

A Proposed Framework for Sharia-Compliant Cross-Border Transactions Using Blockchain and Smart Contracts in Indonesia

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Abstract

This study aims to develop a hybrid Sharia governance framework for blockchain-enabled cross-border Islamic financial transactions in Indonesia. Specifically, the study seeks to address persistent operational inefficiencies, compliance ambiguities, and governance challenges associated with conventional cross-border Islamic finance by integrating blockchain technology, smart contracts, and institutional Sharia oversight. This study adopts a conceptual research design underpinned by a pragmatist research philosophy and an abductive research approach. The proposed framework was developed through a systematic synthesis of secondary data from peer-reviewed academic literature, regulatory documents, industry reports, and technical documentation on Islamic finance, blockchain technology, smart contracts, and financial regulation. A thematic analysis was employed to identify key challenges, governance requirements, and technological capabilities relevant to blockchain-enabled Islamic finance. The findings suggest that blockchain technology can substantially improve the efficiency, transparency, and security of cross-border Islamic financial transactions by reducing intermediaries, automating contractual execution, and creating immutable transaction records. However, the study also reveals that technological automation alone is insufficient to ensure continuous Sharia compliance because smart contracts cannot fully accommodate jurisprudential interpretation and contextual judgement. Consequently, the study proposes a Hybrid Sharia Governance Model integrating on-chain automation with off-chain oversight involving Sharia scholars, technical auditors, legal experts, and regulatory authorities. The framework further operationalizes a cross-border Mudarabah smart contract workflow tailored to Indonesia's legal and institutional environment. This study contributes to the emerging Islamic FinTech literature by proposing one of the first context-specific governance frameworks integrating technological, regulatory, and Sharia dimensions within a single operational architecture for Indonesia. The study further advances the hybrid governance perspective by demonstrating that technological trust and institutional trust should function as complementary mechanisms in blockchain-based Islamic finance.

Keywords: Islamic finance; blockchain; smart contracts; Sharia governance; cross-border transactions; Islamic FinTech; Mudarabah; Indonesia.

A. INTRODUCTION

The global Islamic finance industry has experienced substantial growth over the past decade, driven by increasing demand for ethical, socially responsible, and Sharia-compliant financial products. Global Islamic financial assets are projected to exceed US\$7.5 trillion by 2028, reflecting the increasing significance of Islamic finance within the international financial system (Standard Chartered, 2024). This remarkable expansion has intensified the need for more efficient, transparent, and resilient financial infrastructures capable of supporting increasingly complex cross-border transactions. Cross-border activities, including trade financing, remittances, investment flows, and syndicated financing, constitute a critical component of the contemporary Islamic financial ecosystem. However, despite its rapid expansion, the operational infrastructure underpinning cross-border Islamic finance remains predominantly dependent on conventional correspondent banking systems (Hassan & Al-Saleem, 2022).

Traditional cross-border financial systems are frequently characterized by multiple intermediaries, fragmented information flows, prolonged settlement periods, and significant transaction costs (Benschop & van der Linden, 2019). These inefficiencies are particularly problematic in Islamic finance, where transactions must comply not only with commercial requirements but also with the principles of Sharia. Existing correspondent banking arrangements often involve several intermediary institutions, each introducing additional processing delays, operational costs, and reconciliation requirements (Financial Stability Board, 2020). Consequently, cross-border Islamic financial transactions frequently encounter operational frictions that undermine efficiency and limit market competitiveness. Furthermore, fragmented transaction records across multiple institutions create

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significant challenges for maintaining transparent, continuous Sharia compliance throughout the transaction lifecycle (Zamani & Abdullah, 2021).

Ensuring Sharia compliance becomes even more challenging in cross-border contexts involving multiple jurisdictions, legal systems, and regulatory authorities. Islamic financial transactions must strictly adhere to the prohibition of *riba* (interest), *gharar* (excessive uncertainty), and *maysir* (gambling), while simultaneously promoting transparency, fairness, and accountability (El-Gamal, 2006). However, the opacity inherent in conventional financial infrastructures often complicates the ability of Sharia Supervisory Boards (SSBs) to conduct timely and comprehensive audits of transaction processes (Hassan & Al-Saleem, 2022). The absence of a unified and immutable source of transactional information increases the risk of compliance ambiguity, reputational damage, and governance failures. As Islamic financial institutions increasingly participate in global markets, addressing these challenges has become a strategic imperative.

Recent advancements in financial technology, particularly blockchain and smart contract technologies, have attracted considerable scholarly and industrial attention as potential solutions to longstanding inefficiencies in financial intermediation. Blockchain technology offers a decentralized, immutable, and transparent distributed ledger that facilitates secure peer-to-peer transactions without relying heavily on centralized intermediaries (Nakamoto, 2008; Glaser, 2017). By leveraging cryptographic mechanisms and consensus protocols, blockchain can significantly enhance transparency, traceability, and security within financial transactions (Tapscott & Tapscott, 2017). Complementing blockchain technology, smart contracts—self-executing agreements encoded in computer code—automate contractual obligations, thereby reducing operational costs, minimizing human intervention, and accelerating settlement processes (Szabo, 1997; Buterin, 2014).

A growing body of literature has explored the applicability of blockchain and smart contracts within Islamic finance. Existing studies suggest that blockchain's inherent characteristics of transparency and immutability align closely with key Sharia principles, particularly *amanah* (trustworthiness) and the reduction of *gharar* (Khan & Ahmed, 2023). Moreover, distributed ledger technologies have demonstrated considerable potential to reduce transaction costs and enhance efficiency in cross-border financial transactions (Harvey et al., 2021; Chen & Wu, 2022). Nevertheless, significant challenges remain. The deterministic and immutable nature of smart contracts may conflict with the interpretative flexibility and contextual judgement embedded within Islamic jurisprudence (Rahman, 2022). In particular, issues related to oracle reliability, contractual renegotiation, dispute resolution, and Sharia certification continue to constrain the practical implementation of blockchain-based Islamic financial solutions (Abdullah & Oseni, 2019; Farooq & Al-Suwaidi, 2021).

These challenges are particularly salient in Indonesia, the world's largest Muslim-majority country and an increasingly important actor in the global Islamic economy. Indonesia has explicitly articulated its ambition to become a leading global hub for the Islamic digital economy (Ministry of Finance, 2023). Despite this ambition, the country's Islamic financial sector continues to face substantial technological, institutional, and regulatory constraints. The regulatory framework governing digital financial innovation remains fragmented across multiple authorities, primarily Bank Indonesia (BI) and the Financial Services Authority (OJK), while comprehensive standards governing blockchain-based Islamic finance remain underdeveloped (OJK, 2022). Additionally, limited technical expertise and the absence of standardized Sharia governance mechanisms for digital financial technologies hinder broader institutional adoption.

Despite the increasing scholarly interest in blockchain-enabled Islamic finance, important knowledge gaps remain unresolved. Existing studies predominantly examine either the technological capabilities of blockchain and smart contracts or the Sharia compliance implications of digital financial innovation as separate streams of inquiry. Consequently, insufficient attention has been devoted to integrating technological, governance, regulatory, and Sharia dimensions into a comprehensive operational framework capable of supporting real-world cross-border Islamic financial transactions. Furthermore, although hybrid governance mechanisms have been conceptually discussed (Farooq & Al-Suwaidi, 2021; Khan & Ahmed, 2023), the literature offers limited guidance on operationalizing such arrangements in emerging markets characterized by complex institutional environments.

This limitation is particularly evident in Indonesia, where blockchain adoption in Islamic finance must simultaneously satisfy regulatory requirements imposed by Bank Indonesia and OJK while maintaining compliance with the Sharia governance framework administered by the National Sharia Council (DSN-MUI). To date, no study has proposed an integrated governance architecture that explicitly accommodates these institutional interactions within a blockchain-enabled cross-border Islamic finance ecosystem. This omission represents a significant theoretical and practical gap because governance mechanisms ultimately determine whether

technological innovation can be translated into institutionally legitimate and operationally feasible financial solutions.

Addressing this gap, this study develops a hybrid Sharia governance framework for blockchain-based cross-border Islamic financial transactions in Indonesia. Specifically, the study proposes an integrated model combining on-chain smart contract automation with off-chain human oversight involving Sharia scholars, technical auditors, legal experts, and regulatory institutions. The framework is illustrated through the development of a cross-border Mudarabah smart contract workflow that ensures operational efficiency, transparency, regulatory alignment, and continuous Sharia compliance. Theoretically, this study contributes to the growing literature on Islamic FinTech by advancing a context-specific governance architecture that reconciles technological automation with religious and institutional oversight. In practice, the proposed framework provides actionable guidance for Islamic financial institutions, regulators, and policymakers seeking to foster responsible digital innovation in Indonesia's Islamic finance sector.

Unlike previous studies that primarily emphasize either blockchain technology or Sharia compliance independently, this study integrates both perspectives into a unified governance architecture that links technological infrastructure, institutional oversight, and regulatory coordination. Accordingly, the study contributes to the Islamic FinTech literature in three ways. First, it develops a context-specific hybrid governance framework for blockchain-enabled cross-border Islamic finance in Indonesia. Second, it operationalizes the interaction between smart contract automation and institutional Sharia governance through a structured Mudarabah transaction workflow. Third, it provides practical guidance for regulators and Islamic financial institutions by demonstrating how technological innovation can be implemented without compromising regulatory legitimacy or Sharia compliance.

B. LITERATURE REVIEW

Cross-Border Islamic Finance: Operational Inefficiencies and Compliance Challenges

Cross-border financial transactions are a fundamental component of the contemporary global economy, facilitating international trade, investment, and remittance flows. Within Islamic finance, cross-border transactions are increasingly important due to the expansion of global trade networks, international Sukuk issuances, and transnational investment activities. Nevertheless, the existing infrastructure supporting cross-border Islamic finance remains predominantly dependent on conventional correspondent banking arrangements that have changed little over recent decades (Benschop & van der Linden, 2019). Although these infrastructures have supported the international expansion of Islamic financial institutions, they were originally designed for conventional financial systems rather than for transactions that require continuous Sharia oversight. This structural mismatch creates operational and governance challenges that become increasingly evident as Islamic finance expands across jurisdictions.

The traditional correspondent banking model relies on multiple intermediary institutions to process and settle international transactions. Although functional, this architecture introduces considerable inefficiencies in terms of cost, speed, and transparency. Benschop and van der Linden (2019) report that a typical cross-border transaction may involve three to five intermediary banks, each imposing additional fees and processing requirements. Similarly, the Financial Stability Board (2020) identifies high transaction costs, extended settlement periods, and fragmented information systems as major frictions impeding the efficiency of international payment systems. Transaction settlements may require several business days, while transaction fees can represent a substantial proportion of transferred funds, particularly in developing economies. These operational inefficiencies are not merely technical limitations but also institutional constraints, as each additional intermediary introduces additional reconciliation processes, increases information asymmetry, and reduces transaction visibility across the payment chain.

These inefficiencies are particularly problematic in Islamic finance, where Sharia-compliant transactions require additional layers of governance and supervision. Unlike conventional financial contracts, Islamic financial transactions must comply with a set of religious principles that prohibit *riba* (interest), *gharar* (excessive uncertainty), and *maysir* (gambling), while emphasizing transparency, fairness, and risk-sharing (El-Gamal, 2006). Consequently, Sharia compliance must be maintained continuously throughout the entire transaction lifecycle rather than merely at the contractual initiation stage. This requirement distinguishes Islamic finance from

conventional finance because contractual legitimacy depends not only on legal enforceability but also on the continuous preservation of ethical and religious principles during transaction execution.

However, the fragmented nature of conventional cross-border payment systems complicates the monitoring and verification of Sharia compliance. Hassan and Al-Saleem (2022) argue that the opacity characterizing correspondent banking networks makes it difficult for Sharia Supervisory Boards (SSBs) to conduct timely and comprehensive audits of transaction flows. Transaction information is typically distributed across multiple institutional ledgers, requiring extensive reconciliation procedures and increasing operational complexity (Zamani & Abdullah, 2021). Such fragmentation may create ambiguity about the actual performance of contractual obligations, thereby increasing the risk of Sharia non-compliance and reputational damage. Accordingly, the challenge extends beyond improving payment efficiency to ensuring that transaction records remain sufficiently transparent, traceable, and verifiable to support continuous Sharia governance.

Moreover, the increasing globalization of Islamic finance has intensified regulatory complexity. Cross-border transactions frequently involve multiple jurisdictions with differing legal systems, regulatory requirements, and Sharia interpretations. This multiplicity of governance arrangements may create inconsistencies in compliance standards and increase legal uncertainty. In the absence of a unified transactional infrastructure and standardized governance mechanisms, Islamic financial institutions face significant challenges in balancing operational efficiency with rigorous Sharia compliance requirements. These observations collectively suggest that operational inefficiency, regulatory fragmentation, and Sharia governance are closely interconnected rather than independent challenges. Addressing only one dimension is therefore unlikely to produce sustainable improvements in cross-border Islamic finance.

Taken together, the reviewed studies consistently indicate that existing cross-border payment infrastructures are constrained not only by technological limitations but also by governance deficiencies. This synthesis provides the conceptual foundation for examining whether emerging digital technologies, particularly blockchain and smart contracts, can simultaneously improve operational performance and strengthen governance mechanisms within Islamic finance.

Blockchain Technology and Smart Contracts in Financial Intermediation

Blockchain technology has emerged as one of the most transformative innovations in contemporary financial services. Introduced initially by Nakamoto (2008) in Bitcoin, blockchain is a decentralized, distributed ledger technology capable of recording transactions securely, transparently, and immutably without relying on centralized intermediaries. Unlike conventional financial infrastructures, characterized by siloed databases and institutional fragmentation, blockchain establishes a shared, synchronized ledger accessible to all authorized participants in the network (Glaser, 2017). These characteristics have positioned blockchain as a promising technological infrastructure for financial services that require high levels of transparency, traceability, and transactional integrity.

The core value proposition of blockchain lies in its ability to create trusted transactional environments through technological mechanisms rather than institutional intermediation. By combining cryptographic hashing, distributed consensus protocols, and immutable recordkeeping, blockchain enables participants to verify transactions independently while maintaining data integrity and security (Tapscott & Tapscott, 2017). This decentralized architecture substantially reduces information asymmetry and minimizes the need for extensive reconciliation processes that characterize traditional financial systems. Rather than replacing trust altogether, blockchain transforms the mechanism through which trust is established—from reliance on centralized intermediaries toward cryptographic verification and distributed consensus. This shift has profound implications for cross-border financial transactions, where trust among geographically dispersed parties is often difficult to establish efficiently.

The application of blockchain in financial intermediation has attracted significant scholarly attention because of its potential to improve operational efficiency. According to reports from international financial institutions, distributed ledger technologies can substantially reduce transaction costs and accelerate settlement processes within cross-border payments. These efficiency gains are particularly relevant for Islamic finance because they directly address several structural weaknesses associated with correspondent banking systems, including duplicated verification procedures, fragmented information flows, and prolonged settlement periods. The International Monetary Fund projects that digital payment innovations based on distributed ledger technologies could significantly reduce transaction costs associated with international financial transfers. Similarly, Juniper

Research estimates that blockchain deployment may generate substantial cost savings for global banking institutions by automating processes and reducing reliance on intermediaries.

Building upon blockchain infrastructure, smart contracts further extend the capabilities of distributed ledger systems. Smart contracts are self-executing computer programs that automatically perform contractual obligations when predetermined conditions are satisfied (Szabo, 1997). Implemented on blockchain platforms such as Ethereum (Buterin, 2014), smart contracts facilitate automated execution, verification, and enforcement of contractual arrangements without requiring manual intervention. Consequently, blockchain provides the underlying infrastructure for secure data recording, whereas smart contracts provide the operational logic that governs the execution of contractual obligations. Together, these technologies create an integrated digital environment capable of automating substantial portions of financial transactions.

The automation enabled by smart contracts offers several advantages for financial transactions. First, smart contracts reduce operational costs by eliminating intermediaries and minimizing manual processing. Second, they improve transaction speed by enabling near-instantaneous settlement once contractual conditions are fulfilled. Third, automation reduces counterparty risk because contractual obligations are executed objectively according to predefined rules rather than subjective human judgement (Harvey et al., 2021).

Empirical evidence further demonstrates the transformative potential of blockchain-based financial infrastructures. Chen and Wu (2022), for example, report that blockchain applications in syndicated lending can significantly reduce processing times compared with conventional systems. Collectively, these findings suggest that blockchain and smart contracts possess considerable capacity to improve operational efficiency while simultaneously increasing transparency and transactional certainty within cross-border financial ecosystems.

Despite these advantages, blockchain adoption in financial services is not without challenges. The existing literature identifies several technological limitations, including scalability constraints, interoperability issues, and cybersecurity vulnerabilities. Additionally, regulatory uncertainty remains a major barrier to institutional adoption, particularly in heavily regulated sectors such as financial services (OJK, 2022). More importantly, technological efficiency does not necessarily translate into institutional legitimacy. Financial systems operate within broader legal, regulatory, and governance environments that cannot be fully replicated through software code alone. Consequently, although blockchain may improve how transactions are executed, it does not automatically determine whether those transactions comply with legal requirements, regulatory expectations, or Sharia principles.

This distinction is particularly important in Islamic finance. While blockchain effectively addresses operational inefficiencies by improving transparency, security, and automation, the technology itself remains value-neutral. The determination of whether a transaction satisfies Sharia principles ultimately depends upon jurisprudential interpretation, institutional oversight, and regulatory approval rather than technological functionality alone. Therefore, the literature increasingly suggests that blockchain should be understood as an enabling infrastructure rather than a self-sufficient governance mechanism. This observation provides an important conceptual transition to the following section, which examines the interaction between smart contract automation and Sharia governance in the following section.

Sharia Principles and Smart Contract Logic

The integration of blockchain technology into Islamic finance has generated growing scholarly interest because of the apparent convergence between the ethical foundations of Islamic finance and the technological characteristics of distributed ledger systems. Islamic finance is fundamentally grounded in principles that promote justice ('adl), transparency (amanah), accountability, and equitable risk-sharing while prohibiting exploitative practices such as *riba*, *gharar*, and *maysir* (El-Gamal, 2006). Interestingly, many of these principles align closely with the inherent attributes of blockchain technology. This conceptual compatibility has encouraged scholars to view blockchain not merely as a financial technology but as an infrastructure capable of supporting the ethical objectives embedded within Islamic finance. Nevertheless, conceptual compatibility should not be equated with functional equivalence, as technological capabilities and Sharia governance operate under distinct institutional logics.

One of the most frequently discussed areas of compatibility concerns transparency. Blockchain technology maintains an immutable and shared ledger in which all authorized participants can access and verify transaction histories. Khan and Ahmed (2023) argue that such transparency is inherently consistent with the Islamic principle of *amanah*, which emphasizes honesty, disclosure, and accountability in commercial transactions. By reducing information asymmetry and ensuring transaction traceability, blockchain can significantly mitigate *gharar*, arising

from excessive uncertainty or ambiguity in contractual arrangements. Accordingly, blockchain has the potential to strengthen procedural compliance by improving the visibility and verifiability of financial transactions throughout their lifecycle.

In addition to transparency, blockchain-based systems may also strengthen accountability mechanisms within Islamic finance. Traditional financial systems rely primarily on institutional trust and intermediary oversight to ensure compliance and contractual fulfillment. In contrast, blockchain establishes trust through cryptographic verification and consensus mechanisms (Glaser, 2017). This technological approach to trust creation may enhance confidence among market participants and facilitate more efficient auditing processes. Hasan et al. (2022) further suggest that blockchain can improve governance and accountability in Islamic institutions by creating tamper-proof records that are continuously accessible for verification. These characteristics indicate that blockchain can substantially improve the operational environment in which Sharia governance is exercised by providing auditable and immutable evidence of transactional activities.

Despite these potential benefits, significant challenges remain in translating Islamic jurisprudential principles into executable computer code. Islamic financial contracts are governed by *fiqh al-muamalat*, a body of jurisprudence characterized by interpretative flexibility, contextual reasoning, and scholarly judgement. Smart contracts, by contrast, operate according to deterministic and binary logic in which contractual conditions are predefined and automatically executed without discretionary intervention (Szabo, 1997; Buterin, 2014). This difference represents a fundamental conceptual boundary between technological automation and Islamic jurisprudence. Whereas smart contracts execute predefined instructions with absolute consistency, Sharia compliance often depends upon contextual interpretation, evolving jurisprudential opinions, and the consideration of circumstances that cannot always be anticipated during contract design.

The *Mudarabah* contract illustrates these challenges particularly well. *Mudarabah* represents a profit-and-loss sharing partnership in which one party provides capital (*rab al-mal*), and the other contributes managerial expertise (*mudarib*). Although core contractual elements such as capital contributions, profit-sharing ratios, and contract duration can be readily encoded into smart contracts, verifying actual business performance often depends on external information sources (Rahman, 2022). Consequently, blockchain systems require external data providers, commonly referred to as oracles, to supply verified off-chain information to on-chain smart contracts. This dependency demonstrates that the execution of Sharia-compliant contracts cannot rely solely on blockchain infrastructure, as essential business information continues to originate outside the distributed ledger environment.

The reliance on oracles introduces the "oracle problem." Because smart contracts cannot independently verify real-world events, their functionality depends critically on the reliability, integrity, and compliance of external data providers (Abdullah & Oseni, 2019). Inaccurate or manipulated information may compromise not only operational effectiveness but also Sharia compliance. Consequently, the governance, auditing, and certification of oracle systems become essential components of blockchain-enabled Islamic finance. Therefore, Oracle governance should be understood not merely as a technical challenge but also as a governance issue requiring coordinated oversight from technical experts, Sharia scholars, and regulatory authorities.

Another important challenge concerns the immutable nature of blockchain. Once deployed, smart contracts generally cannot be altered without predefined mechanisms for modification. However, Islamic jurisprudence recognizes the possibility of contractual renegotiation, amendment, and mutual termination through principles such as *iqalah*. Excessive rigidity may therefore conflict with the flexibility traditionally embedded within Islamic commercial law. Farooq and Al-Suwaidi (2021) argue that purely automated blockchain systems are unlikely to fully accommodate the nuanced interpretative processes required in Islamic finance. Instead, they propose hybrid governance arrangements that combine technological automation with ongoing human oversight by Sharia scholars and legal experts. Collectively, the reviewed studies indicate that blockchain technology effectively addresses many operational deficiencies in cross-border financial transactions, while smart contracts improve contractual efficiency through automation. However, neither technology can independently accommodate the interpretative, ethical, and institutional dimensions of Sharia governance. Consequently, technological trust alone remains insufficient to ensure the legitimacy of Islamic financial transactions. Rather than replacing institutional governance, blockchain should be viewed as a complementary technological infrastructure that strengthens, rather than substitutes for, Sharia supervision. This synthesis provides the conceptual justification for the hybrid governance model proposed in this study.

Regulatory Environment and the Emerging Research Gap

Beyond technological and jurisprudential considerations, the implementation of blockchain-based Islamic finance is heavily dependent upon the surrounding regulatory environment. Financial innovation operates within institutional settings that shape the legitimacy, adoption, and sustainability of new technologies. Consequently, regulatory support constitutes a critical prerequisite for the successful deployment of blockchain-enabled financial services. Unlike conventional financial innovation, blockchain-enabled Islamic finance must simultaneously meet technological feasibility, regulatory, and Sharia governance requirements. These multiple layers of institutional oversight make regulatory alignment considerably more complex than in conventional digital finance ecosystems.

Comparative evidence indicates substantial variation in regulatory readiness across jurisdictions. Malaysia has emerged as a regional leader in Islamic FinTech through the proactive engagement of Bank Negara Malaysia (BNM) and the Securities Commission (SC). Regulatory initiatives such as FinTech sandboxes, digital asset frameworks, and explicit support for Islamic digital financial innovation have created an enabling environment for experimentation and institutional adoption (BNM, 2017). Similarly, the United Arab Emirates, particularly through the Dubai International Financial Center (DIFC), has adopted highly progressive regulatory approaches designed to attract global FinTech investment and talent. These experiences demonstrate that successful blockchain adoption depends not only on technological maturity but also on institutional readiness, regulatory coordination, and governance capacity.

In contrast, Indonesia's regulatory framework remains relatively fragmented. Regulatory responsibilities are divided primarily between Bank Indonesia, which oversees payment systems, and the Financial Services Authority (OJK), which regulates financial institutions and digital financial innovation (OJK, 2022). Although important initiatives such as regulatory sandboxes and digital financial innovation frameworks have been introduced, there remains no comprehensive regulatory architecture specifically addressing blockchain-based Islamic finance. Moreover, the legal status of smart contracts, digital assets, and decentralized financial infrastructures continues to evolve. This fragmented regulatory landscape increases institutional uncertainty because multiple authorities exercise complementary yet distinct supervisory responsibilities without an integrated governance framework specifically designed for blockchain-enabled Islamic financial transactions.

The governance of Sharia compliance presents an additional institutional challenge. Indonesia's Islamic financial sector relies extensively on fatwas issued by the National Sharia Council (DSN-MUI). While this system has proven effective for conventional Islamic financial products, specific standards governing blockchain technologies, smart contracts, and distributed ledger applications remain underdeveloped. The absence of standardized procedures for Sharia certification of smart contracts may create uncertainty among financial institutions and potential investors. Consequently, blockchain implementation cannot rely solely on technological innovation; it must also establish governance mechanisms to coordinate regulators, Sharia authorities, and financial institutions throughout the transaction lifecycle.

Existing scholarship has made important contributions to understanding blockchain applications in Islamic finance. Previous studies have explored the efficiency benefits of blockchain technologies, examined conceptual compatibility between blockchain and Sharia principles, and discussed general governance challenges associated with Islamic FinTech (Khan et al., 2020; Khan & Ahmed, 2023). Furthermore, hybrid governance mechanisms integrating technological and human oversight have been proposed conceptually (Farooq & Al-Suwaidi, 2021). Collectively, these studies establish a strong theoretical foundation demonstrating that blockchain possesses considerable potential to improve Islamic financial services. However, the existing literature predominantly conceptualizes governance at a general level and provides only limited guidance regarding how technological, regulatory, and Sharia governance mechanisms should interact within an operational cross-border financial environment.

More importantly, the literature reveals three interconnected shortcomings. First, previous studies have predominantly investigated blockchain technology, Sharia compliance, and regulatory governance as separate analytical domains, resulting in limited integration across these complementary perspectives. Second, although hybrid governance has been proposed conceptually, existing studies provide limited operational guidance regarding how governance actors—including regulators, Sharia Supervisory Boards, legal experts, and technical auditors—should interact throughout the lifecycle of blockchain-enabled financial transactions. Third, most existing frameworks are developed at a generic level and therefore do not adequately account for the institutional characteristics of emerging Islamic financial markets such as Indonesia, where regulatory authority is distributed across multiple agencies and Sharia governance is embedded within a distinctive national institutional structure.

These limitations indicate that the current literature explains why blockchain adoption is desirable but provides insufficient guidance regarding how blockchain-enabled Islamic finance should be governed in practice. Consequently, an important theoretical gap remains regarding the development of an operational governance architecture that integrates technological automation, institutional oversight, and Sharia compliance within a single coherent framework. This gap is particularly important given Indonesia's strategic ambition to become a global hub for Islamic digital finance. Without a context-specific governance architecture that reconciles blockchain automation with institutional oversight and regulatory requirements, the adoption of blockchain in Indonesia's Islamic financial sector may remain limited. To address this gap, the present study develops a hybrid Sharia governance framework that integrates on-chain automation through blockchain and smart contracts with off-chain institutional oversight involving Sharia scholars, regulators, technical auditors, and legal experts. The framework seeks to provide an operational blueprint for implementing Sharia-compliant cross-border financial transactions within the Indonesian context. By explicitly integrating technological infrastructure, institutional governance, regulatory coordination, and Sharia oversight, the proposed framework extends previous conceptual discussions toward a more operational and context-specific governance model that can inform both future research and practical implementation.

Literature Synthesis and Research Positioning

The preceding review demonstrates that existing scholarship has substantially advanced the understanding of blockchain applications in Islamic finance. Collectively, previous studies have established three important streams of knowledge. The first stream focuses on the technological capabilities of blockchain and smart contracts, emphasizing improvements in transparency, traceability, automation, and transaction efficiency (Glaser, 2017; Tapscott & Tapscott, 2017; Harvey et al., 2021; Chen & Wu, 2022). The second stream examines the compatibility between blockchain technology and Islamic financial principles, particularly the potential of distributed ledger technologies to enhance amanah, reduce gharar, and strengthen accountability within Islamic financial transactions (El-Gamal, 2006; Khan & Ahmed, 2023; Hasan et al., 2022). The third stream discusses governance challenges associated with blockchain adoption, highlighting the importance of Sharia supervision, regulatory oversight, oracle reliability, and institutional legitimacy (Abdullah & Oseni, 2019; Farooq & Al-Suwaidi, 2021; Hassan & Al-Saleem, 2022).

Although these streams collectively provide a solid theoretical foundation, they remain largely fragmented. Existing studies generally emphasize either technological innovation, Sharia compliance, or governance mechanisms without adequately explaining how these dimensions interact throughout the lifecycle of cross-border Islamic financial transactions. Consequently, current knowledge remains insufficient to support the practical implementation of blockchain-enabled Islamic finance in jurisdictions characterized by complex institutional arrangements, such as Indonesia. Table 1 synthesizes the principal contributions and limitations of the most relevant studies reviewed in this research and illustrates how the present study extends the existing body of knowledge.

Table 1. Critical Synthesis of Previous Studies and Research Positioning

Study	Primary Focus	Main Contribution	Identified Limitation	Contribution of This Study
Khan et al. (2020)	Blockchain and Islamic finance	Comprehensive literature review on FinTech and blockchain applications	Limited discussion of governance implementation	Develops an operational governance framework integrating technology, regulation, and Sharia oversight
Farooq and Al-Suwaidi (2021)	Hybrid governance	Introduces the concept of hybrid governance for blockchain-based Islamic finance	Conceptual discussion without institutional operationalization	Operationalizes hybrid governance through defined institutional roles and transaction workflows
Khan and Ahmed (2023)	Smart contracts and Sharia compliance	Explains the compatibility of blockchain with Sharia principles	Limited regulatory and institutional perspective	Integrates technological, regulatory, and Sharia governance dimensions into a unified framework
Rahman (2022)	Mudarabah smart contracts	Demonstrates the feasibility of programmable Islamic contracts	Focuses on contract logic rather than governance architecture	Extends contract design into an end-to-end governance framework for cross-border transactions

Study	Primary Focus	Main Contribution	Identified Limitation	Contribution of This Study
Abdullah and Oseni (2019)	Oracle governance	Identifies oracle reliability as a critical challenge	Focuses primarily on technical aspects	Incorporates oracle governance into a comprehensive institutional oversight mechanism
Hassan and Al-Saleem (2022)	Digital Sharia governance	Discusses governance challenges in digital Islamic finance	Does not propose an operational governance architecture	Develops an implementable governance model tailored to Indonesia's institutional environment

Source: Research data, 2025

The synthesis presented in Table 1 highlights three important observations. First, existing studies consistently recognize the potential of blockchain technology to improve operational efficiency and transparency, yet they pay relatively limited attention to the governance structures required to ensure continuous Sharia compliance. Second, although hybrid governance has emerged as a promising conceptual approach, previous studies provide limited guidance regarding how institutional actors—including regulators, Sharia Supervisory Boards, legal experts, and technical auditors—should interact within blockchain-enabled financial ecosystems. Third, the institutional characteristics of emerging Islamic financial markets remain underexplored despite their importance for practical implementation. These observations collectively define the research positioning of the present study. Rather than proposing another conceptual discussion regarding blockchain adoption, this study develops a context-specific governance architecture that integrates technological infrastructure, institutional governance, regulatory coordination, and Sharia supervision into a coherent operational framework. In doing so, the study contributes not only to the theoretical development of Islamic FinTech but also to the practical implementation of blockchain-enabled cross-border Islamic finance within Indonesia.

C. METHODS

This study adopts a conceptual research design to develop a hybrid governance framework for Sharia-compliant cross-border transactions using blockchain technology and smart contracts in Indonesia. A conceptual approach is appropriate because the primary objective of this study is not to test hypotheses empirically but to synthesize existing knowledge and develop an integrated framework to address a contemporary, multifaceted problem in Islamic financial services. Conceptual research plays an important role in advancing emerging fields by integrating fragmented streams of literature and generating theoretically grounded propositions that can guide future empirical investigations. A pragmatist research philosophy underpins the study. Pragmatism emphasizes practical problem-solving and the development of solutions that are applicable in real-world settings (Creswell & Plano Clark, 2018). Given the interdisciplinary nature of blockchain-enabled Islamic finance, which encompasses technological, legal, regulatory, and religious dimensions, a pragmatist perspective enables the integration of diverse bodies of knowledge in order to construct a framework that is both theoretically robust and practically relevant. Rather than privileging a single epistemological perspective, pragmatism focuses on identifying workable solutions to address the operational inefficiencies and governance challenges currently faced by cross-border Islamic finance.

Consistent with this philosophical orientation, the study employs an abductive research approach. Abduction involves moving iteratively between theoretical insights and observed phenomena to develop the most plausible explanation or solution to a given problem (Saunders, Lewis, & Thornhill, 2019). In the present study, the observed phenomena consist of persistent inefficiencies, compliance ambiguities, and governance challenges associated with conventional cross-border Islamic finance. Existing theories and empirical insights relating to blockchain technology, smart contracts, Islamic jurisprudence, and financial regulation are subsequently synthesized to develop an integrated governance framework. The abductive approach is particularly suitable because it allows combining established theoretical concepts with emerging technological developments within a rapidly evolving institutional environment.

The framework development process relies exclusively on secondary data sources. The academic literature provides the primary theoretical foundation for the study. Peer-reviewed journal articles were selected through a systematic review of publications indexed in major academic databases, including Scopus and Web of Science. Particular emphasis was placed on highly ranked journals and studies demonstrating strong relevance to Islamic finance, blockchain technology, smart contracts, Sharia governance, cross-border payments, and financial

regulation. In addition to academic publications, the study incorporates regulatory documents, governmental reports, and industry publications to ensure contextual relevance and practical applicability. Official publications issued by the Financial Services Authority (OJK), Bank Indonesia, the Islamic Financial Services Board (IFSB), the Financial Stability Board (FSB), and other relevant institutions were extensively reviewed to understand the contemporary regulatory landscape governing financial innovation and Islamic finance. Technical documentation, including blockchain white papers and reports from financial institutions, was also consulted to provide insights into the practical capabilities and limitations of distributed ledger technologies.

The analytical process followed several iterative stages. Initially, all selected sources were reviewed thoroughly to identify key concepts, arguments, and recurring themes relevant to blockchain-enabled Islamic finance. Subsequently, a thematic analysis was conducted to identify patterns across the literature concerning operational inefficiencies, Sharia governance challenges, blockchain capabilities, regulatory constraints, and hybrid governance arrangements. These themes were then synthesized into higher-order analytical categories that formed the conceptual building blocks of the proposed framework. Particular attention was paid to identifying areas of convergence and divergence across different streams of literature in order to generate a coherent, integrative understanding of the phenomenon under investigation.

To demonstrate the operational feasibility of the proposed framework, the study further develops a conceptual prototype based on a cross-border Mudarabah transaction. Mudarabah was selected because it is one of the most prominent profit-and-loss-sharing contracts in Islamic finance and embodies several governance complexities associated with Sharia compliance. The conceptual prototype enables the systematic mapping of core Mudarabah principles, including capital contribution, profit-sharing arrangements, contractual consent, and loss allocation, onto blockchain-based smart contract functions. This analytical exercise facilitates assessing how blockchain technology may operationalize Sharia requirements while simultaneously identifying areas where human oversight remains indispensable.

As the study relies exclusively on publicly available secondary data, no human participants were involved, and no confidential organizational information was collected. Consequently, ethical concerns relating to informed consent, confidentiality, and privacy are not applicable. Nevertheless, academic integrity remains a fundamental consideration throughout the research process. All sources have been appropriately acknowledged and cited to ensure transparency, avoid plagiarism, and uphold responsible scholarly practice.

D. RESULTS AND DISCUSSIONS

Guiding Principles of the Proposed Framework

The literature analysis reveals that the successful implementation of blockchain-enabled Islamic finance requires a governance architecture that simultaneously addresses technological efficiency, Sharia compliance, regulatory legitimacy, and operational security. Existing studies frequently emphasize individual dimensions of these requirements; however, very few studies integrate them into a unified operational framework. Consequently, this study proposes a hybrid governance framework grounded in four interrelated guiding principles: Sharia compliance, operational efficiency, regulatory alignment, and security through immutability.

Sharia compliance constitutes the most fundamental principle underpinning the proposed framework. Unlike conventional financial systems, Islamic financial transactions must continuously adhere to the prohibitions of *riba*, *gharar*, and *maysir* while promoting transparency, fairness, and ethical conduct (El-Gamal, 2006). Therefore, the framework is designed to ensure that every operational process, whether automated on-chain or supervised off-chain, remains consistent with the principles of Islamic jurisprudence. This principle is particularly important because technological efficiency alone cannot guarantee the legitimacy of Islamic financial products.

Operational efficiency represents the second guiding principle. The literature consistently identifies high transaction costs, lengthy settlement periods, and extensive reconciliation procedures as major inefficiencies in traditional correspondent banking systems (Benschop & van der Linden, 2019; Financial Stability Board, 2020). Accordingly, the proposed framework seeks to minimize these inefficiencies through automation, reduced intermediation, and the establishment of a shared transactional infrastructure. Smart contracts automate contractual execution, thereby reducing manual intervention and accelerating transaction settlement.

The third principle concerns regulatory alignment. Financial innovation can only be successfully implemented when supported by an enabling institutional environment. Indonesia's fragmented regulatory landscape necessitates a governance architecture that accommodates the supervisory roles of both Bank Indonesia and the

Financial Services Authority (OJK) while remaining consistent with existing Sharia governance mechanisms (OJK, 2022). Consequently, regulatory compatibility is embedded as a central design feature of the framework.

Finally, the framework emphasizes security and immutability. Blockchain technology derives much of its value from the ability to establish tamper-resistant records and a single source of truth shared among network participants (Glaser, 2017). These characteristics are particularly relevant to Islamic finance because immutable records enhance accountability, facilitate auditing, and strengthen trust among stakeholders. Collectively, these principles form the conceptual foundation of the proposed framework and guide the design of both its technological and governance components.

On-Chain Architecture of the Proposed Framework

The findings suggest that the technological architecture of a blockchain-enabled Islamic financial system should primarily operate within a permissioned blockchain environment. While public blockchains provide high levels of decentralization, financial institutions generally require stronger control over participant access, identity verification, and data confidentiality. Therefore, the proposed framework adopts a permissioned blockchain model, such as Hyperledger Fabric or Corda, in which only authorized institutions, regulators, and designated stakeholders are permitted to participate. The proposed on-chain architecture comprises three interconnected layers: the blockchain infrastructure layer, the smart contract layer, and the oracle layer. Figure 1 illustrates the overall architecture of the proposed blockchain ecosystem.

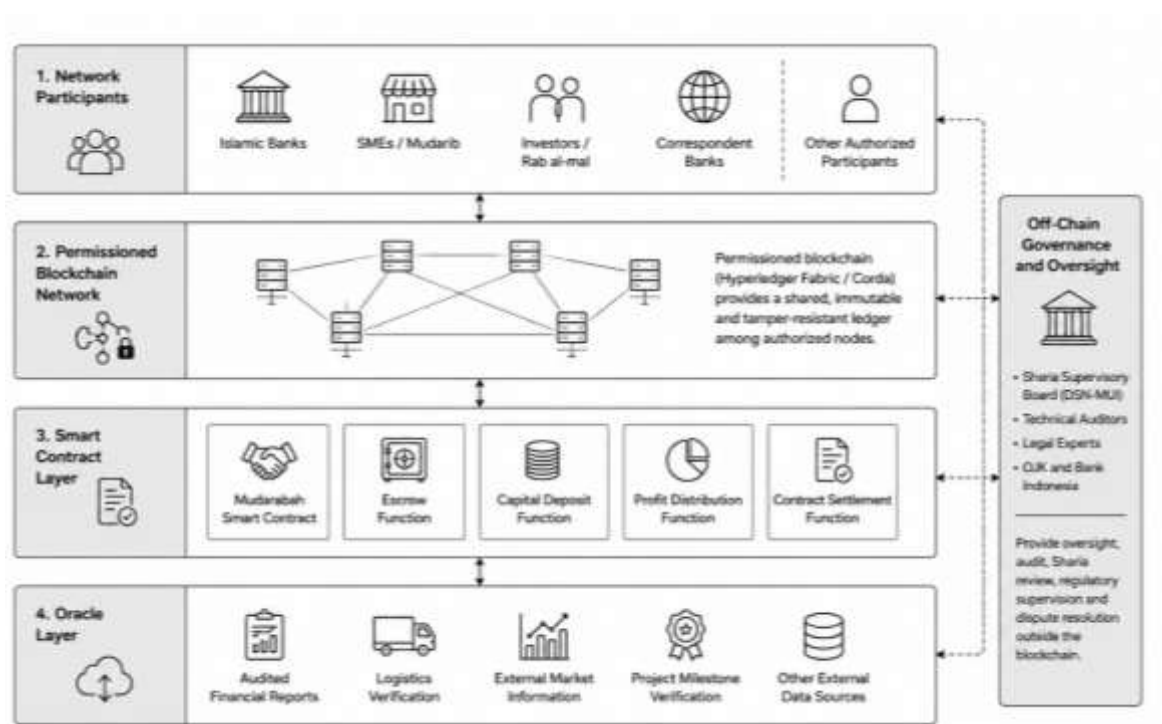


Figure 1. Proposed On-Chain Architecture for Blockchain-Based Cross-Border Islamic Finance

Source: Research data, 2025

The blockchain infrastructure layer serves as the distributed ledger that records all transactional activities. By maintaining synchronized records across network participants, the blockchain eliminates the need for repetitive reconciliation processes that are typical of conventional cross-border payment systems. The shared ledger thereby increases transparency while simultaneously reducing operational costs and settlement delays. Built upon this infrastructure, the smart contract layer automates the execution of contractual obligations. In the context of cross-border Islamic finance, smart contracts encode critical contractual terms, including capital contributions, profit-sharing ratios, project milestones, and contract duration. Once predefined conditions are satisfied, contractual obligations are executed automatically without requiring further human intervention. Such automation significantly reduces counterparty risk and enhances transactional efficiency.

However, blockchain systems cannot access external information independently. Consequently, the framework incorporates an oracle layer serving as a secure interface between on-chain and off-chain environments. Oracles provide verified external information necessary for contract execution, including proof of shipment, audited financial reports, and proof of project milestone completion. The literature identifies oracle reliability as a principal vulnerability of smart contract systems (Abdullah & Oseni, 2019). Therefore, the proposed framework subjects oracle providers to both technical and Sharia auditing procedures within the broader governance architecture. To demonstrate how Islamic contractual principles can be operationalized within blockchain systems, Table 2 maps the essential pillars (arkan) of a Mudarabah contract to corresponding smart contract functions.

Table 2. Mapping Mudarabah Principles to Smart Contract Functions

Mudarabah Principle (Arkan)	Sharia Requirement	Smart Contract Function	Sharia Compliance Justification
Parties (Rab al-mal and Mudarib)	Identity and legal capacity must be clearly established	Verified digital wallet addresses integrated with KYC procedures	Cryptographic identities ensure authenticity and prevent impersonation
Capital (Ra's al-mal)	The capital amount must be clearly specified and transferred	depositCapital() function	Blockchain records provide immutable evidence of capital transfer
Profit-Sharing Ratio (Nisbah)	Profit-sharing ratio must be mutually agreed upon ex ante	Immutable variable embedded during contract deployment	Prevents unilateral modification and reduces gharar
Venture (Mashru')	Underlying business activity must be halal and clearly defined	Project details stored as cryptographic hashes	Ensures the integrity of agreed business activities
Offer and Acceptance (Sighah)	Mutual consent must be explicitly demonstrated	Digital signatures from both contracting parties	Provides cryptographic proof of contractual consent
Profit and Loss Distribution	Profits are shared according to the agreed ratio, and the capital provider bears losses	distributeProfits() function	Automates objective and transparent profit allocation

Source: Research data, 2025

As shown in Table 2, several essential components of Mudarabah contracts can be effectively translated into programmable logic. The immutability of blockchain technology ensures that agreed contractual parameters cannot be altered unilaterally, thereby reducing contractual ambiguity and enhancing transparency. Moreover, the use of digital signatures and cryptographic verification strengthens evidentiary certainty regarding contractual consent and execution. Nevertheless, the analysis also indicates that not all dimensions of Islamic finance can be fully automated. Certain aspects, particularly those involving interpretative judgement, dispute resolution, and contextual assessment, remain beyond the capabilities of deterministic code. Consequently, the findings suggest that technological automation alone is insufficient to guarantee continuous Sharia compliance. These limitations necessitate the incorporation of complementary governance mechanisms operating outside the blockchain environment, which are discussed in the subsequent section.

Hybrid Sharia Governance Model

The findings demonstrate that although blockchain and smart contracts offer substantial improvements in operational efficiency, they are insufficient as standalone governance mechanisms within Islamic finance. The deterministic nature of smart contracts limits their ability to accommodate the interpretative flexibility inherent in Islamic jurisprudence. Consequently, this study proposes a Hybrid Sharia Governance Model that combines on-chain technological automation with off-chain institutional oversight. The proposed model seeks to balance operational efficiency with the contextual and ethical considerations required in Sharia-compliant financial transactions.

The need for hybrid governance arises primarily from the limitations of fully automated systems. Smart contracts execute predefined rules automatically and objectively; however, they cannot independently interpret evolving regulatory requirements, resolve unforeseen disputes, or exercise jurisprudential judgement. Islamic commercial jurisprudence frequently requires contextual interpretation, particularly in situations involving ambiguity, exceptional circumstances, or contractual renegotiation. The principle of iqalah, for example, permits

mutual termination or modification of a contract under certain circumstances. Such flexibility cannot be adequately replicated solely through immutable code. Therefore, human oversight remains indispensable in ensuring that technological processes continue to align with Sharia objectives.

The proposed Hybrid Sharia Governance Model consists of four principal institutional actors: the Sharia Supervisory Board (SSB), technical auditors, legal experts, and regulatory authorities. Figure 2 presents the institutional architecture of the proposed governance model.

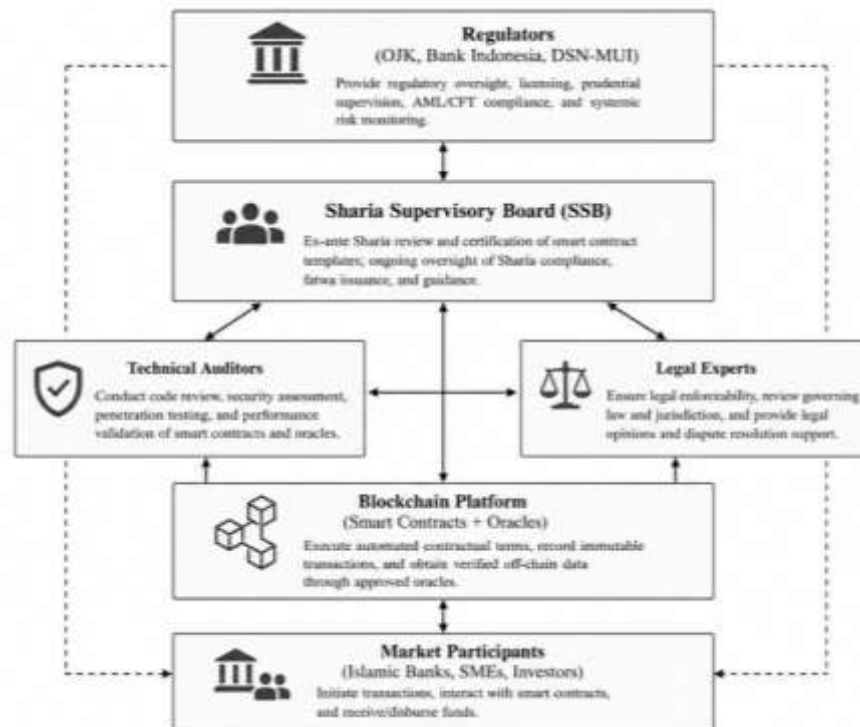


Figure 2. Hybrid Sharia Governance Model for Blockchain-Based Islamic Finance

Source: Research data, 2025

Within the proposed framework, the role of the Sharia Supervisory Board evolves significantly from traditional ex-post auditing toward ex-ante certification and continuous oversight. Prior to deployment, smart contract templates must undergo a comprehensive Sharia review to ensure their embedded logic complies with Islamic legal principles. Rather than auditing completed transactions retrospectively, Sharia scholars participate directly in the design and certification process by evaluating source code, contractual logic, profit-sharing mechanisms, and operational workflows. Upon successful evaluation, the Sharia Supervisory Board issues a formal certification or fatwa validating the smart contract template for operational use. The involvement of technical auditors constitutes a second critical governance component. Although blockchain systems are often regarded as highly secure, vulnerabilities may still arise from programming errors, coding flaws, or malicious exploitation. Smart contract failures can expose financial institutions to significant operational, legal, and reputational risks. Consequently, independent technical audits are required to assess code security, functional correctness, system robustness, and compliance with established technological standards. Technical auditors thereby complement Sharia scholars by ensuring that certified contracts are not only religiously compliant but also technically reliable.

Legal oversight represents another essential component of the governance architecture. Cross-border transactions inherently involve multiple jurisdictions and legal systems, creating uncertainty concerning contractual enforceability and dispute resolution. Accordingly, smart contracts should be explicitly linked to governing legal jurisdictions through complementary legal prose agreements. In cases where disputes cannot be resolved automatically through code execution, specialized arbitration mechanisms involving both legal practitioners and Sharia scholars should be activated. Such arrangements ensure that disputes are addressed within recognized legal frameworks while maintaining consistency with Islamic principles. Regulatory authorities,

particularly Bank Indonesia and the Financial Services Authority (OJK), provide the broader institutional environment within which blockchain-enabled Islamic finance operates. Regulators are responsible for establishing licensing requirements, monitoring systemic risks, enforcing anti-money laundering regulations, and ensuring consumer protection. The integration of regulators within the governance framework also enhances institutional legitimacy, which is particularly important given the emerging and evolving nature of distributed ledger technologies. The proposed governance architecture further addresses the widely recognized oracle problem in blockchain systems. As discussed previously, smart contracts depend heavily upon external information sources to verify real-world events. Within the proposed framework, oracle providers are subject to both technical and Sharia audits prior to authorization. Additional continuous monitoring mechanisms are established to ensure data integrity and reliability throughout the transaction lifecycle. By embedding oracle governance within the broader institutional framework, the proposed model significantly reduces the risk of inaccurate or non-compliant information entering the blockchain ecosystem.

Overall, the findings indicate that hybrid governance represents a pragmatic compromise between complete decentralization and conventional institutional control. Rather than replacing existing institutions, blockchain technology is conceptualized as augmenting and strengthening established governance arrangements. This approach acknowledges that technological and institutional trust should not be viewed as substitutes but rather as complementary mechanisms that jointly support the integrity and legitimacy of Islamic financial transactions.

Operational Workflow of a Cross-Border Mudarabah Smart Contract

To illustrate the practical applicability of the proposed framework, this study develops a conceptual workflow for a blockchain-based cross-border Mudarabah transaction involving an Indonesian small and medium-sized enterprise (SME) acting as the mudarib and an international investor acting as the rab al-mal. The workflow demonstrates how technological automation and institutional oversight interact throughout the transaction lifecycle. Figure 3 illustrates the operational workflow of the proposed Mudarabah smart contract. The transaction process begins with off-chain contractual negotiations between the participating parties. During this stage, the investor and SME agree on key contractual terms, including capital contributions, profit-sharing ratios, project milestones, and contract duration. Legal experts and Sharia advisors subsequently select an appropriate smart contract template from a repository of pre-certified contracts approved by the Sharia Supervisory Board. The agreed contractual parameters are then incorporated into the selected template prior to deployment on the blockchain network.

Following contract deployment, the investor transfers capital into the smart contract through a secure digital escrow mechanism. Unlike conventional arrangements where intermediary institutions hold and transfer funds, the smart contract autonomously manages escrow functions. The deposited capital remains locked within the blockchain environment until predefined contractual conditions are satisfied. This automated escrow arrangement significantly reduces counterparty risk while enhancing transparency and trust among participants. Once project implementation commences, milestone verification becomes a crucial operational activity. Upon completion of a specified project milestone, relevant supporting evidence, such as shipment documentation, delivery confirmations, or audited project reports, is submitted to authorized Oracle providers. After verifying the authenticity and validity of the submitted information, the oracle transmits the verified data to the blockchain network. The smart contract subsequently evaluates whether the predefined conditions have been fulfilled. If verification is successful, the contract automatically releases the next tranche of financing.

At the conclusion of the project, audited financial performance information is submitted through approved Oracle channels. The smart contract then automatically calculates profits based on the pre-agreed profit-sharing ratio and distributes the proceeds directly to the digital wallets of both contracting parties. Importantly, no interest calculation mechanism is embedded within the contract architecture. Returns are determined exclusively by the actual performance of the underlying business venture, thereby ensuring compliance with the Sharia prohibition of *riba*. Finally, once all contractual obligations have been fulfilled, the smart contract terminates automatically, preserving an immutable, auditable record of all transaction activities on the blockchain. Regulators, auditors, and authorized stakeholders may subsequently access these records for compliance verification, reporting, and supervisory purposes. The existence of a single, immutable source of transactional information substantially reduces reconciliation costs and strengthens accountability throughout the transaction lifecycle.

Collectively, the proposed workflow demonstrates the operational feasibility of integrating blockchain technology with Islamic financial principles. More importantly, it illustrates how technological automation and

institutional governance can operate synergistically to deliver both efficiency gains and continuous Sharia compliance in cross-border Islamic finance.

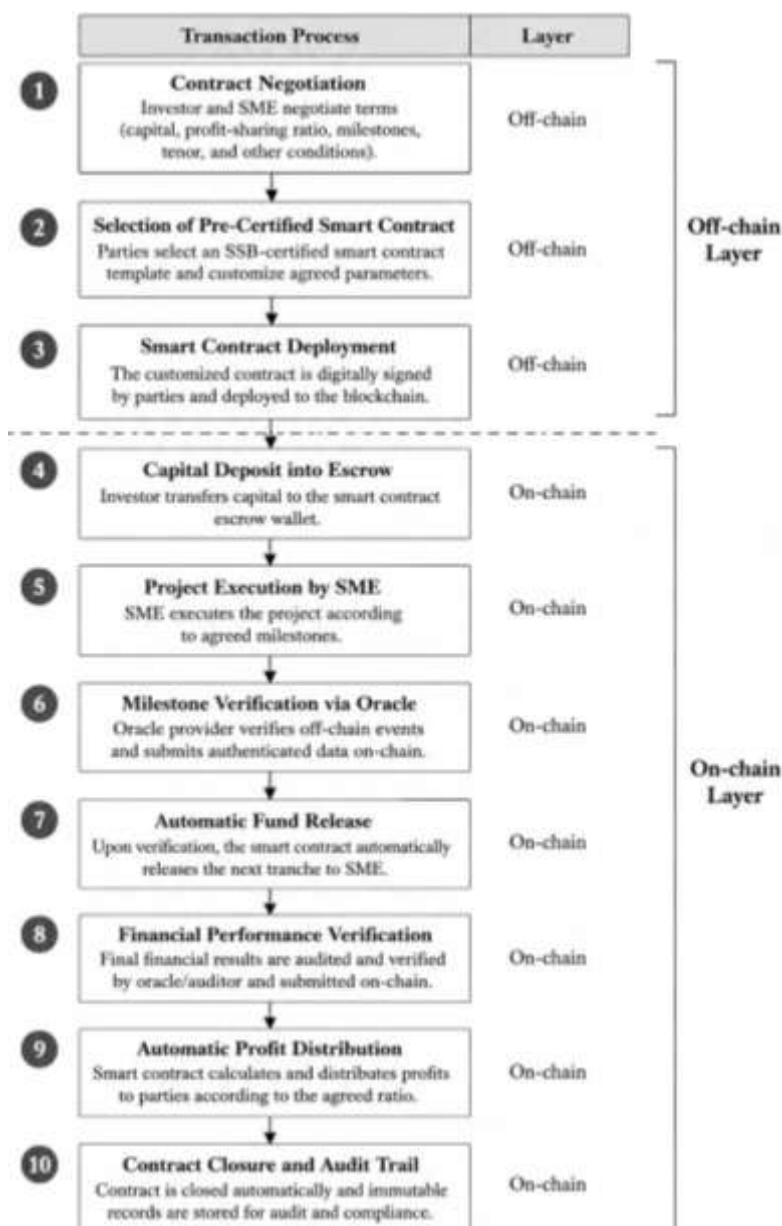


Figure 3. Operational Workflow of a Cross-Border Mudarabah Smart Contract

Source: Research data, 2025

Discussion

The findings of this study provide strong support for the proposition that blockchain technology and Islamic finance are not mutually exclusive domains. Rather, the results suggest that blockchain possesses considerable potential to operationalize and strengthen several foundational principles underpinning Islamic finance. The proposed framework demonstrates that technological innovation and Sharia principles can coexist within a complementary governance architecture that simultaneously promotes efficiency, transparency, accountability, and compliance. A key finding emerging from this study concerns the symbiotic relationship between blockchain characteristics and Islamic ethical principles. Previous literature has frequently emphasized the compatibility between blockchain transparency and the Islamic principle of amanah (Khan & Ahmed, 2023). The present study extends this argument by demonstrating that blockchain does not merely support transparency but may also serve

as a technological mechanism for institutionalizing ethical conduct within financial transactions. The immutable nature of distributed ledgers ensures that all transaction activities are permanently recorded and auditable, thereby substantially reducing opportunities for opportunistic behavior, information asymmetry, and contractual disputes. Consequently, blockchain may be conceptualized as a technological manifestation of trust and accountability in Islamic finance.

Furthermore, the proposed framework addresses one of the most persistent challenges confronting contemporary Islamic finance, namely the tension between operational efficiency and rigorous Sharia compliance. Traditional cross-border financial systems rely heavily upon multiple intermediaries and fragmented infrastructures, resulting in high costs and delays (Benschop & van der Linden, 2019; Financial Stability Board, 2020). The findings indicate that blockchain-based automation can substantially reduce these inefficiencies through smart contract execution, automated escrow mechanisms, and real-time transaction verification. These observations are consistent with previous studies suggesting that distributed ledger technologies can significantly improve efficiency within financial intermediation (Harvey et al., 2021; Chen & Wu, 2022).

However, the findings also reveal important limitations associated with fully automated governance arrangements. The deterministic nature of smart contracts poses challenges when applied in Islamic finance, as Sharia compliance often requires interpretive flexibility and contextual judgement. Islamic jurisprudence is inherently dynamic and often necessitates scholarly deliberation in addressing novel circumstances or unforeseen contractual contingencies. The inability of smart contracts to independently interpret evolving jurisprudential principles highlights the limitations of purely algorithmic governance. The proposed Hybrid Sharia Governance Model addresses these limitations by integrating on-chain automation with off-chain human oversight. This finding reinforces the arguments advanced by Farooq and Al-Suwaidi (2021), who argue that hybrid governance is the most feasible pathway for blockchain adoption in Islamic finance. Nevertheless, this study extends prior scholarship by operationalizing hybrid governance within a specific institutional context and by explicitly incorporating the oversight roles of Indonesian regulatory institutions, Sharia authorities, legal experts, and technical auditors. Consequently, the framework moves beyond conceptual discussions toward a more practically implementable governance architecture.

Another important contribution concerns the governance of external data sources or oracles. The existing literature has identified the oracle problem as a principal vulnerability in smart contract ecosystems, as inaccurate external information may compromise both operational effectiveness and Sharia compliance (Abdullah & Oseni, 2019). The findings suggest that oracle governance should not be treated merely as a technical issue but rather as a multidimensional governance challenge involving technological, legal, and religious considerations. By subjecting Oracle providers to continuous technical and Shariah audits, the proposed framework significantly enhances the reliability and legitimacy of blockchain-enabled Islamic financial transactions. The Indonesian context further enriches the discussion. Unlike jurisdictions such as Malaysia and the United Arab Emirates, Indonesia continues to operate within a relatively fragmented regulatory environment (OJK, 2022). The findings indicate that the successful implementation of blockchain-based Islamic finance requires close coordination among multiple regulatory stakeholders, particularly Bank Indonesia, OJK, and the National Sharia Council (DSN-MUI). Without such coordination, inconsistencies in regulatory interpretation and supervisory responsibilities may inhibit innovation and delay institutional adoption. Therefore, regulatory integration emerges as an essential precondition for the successful digital transformation of Islamic finance in Indonesia.

Collectively, these findings suggest that blockchain should not be viewed as a disruptive technology intended to replace existing institutions. Rather, blockchain should be conceptualized as an enabling infrastructure that augments and strengthens existing governance mechanisms. The combination of technological and institutional trust offers a more balanced and sustainable approach to financial innovation, particularly in highly regulated, ethically sensitive sectors such as Islamic finance.

Theoretical Contributions

This study contributes to the emerging literature on Islamic FinTech in several important ways. First, the study advances existing scholarship by moving beyond generalized discussions concerning blockchain applications in Islamic finance and proposing a comprehensive governance architecture that integrates technological, regulatory, and Sharia dimensions. Previous studies have largely examined these dimensions independently, whereas the present framework synthesizes them into a coherent operational model. Second, the study extends the hybrid governance perspective proposed by (Farooq and Al-Suwaidi, 2021) by demonstrating how it can be operationalized in a specific national setting. By incorporating institutional actors such as OJK, Bank Indonesia,

and DSN-MUI, the framework illustrates how technological innovation may be embedded within existing governance structures without undermining institutional legitimacy.

Third, the findings contribute to the broader discourse concerning trust in digital financial systems. Conventional blockchain literature frequently assumes that cryptographic mechanisms can substitute for institutional trust. In contrast, this study demonstrates that within Islamic finance, technological trust and institutional trust function as complementary rather than competing governance mechanisms. This insight is particularly relevant for understanding digital transformation within highly institutionalized sectors characterized by strong ethical and religious foundations. Finally, the study contributes conceptually by proposing that blockchain may serve as a technological tool to advance the broader objectives of Sharia (maqasid al-Sharia). By enhancing transparency, accountability, and fairness, blockchain-enabled financial infrastructures may facilitate the realization of ethical, socially responsible financial systems aligned with the normative aspirations of Islamic finance.

Practical and Policy Implications

The proposed framework also generates several important practical implications for financial institutions, regulators, and policymakers. For Islamic financial institutions, the findings suggest that blockchain adoption should be approached strategically through phased implementation initiatives. Financial institutions may initially utilize regulatory sandboxes to pilot blockchain-based products and gradually build organizational capabilities. Collaborative partnerships with FinTech firms may further accelerate innovation while reducing development costs and technological uncertainty. The findings additionally highlight the importance of human capital development. Successful implementation of blockchain-enabled Islamic finance requires multidisciplinary expertise encompassing Islamic jurisprudence, financial regulation, computer science, and cybersecurity. Consequently, Islamic financial institutions should invest in workforce development programs designed to bridge existing knowledge gaps and foster cross-disciplinary collaboration. For regulators, the findings underscore the need to establish an integrated regulatory framework governing blockchain-based Islamic finance. Greater coordination between Bank Indonesia and OJK is essential to minimize regulatory fragmentation and provide greater certainty for market participants. Regulatory clarity concerning smart contract enforceability, digital asset classification, and distributed ledger governance would significantly reduce institutional uncertainty and encourage investment.

The study further recommends developing national standards for Sharia-compliant smart contracts. Collaboration between regulators, DSN-MUI, industry associations, and technology experts may facilitate the establishment of standardized certification procedures, audit mechanisms, and governance protocols. Such standardization would enhance interoperability, strengthen market confidence, and promote wider adoption across the Islamic financial sector. At a broader policy level, the findings indicate that Indonesia possesses significant opportunities to strengthen its position within the global Islamic digital economy. By leveraging its large Muslim population, established Islamic financial sector, and growing digital ecosystem, Indonesia may emerge as a leading center for Sharia-compliant financial innovation. However, realizing this ambition requires proactive institutional reforms, regulatory harmonization, and sustained investment in technological capabilities.

E. CONCLUSION

This study developed a hybrid Sharia governance framework for blockchain-enabled cross-border Islamic financial transactions within the Indonesian context. Motivated by persistent inefficiencies, compliance ambiguities, and governance challenges associated with conventional cross-border financial infrastructures, the study examined how blockchain technology and smart contracts can be integrated with Sharia governance mechanisms to facilitate efficient, transparent, and compliant Islamic financial transactions. The findings indicate that blockchain technology possesses considerable potential to transform cross-border Islamic finance by enhancing operational efficiency, reducing transaction costs, accelerating settlement processes, and improving transparency. Through distributed ledger technology and smart contract automation, several longstanding inefficiencies associated with correspondent banking systems may be significantly reduced. The study further demonstrates that essential components of Islamic financial contracts, particularly Mudarabah arrangements, can be effectively translated into programmable logic while preserving core Sharia principles, including risk sharing, transparency, and the prohibition of *riba*.

Nevertheless, the findings also reveal that technological automation alone is insufficient to ensure continuous Sharia compliance. The deterministic nature of smart contracts limits their ability to accommodate the interpretative flexibility, contextual judgement, and ethical deliberation embedded within Islamic jurisprudence. Consequently, fully automated governance arrangements may not adequately address the complexities inherent in Islamic financial transactions. To overcome these limitations, the study proposed a Hybrid Sharia Governance Model integrating on-chain automation with off-chain institutional oversight involving Sharia scholars, technical auditors, legal experts, and regulatory authorities. The study contributes to the literature in several important ways. First, it advances the emerging field of Islamic FinTech by proposing a comprehensive governance architecture that synthesizes technological, regulatory, and Sharia dimensions within a single operational framework. Second, it extends existing hybrid governance perspectives by demonstrating how technological trust and institutional trust may function complementarily rather than competitively within Islamic finance. Third, the study provides one of the first context-specific governance frameworks explicitly designed for Indonesia's unique legal, regulatory, and institutional environment, thereby addressing a significant gap within the current literature. From a practical perspective, the proposed framework offers actionable guidance for Islamic financial institutions seeking to adopt blockchain technologies responsibly. The framework also provides policymakers and regulators with a conceptual blueprint for developing integrated regulatory arrangements and standardized Sharia governance mechanisms that support digital financial innovation. More broadly, the findings suggest that blockchain technology may serve as an important enabler in advancing Indonesia's ambition to become a global hub for Islamic digital finance.

Several limitations should nevertheless be acknowledged. First, this study is conceptual in nature and does not involve the implementation or empirical testing of a live blockchain application. Consequently, the operational effectiveness, scalability, and cost efficiency of the proposed framework remain to be validated empirically. Second, the regulatory analysis reflects the institutional environment and publicly available information at the time of the study and may therefore not fully capture future regulatory developments. Finally, although the framework was specifically designed for Indonesia, its applicability to other jurisdictions may require adaptation to accommodate different legal and Sharia governance structures. These limitations provide several avenues for future research. Subsequent studies should develop and experimentally test prototype applications to evaluate the operational performance and security of blockchain-based Mudarabah smart contracts in real-world settings. Quantitative investigations into stakeholder acceptance, organizational readiness, and the potential macroeconomic impacts of blockchain adoption in Islamic finance would further enrich the literature. Comparative studies involving multiple jurisdictions are also needed to examine the interoperability of blockchain governance frameworks across different legal and regulatory environments. Such research would substantially advance globally integrated, Sharia-compliant digital financial ecosystems.

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