core legal concepts such as trust, contractual enforcement, and institutional accountability within financial systems. A significant strand of literature focuses on the regulatory implications of cryptocurrencies. Authors such as De Filippi and Wright argue that blockchain undermines the intermediary-centric model of financial regulation, necessitating a rethinking of legal frameworks. They highlight that existing securities, banking, and payment laws were not designed to regulate decentralised digital assets. Similarly, Arner, Barberis, and Buckley emphasise the emergence of FinTech and RegTech as both a challenge and an opportunity for financial regulators, suggesting that technology itself may assist in regulatory compliance and supervision.

Another substantial body of research addresses decentralised finance (DeFi) and smart contracts. Scholars have examined how DeFi platforms replicate traditional financial functions—such as lending, trading, and derivatives—without central governance. Werbach and Cornell argue that smart contracts blur the distinction between legal agreements and computer code, raising questions about enforceability, liability, and regulatory oversight. These studies highlight the difficulty of

applying conventional regulatory tools to autonomous systems that operate beyond direct human control.

Consumer and investor protection is a recurring theme in the literature. Numerous studies document the risks associated with blockchain-based financial products, including volatility, fraud, cybersecurity vulnerabilities, and information asymmetry. Zetsche et al. analyse initial coin offerings (ICOs) and demonstrate how inadequate disclosure and regulatory oversight expose investors to significant risks. Scholars emphasise the need for tailored regulatory safeguards to protect users without undermining innovation.

Anti-money laundering (AML) and counter-terrorism financing (CTF) compliance has also received considerable scholarly attention. Research by the Financial Action Task Force and academic commentators highlights the challenges of applying AML/CTF obligations to pseudonymous and decentralised systems. While blockchain's transparency offers potential benefits for traceability, the absence of central intermediaries complicates customer due diligence and enforcement. The literature suggests that existing AML frameworks require adaptation to address blockchain-specific risks.

Comparative and international regulatory analyses form an important component of the literature. Studies comparing regulatory approaches in the European Union, United States, and Asia reveal divergent strategies ranging from comprehensive legislative frameworks to enforcement-based regulation. Authors analysing the EU's Markets in Crypto-Assets Regulation view it as a step toward harmonisation and legal certainty, while critics question its effectiveness in regulating decentralised systems. In contrast, literature on the U.S. approach highlights regulatory uncertainty resulting from overlapping agency jurisdiction and reliance on judicial interpretation.

Despite the growing body of scholarship, significant gaps remain. Much of the literature focuses on specific aspects of blockchain regulation, such as cryptocurrencies or ICOs, without offering a holistic

evaluation of blockchain-based financial systems. Additionally, there is limited consensus on how to balance innovation with regulatory objectives such as financial stability and consumer protection. This study seeks to address these gaps by providing a comprehensive and critical review of legal approaches to blockchain-based finance through a comparative and policy-oriented lens.

The literature demonstrates broad agreement on the disruptive potential of blockchain technology and the inadequacy of traditional regulatory frameworks to address decentralised financial systems. However, scholarly debates continue regarding the optimal regulatory model. This paper builds on existing literature by integrating comparative legal analysis with policy evaluation to propose adaptive regulatory strategies for blockchain-based financial systems.

Conceptual Framework of Blockchain and Financial Systems:

Blockchain is a form of distributed ledger technology (DLT) in which transaction records is maintained across a network of computers through consensus mechanisms. Key characteristics include decentralisation, immutability, transparency, and cryptographic security. In the financial sector, blockchain supports cryptocurrencies, decentralised exchanges, stablecoins, and programmable smart contracts. These applications reduce reliance on intermediaries but also create legal uncertainty regarding governance, liability, and dispute resolution. The conceptual framework of blockchain and financial systems is grounded in the interaction between decentralised technological architecture and traditionally centralised financial institutions. Blockchain technology functions as a distributed ledger system in which transactions are recorded in a secure, transparent, and immutable manner across a network of participants. Unlike conventional databases controlled by a single authority, blockchain relies on cryptographic techniques, consensus mechanisms, and peer-to-peer networking to validate and record transactions without the need for trusted intermediaries. This foundational shift

has profound implications for the structure, governance, and regulation of financial systems.

At the core of blockchain technology lies the concept of decentralisation. In traditional financial systems, trust is institutional and hierarchical, vested in regulated entities such as banks, clearing houses, and payment service providers. Blockchain replaces institutional trust with algorithmic trust, where consensus protocols—such as Proof of Work (PoW), Proof of Stake (PoS), and other variants—ensure the integrity and authenticity of transactions. This decentralised trust model enables participants to transact directly, reducing reliance on intermediaries and potentially lowering transaction costs, increasing speed, and enhancing transparency. Blockchain-based financial systems encompass a broad range of applications. Cryptocurrencies represent the most well-known use case, functioning as digital assets that can be transferred and stored without central bank involvement. Beyond cryptocurrencies, decentralised finance (DeFi) platforms facilitate lending, borrowing, trading, and derivatives through smart contracts—self-executing agreements coded on the blockchain. Tokenisation allows real-world assets such as securities, real estate, and commodities to be represented digitally on a blockchain, thereby improving liquidity and accessibility. Stablecoins, which are designed to maintain price stability by pegging their value to fiat currencies or other assets, serve as a bridge between traditional finance and decentralised ecosystems. The integration of blockchain into financial systems challenges the traditional regulatory paradigm. Financial regulation is typically built on identifiable intermediaries who are subject to licensing, supervision, and compliance obligations. Blockchain networks often lack a central governing entity, making it difficult to determine who bears legal responsibility for regulatory compliance, risk management, and consumer protection. Developers, miners or validators, platform operators, and users may all play roles in the ecosystem, yet none may exercise complete control. This diffusion of responsibility complicates the application of existing

legal concepts such as fiduciary duty, liability, and regulatory accountability.

Another critical component of the conceptual framework is the tension between transparency and privacy. Blockchain ledgers are inherently transparent, allowing transactions to be publicly verified. While this transparency enhances auditability and trust, it raises concerns regarding data protection, confidentiality, and compliance with privacy regulations. Financial systems traditionally rely on controlled disclosure and confidentiality obligations, particularly in relation to customer data. Reconciling blockchain transparency with data protection principles, such as purpose limitation and the right to erasure, remains a significant conceptual and legal challenge. The framework also encompasses issues of governance and standard-setting. In the absence of central authority, governance in blockchain-based financial systems is often achieved through protocol rules, community consensus, and, in some cases, decentralised autonomous organisations (DAOs). These governance models differ fundamentally from regulatory governance in traditional finance, which is exercised by state authorities and supervisory agencies. The interaction between decentralised governance mechanisms and state-based regulation raises complex questions regarding legitimacy, enforceability, and regulatory oversight. From a systemic perspective, blockchain technology has the potential to both enhance and threaten financial stability. On one hand, distributed ledgers can improve resilience by eliminating single points of failure and increasing transparency. On the other hand, the volatility of crypto-assets, interconnectedness of DeFi platforms, and lack of effective risk controls may amplify systemic risks. The conceptual framework must therefore account for the dual role of blockchain as both an enabler of financial innovation and a source of new regulatory and systemic challenges.

In sum, the conceptual framework of blockchain and financial systems reflects a dynamic interaction between technological innovation and legal regulation. Blockchain redefines fundamental

concepts of trust, intermediation, governance, and accountability within finance. Understanding this framework is essential for developing regulatory approaches that can effectively address the unique risks and opportunities posed by blockchain-based financial systems while preserving the core objectives of financial regulation, including stability, fairness, transparency, and consumer protection.

Regulatory Challenges in Blockchain-Based Finance: The rapid expansion of blockchain-based financial systems has exposed fundamental limitations within existing regulatory frameworks. Financial regulation has traditionally evolved around centralised intermediaries, clearly identifiable legal entities, and territorially defined jurisdictions. Blockchain-based finance, however, operates through decentralised networks that transcend national boundaries and rely on automated protocols rather than institutional oversight. This structural divergence gives rise to a range of complex regulatory challenges that existing legal frameworks are ill-equipped to address.

Jurisdictional Uncertainty and Cross-Border Transactions: One of the most significant regulatory challenges in blockchain-based finance is jurisdictional uncertainty. Blockchain networks operate globally, with nodes, developers, users, and validators often located across multiple jurisdictions. Traditional regulatory frameworks rely on territorial jurisdiction to enforce compliance and supervision. In decentralised systems, determining the applicable law, regulatory authority, and forum for dispute resolution becomes inherently complex. This ambiguity complicates enforcement actions and creates opportunities for regulatory arbitrage, where entities structure operations to exploit differences between national regulatory regimes.

Absence of Identifiable Intermediaries: Conventional financial regulation is predicated on the presence of intermediaries such as banks, brokers, and exchanges, which are subject to licensing, capital requirements, and ongoing supervision. Blockchain-based finance often eliminates or significantly reduces the role of

intermediaries. In decentralised finance (DeFi), financial services are provided through smart contracts that operate autonomously once deployed. The absence of a clearly identifiable entity responsible for compliance creates challenges in assigning legal liability, enforcing regulatory obligations, and ensuring accountability for misconduct or system failures.

Consumer and Investor Protection: Protecting consumers and investors is a core objective of financial regulation. Blockchain-based financial products frequently expose users to heightened risks, including extreme price volatility, market manipulation, cybersecurity threats, and smart contract vulnerabilities. Unlike traditional financial markets, blockchain-based platforms often lack disclosure requirements, suitability assessments, and investor safeguards. Users may have limited recourse in the event of fraud, system malfunction, or loss of assets. The decentralised and pseudonymous nature of blockchain transactions further complicates the enforcement of consumer protection laws.

Anti-Money Laundering and Counter-Terrorism Financing: Compliance with anti-money laundering (AML) and counter-terrorism financing (CTF) obligations presents another major regulatory challenge. Blockchain transactions can be conducted pseudonymously, enabling the movement of funds without direct identification of parties. While blockchain ledgers are transparent, linking addresses to real-world identities remains difficult. Decentralised platforms often lack a central authority capable of implementing customer due diligence, transaction monitoring, and reporting obligations. This undermines the effectiveness of existing AML/CTF frameworks and raises concerns regarding illicit financial activities.

Data Protection and Privacy Concerns: Blockchain technology presents unique challenges for data protection and privacy regulation. Public blockchains record transaction data in an immutable and transparent manner, which may conflict with data protection principles such as purpose limitation, data minimization, and the right to erasure.

Financial systems traditionally rely on controlled access to sensitive personal and financial data. Ensuring compliance with data protection laws in a decentralized and immutable environment remains a complex regulatory issue, particularly where personal data is stored or processed on-chain.

Technological Complexity and Regulatory Capacity: The technical complexity of blockchain systems poses challenges for regulatory capacity and expertise. Regulators must understand rapidly evolving technologies, consensus mechanisms, cryptographic tools, and decentralised governance models to effectively supervise blockchain-based finance. Many regulatory authorities face resource constraints and skill gaps, limiting their ability to assess risks, monitor compliance, and respond to technological innovation. This asymmetry between technological development and regulatory understanding can undermine effective oversight.

Financial Stability and Systemic Risk: Blockchain-based finance raises concerns regarding financial stability and systemic risk. The growing interconnectedness of crypto-asset markets, decentralised lending platforms, and stablecoins may transmit shocks across the financial system. The absence of prudential regulation, capital buffers, and lender-of-last-resort mechanisms in decentralised systems increases vulnerability to market crashes and liquidity crises. The collapse of major crypto-asset platforms has highlighted the potential for contagion effects and broader market disruption.

Enforcement and Accountability Challenges: Enforcing financial regulation in blockchain-based systems remains a persistent challenge. Smart contracts operate automatically and may execute transactions even when they result in regulatory breaches. Identifying responsible parties—such as developers, protocol governors, or users—raises difficult questions of legal attribution. Traditional enforcement mechanisms, including sanctions and injunctions, may be ineffective against decentralised networks lacking a central point of control. The regulatory challenges in blockchain-based finance stem from the fundamental mismatch

between decentralised technological architectures and centralised regulatory frameworks. Addressing these challenges requires rethinking traditional legal concepts of jurisdiction, intermediation, accountability, and supervision. Effective regulation must strike a balance between mitigating risks and fostering innovation, ensuring that blockchain-based financial systems operate in a manner consistent with public interest objectives.

Comparative Legal Approaches to Blockchain and Financial Regulation: The regulation of blockchain-based financial systems has evolved unevenly across jurisdictions, reflecting differing legal traditions, policy priorities, and levels of technological adoption. While some jurisdictions have enacted comprehensive legislative frameworks tailored specifically to crypto-assets and decentralised finance, others continue to rely on the application of existing financial laws through regulatory interpretation and enforcement. A comparative analysis of these approaches reveals both convergence and divergence in regulatory strategies and highlights the absence of a uniform global framework.

European Union: Comprehensive and Harmonized Regulation: The European Union has adopted one of the most comprehensive and proactive regulatory approaches to blockchain-based finance. The introduction of the Markets in Crypto-Assets Regulation (MiCA) represents a landmark effort to create a harmonized legal framework governing crypto-assets across all EU member states. MiCA establishes clear definitions for different categories of crypto-assets, including asset-referenced tokens, e-money tokens, and utility tokens, and imposes licensing, disclosure, and governance requirements on crypto-asset service providers. A key strength of the EU approach lies in its emphasis on legal certainty and consumer protection. By providing uniform rules across member states, MiCA reduces regulatory fragmentation and limits opportunities for regulatory arbitrage. The framework also integrates prudential safeguards, transparency obligations, and market abuse provisions, aligning blockchain-based finance with broader financial regulatory objectives.

However, critics argue that MiCA may struggle to address decentralised finance platforms that lack identifiable issuers or service providers, leaving gaps in the regulation of fully decentralised protocols.

United States: Fragmented and Enforcement-Driven Regulation: The United States has adopted a fragmented and enforcement-oriented approach to blockchain and financial regulation. Rather than enacting a dedicated federal statute for crypto-assets, U.S. regulators apply existing securities, commodities, and banking laws to blockchain-based financial activities. Agencies such as the Securities and Exchange Commission (SEC), the Commodity Futures Trading Commission (CFTC), and the Financial Crimes Enforcement Network (FinCEN) assert overlapping jurisdiction based on the nature of the asset or activity. This approach provides regulatory flexibility but has resulted in significant legal uncertainty. The classification of crypto-assets as securities, commodities, or payment instruments often depends on case-by-case analysis, leading to inconsistent outcomes. Enforcement actions against crypto-asset issuers and exchanges have played a central role in shaping regulatory boundaries. While this model allows regulators to respond quickly to emerging risks, it has been criticised for lacking clarity, predictability, and comprehensive consumer protection standards.

United Kingdom: Principles-Based and Adaptive Regulation: The United Kingdom has adopted a principles-based regulatory approach that seeks to balance innovation with risk management. The Financial Conduct Authority (FCA) regulates crypto-asset activities primarily through existing financial services laws, supplemented by targeted rules for specific activities such as crypto-asset exchanges and custodial services. The UK has also established regulatory sandboxes that allow blockchain-based firms to test innovative products under regulatory supervision. This flexible framework enables adaptation to technological developments while maintaining oversight. However, the reliance on existing legal categories has limited the scope of regulation for decentralised

finance and non-custodial services. The UK approach reflects a cautious regulatory philosophy that prioritises market integrity and consumer protection without imposing overly prescriptive rules.

Emerging Economies: Cautious and Evolving Frameworks: Emerging economies have generally adopted cautious and evolving approaches to blockchain-based finance. In India, regulatory responses have fluctuated between restriction and accommodation. While cryptocurrencies are not recognised as legal tender, regulatory authorities have emphasised taxation, AML compliance, and consumer risk warnings. The absence of comprehensive legislation has resulted in uncertainty for market participants. Other emerging jurisdictions have pursued regulatory experimentation. Countries such as Singapore and Japan have introduced licensing regimes for crypto-asset service providers, focusing on AML compliance and operational resilience. These approaches aim to foster innovation while mitigating financial and systemic risks, reflecting a pragmatic regulatory strategy.

International and Soft Law Approaches: At the international level, standard-setting bodies such as the Financial Action Task Force (FATF), the International Organization of Securities Commissions (IOSCO), and the Bank for International Settlements (BIS) have issued guidelines and recommendations on crypto-asset regulation. These soft law instruments promote regulatory consistency by establishing minimum standards for AML compliance, investor protection, and systemic risk management. However, the non-binding nature of these standards limits their effectiveness and leads to uneven implementation across jurisdictions.

Comparative Assessment: Comparative analysis reveals that no single regulatory model fully addresses the complexities of blockchain-based finance. Comprehensive legislative frameworks provide legal certainty but may struggle to regulate decentralised systems effectively. Enforcement-driven models offer flexibility but create uncertainty

and inconsistency. Principles-based approaches promote innovation but may leave regulatory gaps. The diversity of approaches underscores the need for international coordination and adaptive regulatory strategies that can respond to technological change while safeguarding public interest objectives.

Comparative legal approaches demonstrate that blockchain-based finance challenges traditional regulatory paradigms across jurisdictions. Effective regulation requires a balanced approach that integrates clear legal standards, flexible supervision, and international cooperation. By learning from comparative experiences, policymakers can develop regulatory frameworks that support innovation while ensuring financial stability, consumer protection, and market integrity.

Results & Discussion

Results: The analysis of blockchain-based financial systems and their regulatory treatment across jurisdictions reveals significant findings regarding the effectiveness, limitations, and future direction of legal frameworks. The results of this study emerge from a comparative evaluation of regulatory approaches, doctrinal legal analysis, and policy developments, and they highlight the complex interaction between technological innovation and financial regulation.

Fragmentation of Regulatory Frameworks: One of the most prominent findings is the fragmentation of regulatory approaches across jurisdictions. While certain regions, such as the European Union, have adopted comprehensive and harmonised frameworks, others rely on piecemeal or enforcement-driven models. This fragmentation creates legal uncertainty for market participants operating in multiple jurisdictions and encourages regulatory arbitrage. Blockchain-based financial entities often structure operations to take advantage of regulatory gaps or inconsistencies, thereby undermining the effectiveness of national regulatory controls. The lack of uniformity also complicates cross-border enforcement and cooperation. Decentralised financial activities frequently transcend national boundaries, yet regulatory

oversight remains largely territorial. As a result, regulatory actions in one jurisdiction may have limited impact on global blockchain networks, reducing deterrence and compliance effectiveness.

Effectiveness of Existing Legal Frameworks: The study indicates that existing financial laws, when applied to blockchain-based systems, are only partially effective. Traditional legal concepts such as licensing, disclosure, fiduciary duty, and capital adequacy were developed for centralised intermediaries and do not seamlessly translate to decentralised platforms. Enforcement-based approaches, particularly in jurisdictions such as the United States, have clarified certain legal boundaries but have failed to provide comprehensive guidance for emerging technologies such as decentralised finance and autonomous protocols. Conversely, comprehensive frameworks like the EU's Markets in Crypto-Assets Regulation have enhanced legal certainty and consumer protection but face challenges in regulating decentralised systems that lack identifiable issuers or service providers. This suggests that while legislative clarity is valuable, overly rigid regulatory models may struggle to keep pace with technological evolution.

Consumer and Investor Protection Outcomes: The results demonstrate that consumer and investor protection remains inconsistent across blockchain-based financial markets. Jurisdictions with licensing and disclosure requirements provide greater safeguards, including transparency obligations and accountability mechanisms. However, decentralised platforms often fall outside these regulatory protections, leaving users exposed to risks such as fraud, market manipulation, and technological failures. High-profile collapses of crypto-asset platforms and decentralised protocols illustrate the consequences of regulatory gaps. These events have resulted in significant financial losses for users and have highlighted the absence of effective redress mechanisms. The findings suggest that current regulatory models inadequately address user protection in fully decentralised environments.

AML, Compliance, and Enforcement Challenges: The analysis confirms persistent difficulties in

applying anti-money laundering and counter-terrorism financing obligations to blockchain-based finance. While centralised exchanges and custodial service providers have increasingly adopted compliance measures, decentralised platforms lack the institutional capacity to implement customer due diligence and transaction monitoring. This creates vulnerabilities in the global financial system and raises concerns regarding illicit financial activities. Enforcement challenges are compounded by the pseudonymous nature of blockchain transactions and the absence of central control points. Regulatory authorities often rely on indirect measures, such as targeting intermediaries or developers, which may not fully address underlying risks.

Discussion: The discussion highlights the central tension between innovation and regulation. Overly restrictive regulation may hinder technological development and limit the potential benefits of blockchain, including financial inclusion and efficiency. Conversely, insufficient regulation exposes markets and users to significant risks. The study finds that neither extreme is desirable. Effective regulation requires adaptive, technology-neutral, and risk-based approaches that recognise the unique features of blockchain technology. International coordination, regulatory sandboxes, and flexible compliance mechanisms emerge as key tools for addressing regulatory challenges while supporting innovation.

The results underscore the need for regulatory reform that moves beyond traditional, institution-centric models. Policymakers must reconsider legal concepts of accountability, governance, and supervision in decentralised environments. Collaborative regulatory frameworks, informed by comparative experience and international standards, offer the most promising path forward.

The results and discussion reveal that current regulatory approaches to blockchain-based finance are fragmented, incomplete, and often ill-suited to decentralised systems. While progress has been made in enhancing legal certainty and consumer protection, significant gaps remain. Addressing these challenges requires adaptive legal frameworks,

international cooperation, and a nuanced balance between innovation and regulatory oversight..

Conclusion and Future Scope: Blockchain technology is poised to play a central role in the future of global finance. Effective regulation is essential to harness its benefits while mitigating risks. Policymakers should adopt adaptive, risk-based, and internationally coordinated regulatory frameworks. Future research should focus on harmonisation of global standards, regulation of decentralised finance, and the legal implications of central bank digital currencies (CBDCs).

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